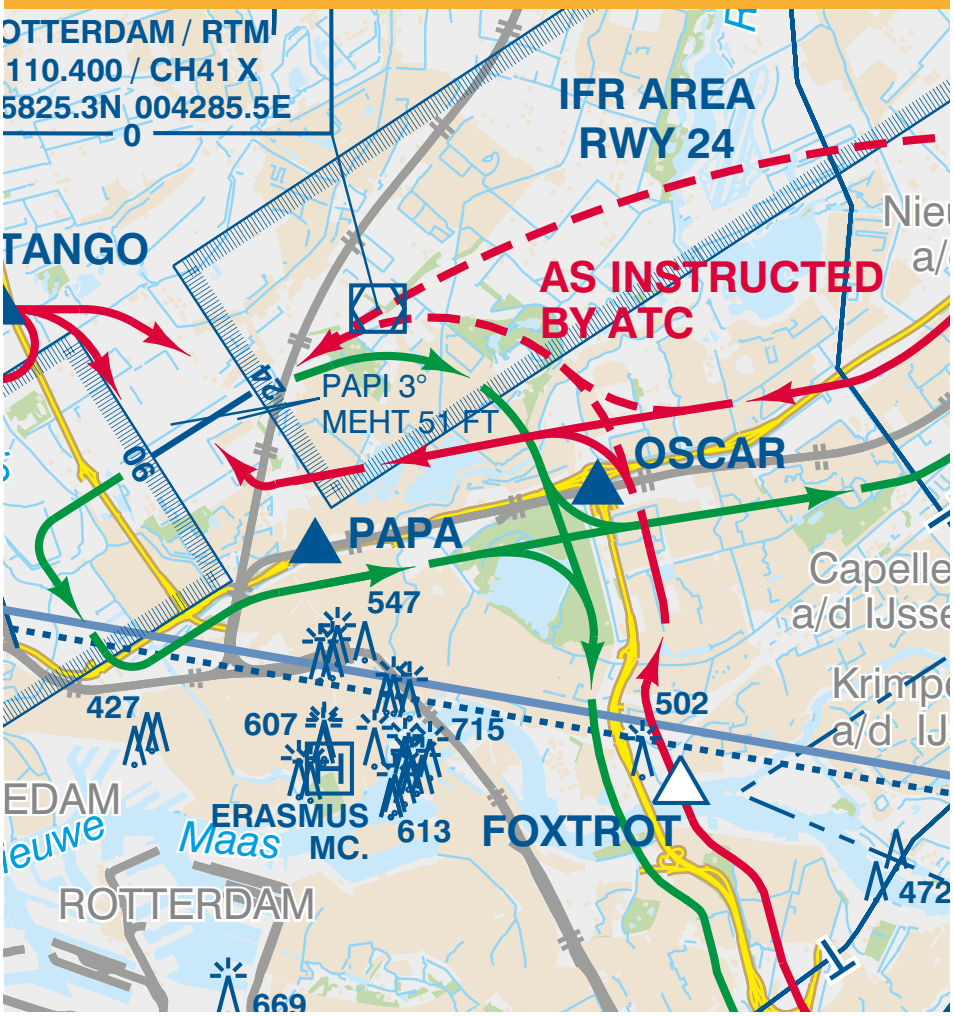
DUTCH
SAFETY BOARD

Near mid-air collision in the Rotterdam Control Zone

15 June 2022



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15 June 2022

The Hague, November 2024

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Cover photograph: Dutch Safety Board

The Dutch Safety Board

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N.B.: This report has been published in the Dutch and English language. If there are differences in interpretation the Dutch report prevails.

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SUMMARY

On the 15th of June 2022 a Cessna 172S, registered as D-EBTO with a pilot and passenger (a licensed aviator) on board, flew under visual flight rules (VFR) from Münster Osnabrück Airport, Germany (EDDG) to Rotterdam The Hague Airport (EHRD). The pilot followed the standard ROMEO arrival route in the Rotterdam Control Zone (CTR) at 1,500 feet on its way to Runway 06. Meanwhile another Cessna 172, registered as N98825, took off from Runway 06 under VFR following a standard ROMEO departure route in the Rotterdam CTR on 1,500 feet. The pilot, being the only occupant, flew to Frankfurt Egelsbach Airport (EDFE) in Germany.

When Runway 06 is in use, the ROMEO arrival route crosses the ROMEO departure route at 1,500 feet near the reporting point OSCAR. Both aircraft neared the crossing point at the same prescribed altitude and at the same moment. Although Air Traffic Control (ATC) had informed both pilots earlier that they had opposite traffic, both pilots did not have the other aircraft (conflicting traffic) in sight when nearing the crossing point. When D-EBTO was about to cross the ROMEO departure route, the pilot observed the N98825 at a late stage on his right and initiated an evasive action (a dive) to increase the vertical distance. The Dutch Safety Board classified the event as a serious incident.

Two comparable events had previously occurred at or near the same crossing point when Runway 06 was inuse. In 2014 one aircraft flew a standard Mike departure procedure at 1,000 feet and another aircraft flew a standard Mike arrival procedure at 1,000 feet. In 2020 one aircraft flew a Mik e departure procedure at 1,000 feet and an arriving aircraft cleared for a 'direct course' in opposite direction flew at or approximately at 1,000 feet. In both of these near mid-air collison events arriving and departing traffic had crossing routes at the same or almost at the same altitude. Similar to the event on 15 June 2022, these two events and studies addressing the limitations of 'see and avoid' show that 'see and avoid' is sensitive to failure and therefore an unreliable safety barrier. As demonstrated by the events, in particular when Runway 06 is in use, adherence to prescribed VFR procedures and instructions may perpetuate the risk for conflict instead of mitigating it.

To fullfill the responsibility for VFR pilots to prevent collisions, they need to have the other traffic in sight in time. As demonstrated in the event in 2022, despite the provision of traffic information by ATC visual contact between D-EBTO and the N98825 remained uncertain and ATC did not additionally aid in solving the upcoming risk for a collision. The investigation revealed that Air Traffic Control the Netherlands (LVNL) considers separation between VFR traffic solely as a responsibility for VFR pilots. Strictly speaking, it is correct that ATC has no formal responsibilty to separate VFR traffic from VFR traffic and no references exist. However, this should not be confused with the overarching responsibillty for preventing collisions. As laid down in the regulatory framework, Air Traffic Services Providers have a responsibility in preventing (mid-air) collisions in class C airspace. VFR traffic is not exempted from this. Therefore, the Dutch Safety Board has included recommendations to LVNL.

ABBREVIATIONS

Abbreviation	Description
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
AOPA	Aircraft Owners & Pilots Association
APP	Approach
ATC	Air Traffic Control
ATS	Air Traffic Services
CPL	Commercial Pilot Licence
CTR	Control Zone
EASA	European Union Aviation Safety Agency
EHRD	Rotterdam The Hague Airport
EU	European Union
FIR	Flight Information Region
IFR	Instrument Flight Rules
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
ILT	Human Environment and Transport Inspectorate
KNVvL	Royal Netherlands Aeronautical Association
LVNL	Air Traffic Control the Netherlands
LT	Local time
METAR	Meteorological Aerodrome Report
NOTAM	Notice To Airmen
NSA	National Supervisory Authority
NSC	No Significant Clouds
OM RD TWR-APP	Operations Manual Rotterdam Tower-Approach
PPL(A)	Private Pilot Licence – Aeroplane
SEP	Single Engine Piston

Abbreviation	Description
SERA	Standardised European Rules of the Air
SIA	Safety Investigation Agency
TWR	Tower
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VLA	Department of Flight Procedures and Airspace Advice (in Dutch: *Vakgroep Vliegprocedures en Luchtruim Advies*)
VMC	Visual Meteorological Conditions

GENERAL OVERVIEW

Synopsis	Explanation
Identification number:	2022070
Classification:	Serious incident
Date, time of occurrence:	15 June 2022, 13.21 hrs[1]
Location of occurrence:	Control Zone of Rotterdam The Hague Airport
Registration:	D-EBTO N98825
Aircraft type:	Cessna 172S Cessna 172P
Aircraft category:	Fixed wing single-engine
Type of flight:	General Aviation - Pleasure
Phase of operation:	Approach (VFR arrival route) Departure (VFR departure route)
Damage to aircraft:	None
Flight crew:	One One
Passengers:	One None
Injuries:	None
Other damage:	None
Light conditions:	Daylight

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

1 INTRODUCTION

An aircraft proximity[2] (hereafter: airprox) between two general aviation aircraft occurred in the control zone (CTR) of Rotterdam The Hague Airport (EHRD), which is classified as class C airspace, on 15 June 2022. Both flights were conducted under Visual Flight Rules (VFR). A Cessna 172S with registration D-EBTO followed the ROMEO arrival route while a Cessna 172P with registration N98825 followed the ROMEO departure route. When Runway 06 is in use, as was the case, the ROMEO arrival and departure routes cross each other at the same altitude near point OSCAR. The airprox occurred at the position where both routes cross each other. The pilot of D-EBTO made an evasive action to avoid a collision.

The Dutch Safety Board classified the occurrence as a serious incident and, representing the State of Occurrence, conducted the safety investigation. As one aircraft has a German registration and also the pilots in command of both aircraft are German nationals, the German Federal Bureau of Air Accident Investigation (BFU) assisted in the investigation.

The Dutch Safety Board investigated two other airprox incidents, also near point OSCAR, in the Rotterdam CTR: one in 2014 and one in 2020. In the first event one aircraft flew the MIKE arrival route and the other one the MIKE departure route at the same altitude. In the second event one aircraft flew a MIKE departure and another aircraft flew 'a direct course' in opposite direction as instructed by Air Traffic Control (ATC), which crossed the MIKE departure route at (approximately) the same altitude. Similar to the event with D-EBTO and N98825, both serious incidents (in 2014 and in 2020) occurred at or near the same prescribed crossing point on the MIKE departure route and the MIKE arrival route. The standard ROMEO departure and arrival routes are in the same sector ('pizza slice) of the CTR. The same applies for the MIKE departure and arrival routes.

What the three occurrences have in common is that arriving and departing VFR flights in class C airspace were cleared in such a way by ATC that there was a real risk for mid-air collisions. Pilots must have conflicting traffic in sight in time to prevent collisions. When aircraft are flying towards each other and visual contact – despite traffic information from ATC - has not been established yet, the reaction time may be significantly reduced. As this is decreasing the impact on 'see and avoid', being the primary principle for VFR operations, safety is impaired. Though the number of these serious incidents is relatively low, the consequence of a mid-air collision is nevertheless high as mid-air collisions are usually fatal.

2 An aircraft proximity, or airprox, is a situation in which, in the opinion of a pilot or air traffic services personnel, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved may have been compromised. (Source: ICAO Doc 4444 Procedures for Air Navigation Services, Air Traffic Management, Sixteenth Edition, 2016.

The investigation aimed at answering the following questions:

> What was the cause, or were the causes, of the near mid-air collison between D-EBTO and N98825?
>
> What lessons can be learned from this serious incident?

The Dutch Safety Board gathered information from the pilots, Air Traffic Control the Netherlands (LVNL), Ministry of Transport and Water Management, Aircraft Owners & Pilots Association (AOPA) Netherlands, Royal Netherlands Aeronautical Association (KNVvL) and two flying clubs at Rotterdam The Hague Airport.

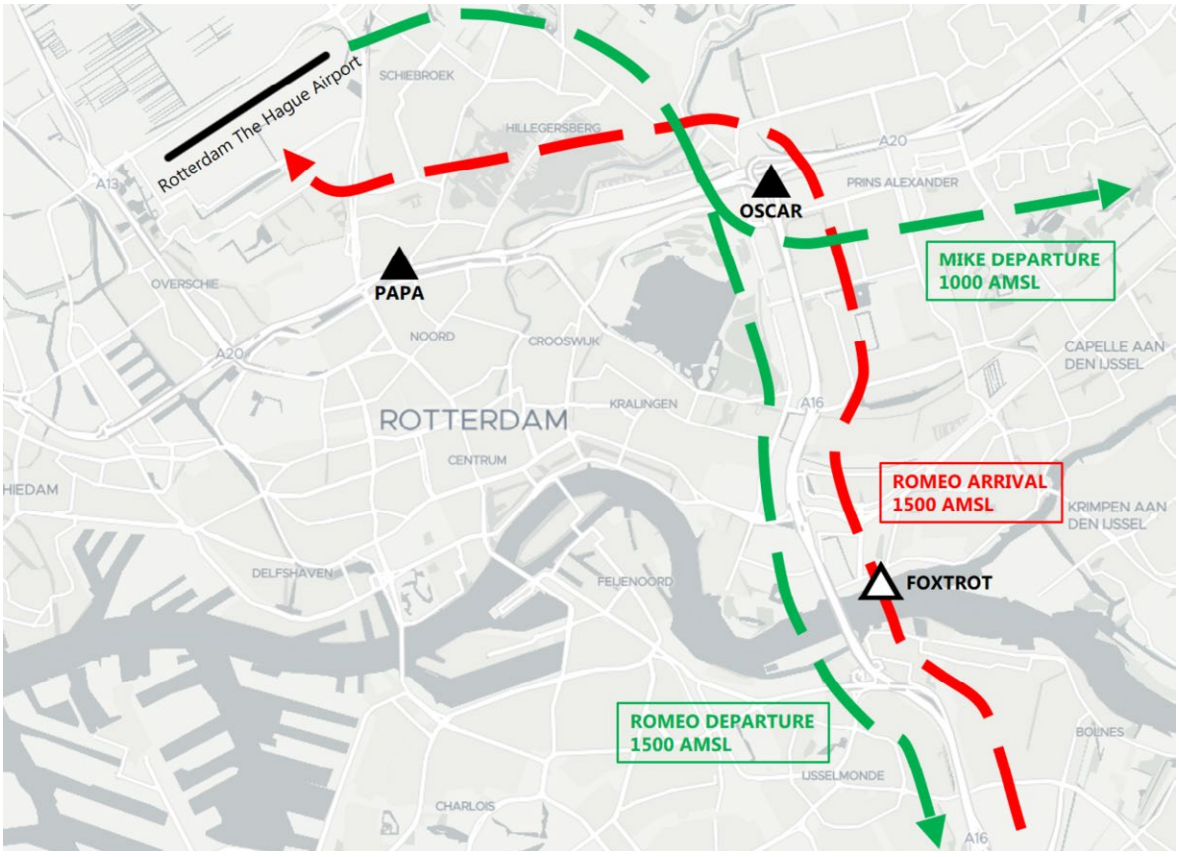
Chapter 2 presents the relevant factual information. In Chapter 3, the analysis is presented. Findings and conclusions are summarized in Chapter 4. The safety recommendations are presented in Chapter 5.

2 FACTUAL INFORMATION

2.1 History of the flight

D-EBTO, a Cessna 172S with a pilot and passenger (a licensed aviator) on board, departed Münster Osnabrück Airport, Germany (EDDG) for a visual flight rules (VFR) flight to Rotterdam The Hague Airport (EHRD). At 13.06:40 hrs, the pilot of D-EBTO made initial contact with the tower controller of EHRD and requested a ROMEO arrival and landing at the airport.[3]

At the same time, N98825, a Cessna 172P with a pilot on board, was taxiing towards Runway 06 for a VFR departure from EHRD. At 13.10 hrs, the pilot of N98825 asked the tower controller the available departure routes. The tower controller indicated that both MIKE and ROMEO departure routes were available and the pilot of N98825 confirmed to opt for the ROMEO departure route.



▲ *Figure 1: The ROMEO arrival route for D-EBTO and the available MIKE and ROMEO departure routes for N98825. (Source map: based on AIP the Netherlands, modified by Dutch Safety Board)*

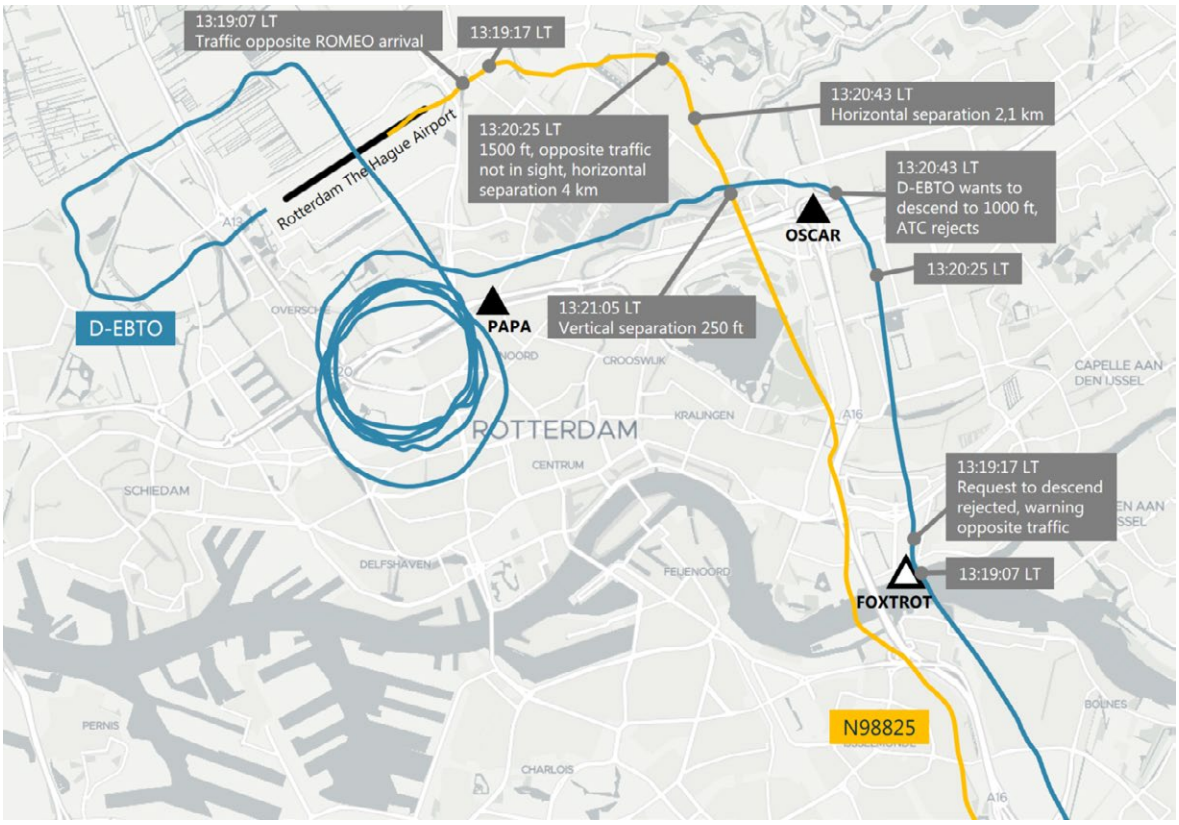
3 See Section 2.5.1 for the visual approach chart with Visual Flight Rules (VFR) routes.

At 13.16:20 hrs, the pilot of D-EBTO reported to be over point ROMEO at 1,500 feet. The tower controller replied and instructed to the pilot to report when passing point OSCAR. Shortly after, N98825 was cleared for take-off from Runway 06 on a ROMEO departure.

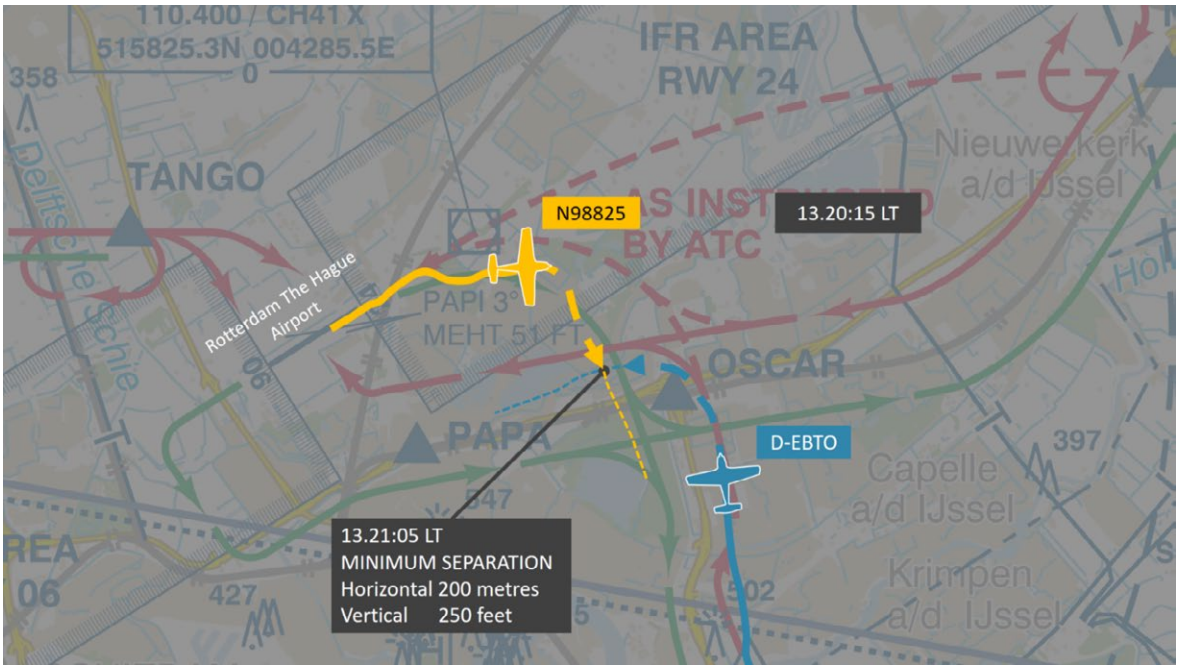
At 13.18 hrs, the tower controller informed D-EBTO for opposite traffic on the ROMEO departure at the same altitude. Radar information showed that the distance between both aircraft was approximately 6 nautical miles (11 km). After this, the tower controller also indicated to N98825 that there was opposite traffic on the ROMEO arrival at the same altitude. The pilot of N98825 acknowledged the information and reported that he was keeping a close lookout.

At 13.19:17 hrs, D-EBTO indicated that he was approaching OSCAR and asked to descend to 1,000 feet. The tower controller rejected this and instructed the pilot to maintain 1,500 feet and stay on the right side of the highway. D-EBTO asked whether he could proceed on the arrival or hold over OSCAR. The controller confirmed that he could continue to point PAPA with a sharp look-out for opposite traffic.

At 13.20:25 hrs, N98825 indicated to the tower controller that he was at 1,500 feet and did still not have the opposite traffic in sight. The tower controller replied to the pilot to report leaving ROMEO and that the opposite traffic was now over OSCAR. Shortly after this communication, the pilot of D-EBTO reported to be over OSCAR and descending to 1,000 feet. The controller disapproved and instructed D-EBTO to maintain 1,500 feet and report PAPA next. When D-EBTO was about to cross the departure track, the pilot observed the N98825 on his right. The pilot of D-EBTO initiated a descent to increase the vertical distance between the two aircraft.



▲ *Figure 2: Flight track (and holds flown) of D-EBTO (blue) and flight track of N98825 (yellow). (Source radar data: LVNL)*



▲ *Figure 3: Trajectories of both aircraft and point of minimum separation. (Source radar data: LVNL)*

Radar data (see figures 2 and 3) indicate that around 13.21:05 hrs the minimum vertical separation was 250 feet and the minimum horizontal separation was 200 metres. Shortly after, the pilot of D-EBTO reported to be back at 1,500 feet and that he had a near miss with other traffic. Radar data showed that at the moment depicted in figures 2 and 3, no other VFR traffic nor IFR[4] traffic was present in the vicinity of D-EBTO nor N98825.

The pilot of D-EBTO stated to the Dutch Safety Board that, although he did not mention this specifically during his communications, he had asked the controller whether he could descend to 1,000 feet and otherwise suggested to hold over OSCAR in order to safely avoid the departing traffic. He considered the traffic information the controller gave not very helpful, since the only information the controller gave was that the opposite traffic was at the same altitude and somewhere on the ROMEO departure.

From the first contact with D-EBTO on, there was frequent contact in the control tower between the tower controller, the airport authorities, the flying club and the pilot. According to the airport authority it was unclear which flying club or agency would handle D-EBTO once landed. The majority of these conversations were held after the incident. The pilot of D-EBTO flew five holds before permission for landing was received from the airport authorities and landing clearance from the tower controller finally was obtained.

The occupants had no injuries and the aircraft were not damaged.

2.2 Pilot and aircraft information

Information of the pilots
The pilot of D-EBTO is a German national. He holds a Private Pilot Licence (PPL(A)), initial issue on 4 May 2021 and his medical certificate was valid till 12 September 2023. The passenger - his father - held a Commercial Pilot Licence (CPL).

The pilot of the N98825 is a German national as well. He holds a Private Pilot Licence (PPL(A)). For unknown reasons the pilot did not provide information about his flight experience, his medical certificate and licence.

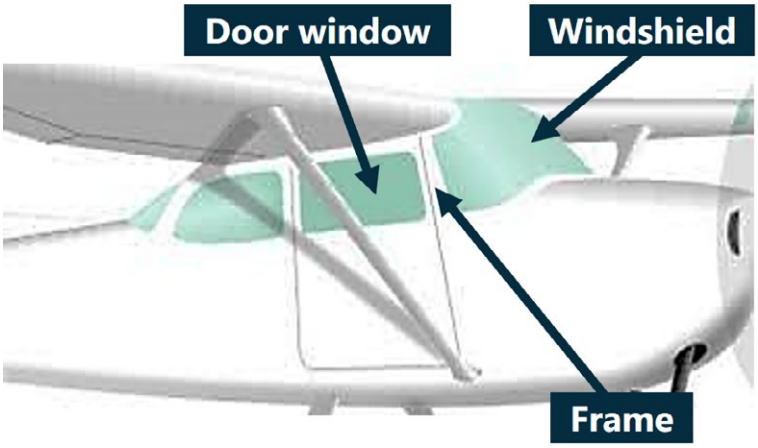
▼ *Table 1: Licences and flight hours.*

Pilot	Licence	Hours on type	Total hours	Pilot in command hrs
D-EBTO	PPL (A)	38,8	77,3	21,3
N98825	PPL (A)[5]	unknown	unknown	unknown

4 Instrument Flight Rules
5 The PPL of the pilot of the N98825 was issued by the FAA allowing to operate aircraft registered in the United States of America.

Information of both Cessna aircraft
Both aircraft involved were two variants of Cessna 172 aircraft: a Cessna 172S (D-EBTO) and a Cessna 172P (N98825). Both single piston high wing aircraft have a similar basic structural design.

The aircraft have a windshield for a forward field of vision and a window in both left and right entrance doors, allowing field of vision to each side along the lower side of the wings (see figure 4). The frame, in which the windshield and doors are installed, limits the free field of view. During turns (due to the roll movement) of high wing aircraft, the lower wing obstructs the field of view.



▲ *Figure 4: Cessna 172 windows and windscreen. (Source: Great Lakes Aero Products)*

Both aircraft have a landing light. Within the Rotterdam Control Zone (CTR) the use of the landing light is mandatory. Landing lights are usually installed in front of the fuselage under the engine or in the leading edge in one of its wings. For both aircraft it is unknown whether the landing lights were on at the time of the incident.

Traffic detection and warning system
The pilot of the N98825 stated to the Dutch Safety Board that a traffic warning system[6] was on board. This system can detect a conflict with another aircraft (equipped with mode S transponder and altitude mode activated). The detected aircraft (conflict aircraft) is presented as a circle on the system display indicating its mutual distance without bearing information. Furthermore, the system presents altitude information of the conflicting aircraft. According to the pilot, the system should generate an aural alert when traffic comes within a range of 1,000 metres. He stated that he 'had verified status and functionality of the system as part of the pre-taxi checklist'. He also stated that the installed traffic warning system on board the aircraft gave no aircraft proximity alarm.

6 An AIR Avionics AIRTraffic FLARM/ADS-B/Mode S receiver and an associated ATD-57 (AIRTraffic Display).

Apart from no altitude mode of the transponder in the conflict aircraft, various other reasons for the non-display of conflict aircraft (targets) exist, like installation/configuration features[7] or system failures in the traffic warning system and human factors[8].

According to the pilot of the D-EBTO, his aircraft was equipped with a Traffic Collision Avoidance System I[9] (TCAS I) as well as a mode S transponder operating in the altitude mode. General system information[10] indicates that a traffic advisory is generated if the system detects that the current track of the intruder could result into a near miss or collision. The system generated an audible alert indicating a traffic advisory of the relative position of the conflicting traffic. The pilot stated that this aided him in establishing visual contact with N98825, after which he started the evasive manoeuvre in order to avoid the conflicting traffic.

2.3 Meteorological information

The Meteorological Aerodrome Report (METAR) for EHRD is depicted in Table 2. Around the time of the incident, the visibility was greater than 10 km (9999) and no significant clouds (NSC) were present.

▼ *Table 2. METAR EHRD for 15/06/2022. (Source METAR: Ogimet)*

Time (LT)	METAR
12.25	151025Z AUTO 08006KT 360V160 9999 NCD 22/10 Q1019 NOSIG=
12.55	151055Z AUTO VRB06KT 9999 NSC 21/10 Q1019 NOSIG=
13.25	151125Z AUTO 08006KT 030V120 9999 NSC 22/10 Q1019 NOSIG=
13.55	151155Z AUTO 06007KT 9999 NSC 23/10 Q1019 NOSIG=

The azimuth of the sun's position, which is the horizontal angle with respect to north, was 169 degrees.[11]

2.4 Air Traffic Control process

Airspace requirements and responsibilities
The airprox occurred in the Rotterdam CTR. The airspace classification of this airspace is class C. This means that within the CTR, air traffic flying under Instrument Flight Rules (IFR) is separated from each other and from air traffic flying under Visual Flight Rules

7 Not correctly installed antenna creating poor coverage, outdated software stopping the system, incomplete ICAO address or configuration settings allowing switching off the system or disabled warnings.
8 Warnings not recognised by the flight crew due to - for instance - position of the display, or task saturation.
9 An Avidyne TAS600 (Traffic Advisory System) and Garmin GTN750 display.
10 Information from the Traffic Advisory System pilot operating handbook of Avidyne P/N 600-00145-000 (32-2352, Rev 09 27 June 2018).
11 Source https://www.suncalc.org/

(VFR). Pilots of VFR flights receive traffic information[12] from Air Traffic Control (ATC) and traffic avoidance advice on request. According to Air Traffic Control the Netherlands[13] (LVNL) the pilots of D-EBTO and N98825 were responsible for their separation. VFR pilots are supposed to have the other traffic in sight.

More general, LVNL[14] could not trace back the way the ROMEO procedures within the Rotterdam CTR have been developed over time. According to LVNL, no specific design criteria exist for VFR routes because the VFR pilot is responsible for his or her own separation. Only obstacle clearance and noise are included in the procedures. For more details, see section 2.5.

According to information from experts from the European Union Aviation Safety Agency (EASA) and relevant European Union regulations, between two VFR flights no separation requirements exist for Air Traffic Services (ATS, which includes ATC) nor for the VFR pilots. In class C airspace the VFR pilot is responsible for avoiding a collision[15] and to operate the aircraft according to the regulations and the received clearances from ATC. In class C airspace all flights shall be subject to a clearance. ATC has a responsibility[16] to prevent collisions and to expedite and maintain an orderly flow of air traffic.

The minimum required visibility for VFR flights in class C airspace is 5,000 metres, the minimum required distance from clouds is 1,500 metres horizontally and 300 metres (1,000 feet) vertically.[17]

Traffic and radio load for ATC
The Rotterdam CTR is characterized by a mix of commercial traffic and business aviation flying under IFR, as well as general aviation mostly operating under VFR. Due to the mentioned mix of (large) commercial air transport and general aviation traffic, congestion in the CTR may occur with various aircraft operating under both IFR and VFR flying at different speeds.

Air traffic and the associated radio frequency load can quickly increase. The moment (i.e. timing) that an air traffic controller can provide (traffic) information may depend upon other tasks and priorities. Around the time of the incident, the traffic load in the CTR of Rotterdam The Hague Airport was relatively low.

Radar data, Radio Transmission (R/T) and the ambient workplace recording[18] in the control tower were used for investigation.

12 Traffic information is information issued by an air traffic services unit to alert a pilot to other known or observed air traffic which may be in proximity to the position or intended route of flight and to help the pilot avoid a collision. Source: ICAO Annex 11 Air Traffic Services, Fifteenth Edition, *July 2018*.
13 Based upon interviews and information exchange with LVNL.
14 LVNL PRO/ATMP department.
15 Standardised European Rules of the Air (SERA) section 3, chapter 2 'Avoidance of collisions' always applies.
16 For EU Member States the common requirements as shown in Commission Implementing Regulation (EU) 2017/373 for Air Traffic Services are applicable.
17 Standardised European Rules of the Air (SERA), SERA 5001 VMC visibility and distance from cloud.
18 See Section 2.9.

Staffing on control tower
Around the time of the incident, the tower was staffed with an instructor tower controller, a trainee tower controller and an assistant. The trainee tower controller provided air traffic control under the supervision of the instructor. The trainee was in the final phase of training and worked independently without direct need for guidance by the instructor.

Operations Manual
The Operations Manual Rotterdam Tower-Approach (OM RD TWR-APP) of LVNL provides the framework within which the tower controllers at EHRD perform their duties. This manual contains the procedures regarding VFR flights in the Rotterdam CTR, amongst others the conditions for VFR flights and the responsibilities of the tower controllers regarding separation and the provision of traffic information. The manual also lists the available VFR arrival and departure routes, which are the MIKE departure en MIKE arrival (both 1,000 feet), ROMEO departure and ROMEO arrival (both 1,500 feet) and HOTEL departure (1,000 feet) and HOTEL arrival (1,500 feet).

When Runway 24 is in use, the arrival and departure routes remain separated at the same altitude. When Runway 06 is in use, based on MIKE and ROMEO procedures arriving and departing routes cross each other at the same altitude near reporting point OSCAR.

2.5 VFR procedures

2.5.1 Routes at EHRD

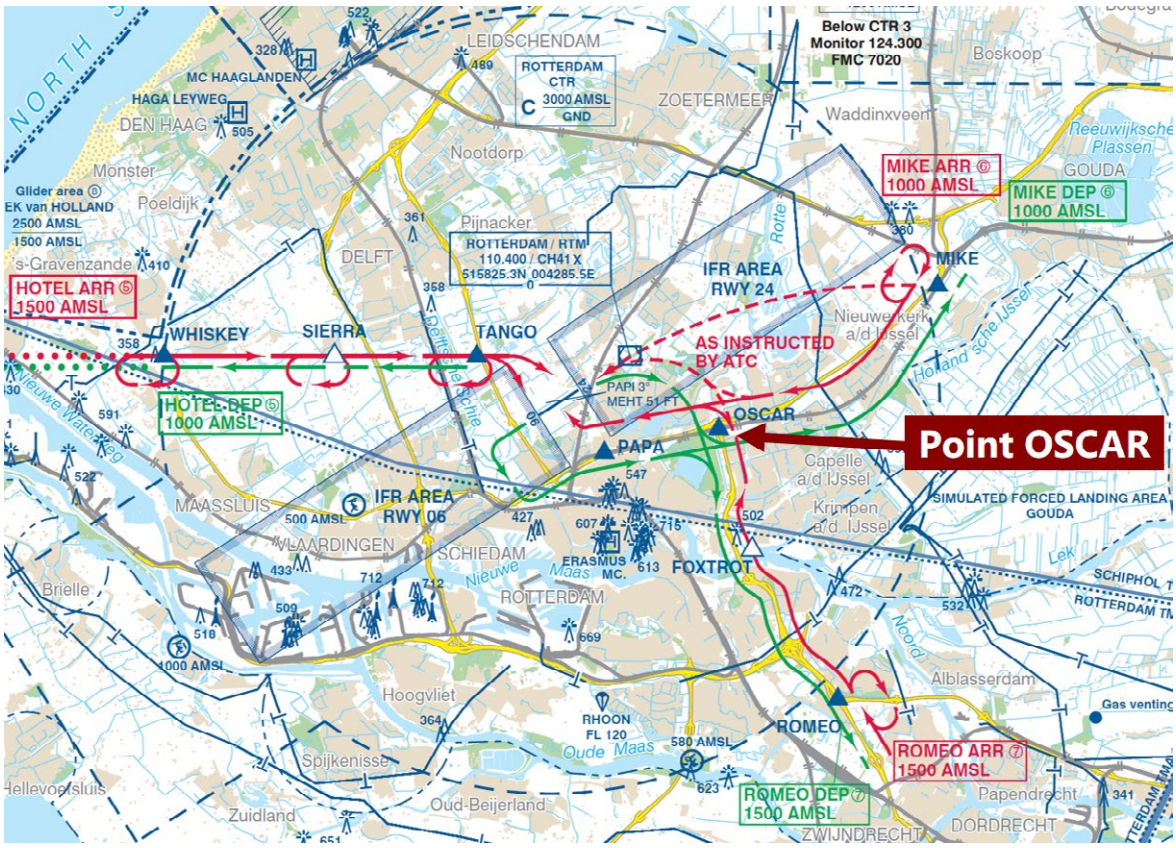
The Aeronautical Information Publication (AIP) of the Netherlands contains the VFR flight procedures and regulations.[19] The ROMEO arrival and departure routes are laid down in the AIP as follows:

- *ROMEO Arrival*: Enter the CTR via ROMEO at 1,500 feet AMSL[20]; follow the VFR route via OSCAR (or abeam OSCAR) to PAPA and keep 500 meter to the right-hand side of the highway.
  (…)
  When instructed to approach via abeam PAPA, the following applies for RWY 06/24:
  a. Join the circuit as instructed by ATC
  b. Maintain 1,000 feet AMSL (MIKE Arrival) or 1,500 feet AMSL (ROMEO Arrival)
  (…)
- *ROMEO Departure*: After take-off follow the VFR route via OSCAR (or abeam OSCAR) and FOXTROT to ROMEO while climbing to 1,500 feet AMSL and keep 500 meter to the right-hand side of the highway.

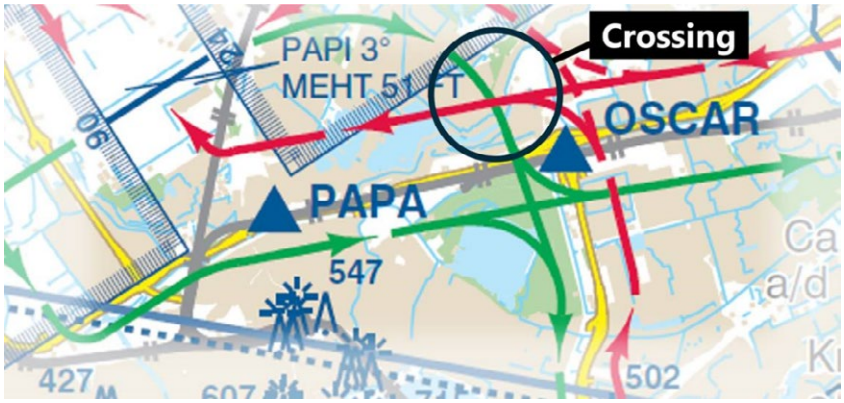
The different VFR routes are depicted in the AIP on the visual approach chart (see figure 5). The AIP specifically states that pilots shall adhere to the approach or departure route as indicated on the charts, unless otherwise instructed by ATC.

19 AIP The Netherlands, AD 2.EHRD-26, Section 4 VFR Flight Procedures and Regulations, 24 Feb 2022.
20 Above Mean Sea Level

The situation in which arrivals and departures intersect at the same altitude only occurs when Runway 06 is in use (see figure 6). Because of prevailing westerly winds, Runway 06 at EHRD is in use[21] approximately 34% of the time.



▲ *Figure 5: Visual approach chart with VFR routes. Reference to point OSCAR added. (Source chart: AIP The Netherlands)*



▲ *Figure 6: Visual approach chart with a partial view of the ROMEO departure route (in green) and ROMEO arrival route (in red), marking their crossing with a circle. (Source chart: AIP The Netherlands)*

21 Source: https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/rotterdam-the-hague-airport_netherlands_6296690

2.5.2 Design of VFR routes

No specific design criteria or standards exist for VFR procedures and routes, except for requirements in the Standardised European Rules of the Air (SERA) regarding minimum height above ground and obstacles, cruising levels and provision of air traffic control service and flight information service to VFR flights.[22]

In general, the primary principle for the design of VFR procedures within a CTR (class C airspace) is to achieve geographical separation between VFR and IFR traffic.[23] In addition, noise abatement requirements may be applicable. Unlike for IFR routes, there are no criteria for separation between VFR routes or regarding the feasibility to fly a VFR-route in daily practice. No safety analyses are performed for VFR routes that focus on mutual collision probabilities.

The VFR routes depicted in the AIP on the visual approach charts are a visual representation of the route with respect to visual reference points, such as highways or railways, on the ground. These routes also create, in addition to separation from IFR traffic, more predictability of VFR traffic flows for both pilots and air traffic controllers.

The history of the design of the ROMEO arrival and departure routes could not be determined. Based on statements from interviewees of LVNL, the routes were presumably established in the 1980's. According to the interviewees of LVNL and the Human Environment and Transport Inspectorate (ILT), no changes to the procedures appeared in recent years that would have required an evaluation of the route design.

Overall, the IFR areas and the VFR arrival and departure procedures at EHRD have been designed with the aim to achieve geographical separation between IFR and VFR flights.[24] Where the HOTEL arrival and departure route are separated vertically, the ROMEO arrival and departure and MIKE arrival and departure are separated laterally. The highest obstacle along the ROMEO routes is 502 feet (near reporting point FOXTROT).

When Runway 06 is in use, the ROMEO arrival and ROMEO departure routes cross each other near point OSCAR at the same altitude with risk for conflicting traffic. The same applies to the MIKE arrival and MIKE departure routes.

2.5.3 Current approval process for VFR procedures

For civil aviation, the Department of Flight Procedures and Airspace Advice (VLA) and the National Supervisory Authority (NSA) within the Human Environment and Transport Inspectorate (ILT) primarily have a supervisory role in the airspace and flight procedures modification process. For more details, see appendix B.

22 See SERA.5005(f) and (g), SERA Section 8, and SERA Section 9.
23 Source: Interview with LVNL, conducted as part of the investigation.
24 Source: LVNL Operations Manual OM RD TWR-APP, 5 December 2019.

As of 27 January 2022, European Union (EU) regulations require that Member States shall ensure that maintenance and periodic review of flight procedures for aerodromes and airspace under their authority are conducted.[25] No periodic review took place yet. In addition, occurrences in recent years did not trigger a review of the procedures, see also Section 2.6.

2.6 Other relevant airprox occurrences

The Dutch Safety Board investigated two comparable events that occurred in the Rotterdam CTR.

Near collision, Rotterdam CTR, 6 December 2014[26]
The pilot of a Reims F172L flew the MIKE arrival procedure for landing on Runway 06 at Rotterdam The Hague Airport. The aircraft was flying at an altitude of 1,000 feet within the Rotterdam CTR. The flight took place under visual flight rules and the pilot was on the radio frequency of Rotterdam Tower. He stated that the weather conditions were CAVOK (Ceiling and Visibility OK) with visibility more than 10 km. When the aircraft, whilst flying into the sun, was approaching point OSCAR, the pilot was informed by the tower controller that another departing aircraft, flying the MIKE departure procedure, was also approaching point OSCAR. The pilot stated that he and the other pilot confirmed over the radio that they heard the message from the tower controller. Despite looking carefully for the other aircraft, a near collision between the two aircraft occurred near point OSCAR. The pilot stated that the other aircraft came from the right and was flying a few meters higher than his aircraft. The Reims made a safe landing at the aerodrome. The Dutch Safety Board classified the occurrence as serious incident.

Relevant factors identified:
- Arriving and departing traffic following respectively the MIKE arrival and MIKE departure procedure, are directed towards point OSCAR at the same altitude (1,000 feet). Both procedures aim for a lateral separation by the use of a railway for orientation. However, when Runway 06 is in use, the arrival and departure routes cross each other near point OSCAR.
- Traffic information about the conflicting aircraft was provided by the tower controller. However, both pilots did not see each other.

Airprox, Rotterdam CTR, 24 June 2020[27]
An EC135 P3H air ambulance helicopter was on its way from Arnhem to Rotterdam The Hague Airport. Just before the helicopter reached the Rotterdam CTR, the crew received clearance from the air traffic controller to enter the CTR and was instructed to fly at 1,500 feet AMSL or lower directly towards point PAPA for the approach and landing. Meanwhile, a Reims F172N received clearance for the VFR MIKE departure and took off from Runway 06. The helicopter descended, after the clearance from the ATC, to about

25 Commission Implementing Regulation (EU) No 2020/469, Article 3. Applicable as of 27 January 2022.
26 https://onderzoeksraad.nl/onderzoek/kwartaalrapportage-luchtvaart-1e-kwartaal-2015/
27 https://onderzoeksraad.nl/onderzoek/kwartaalrapportage-luchtvaart-3e-kwartaal-2021/

800 feet and continued its route via point OSCAR to point PAPA. At the same time, the Reims F172N flew the MIKE departure at 1,000 feet AMSL and turned after point OSCAR to a course of 080 degrees. At about 3 NM east of point OSCAR both aircraft faced one another head on and at short distance. Both aircraft made an evasive manoeuvre and passed each other at about 150 metres horizontally and 200 feet vertically. At the time of the airprox, ATC was congested due to a large number of flights in the CTR (two IFR and eight VFR flights). Therefore, ATC did not provide traffic information to the aircraft of a possible conflict. The Dutch Safety Board classified the occurrence as serious incident.

Relevant factors identified:

- Departing traffic and arriving traffic following respectively the MIKE departure procedure and a direct route close and opposite to the MIKE departure route, crossed each other under a shallow angle with a relative speed of 222 knots (411 km/h) towards each other. The flights had been cleared such a way that a real risk for a mid-air collision could develop.
- ATC did not provide traffic information to the aircraft of a possible conflict and the pilots only saw each other at the last moment. According to an internal occurrence dossier[28], LVNL had no responsibility for separation and both VFR flights were responsible for their separation.
- In the internal occurrence dossier it is mentioned that Rotterdam tower was very busy. A potential conflict situation was overlooked and the two VFR aircraft flew very close to each other.
- LVNL made an internal recommendation: to develop a tool and/or methodology that enables Rotterdam ATC to always properly manage the amount of traffic in advance and thus prevent potential overload situations.

Airproxes near Lelystad

In February 2022, the Dutch Safety Board published a report[29] of eight occurrences in the CTR of Lelystad Airport (EHLE). In one of the investigated events[30] two arriving aircraft (a helicopter and a single engine aircraft) were both following the MIKE arrival procedure in the Lelystad CTR at 1,500 feet. At the same time a departing single engine aircraft following a MIKE departure at 1,500 feet procedure came in conflict with these arriving aircraft, as their prescribed routes crossed at the same altitude. The Dutch Safety Board classified this event as a serious incident. The other seven occurrences mentioned in the report are less comparable to the Rotterdam 2022 event, but all situations concerned an airprox event.

28 Voorvaldossier "2020-06-24 PHRES – LIFELN", IRIS DOSSIER 142804, LVNL.
29 Dutch Safety Board, *Airproxes near Lelystad Airport*, February 2022, see https://onderzoeksraad.nl/en/onderzoek/airproxes-near-lelystad-airport/
30 Dutch Safety Board, *Airproxes near Lelystad Airport*, February 2022, Chapter 2.2.9 occurrence 8.

The report also mentioned that local users (flight schools, other companies) halted their flight operations, as they considerd the situation not as safe due to the new route design.[31] According to those involved, there had been dozens of incidents where aircraft had come too close to each other. The investigation identified multiple factors and one of them was the convergence of departing and arriving VFR routes.

Temporary measures taken
The LVNL changed the VFR flight standard procedures with approval of ILT. Arriving VFR traffic was routed only via a MIKE arrival north of the airport and departing VFR traffic was only routed via a Bravo departure south of the airport. MIKE departure and Bravo arrival procedures/routes were no longer available. On the moment of release of this report they are still not available, as published by NOTAM. If the traffic situation permits, direct routings in the Lelystad CTR are allowed. No more occurrences that were caused by the convergence of departure and arrival VFR routes, were reported to the Dutch Safety Board.[32]

2.7 Information from flying clubs and other stakeholders for pilots

Flying clubs at Rotterdam The Hague Airport
The Dutch Safety Board organised two meetings with both flying clubs at Rotterdam The Hague Airport. Local pilots are very aware of the situation with crossings in the routes at the same altitude and remain vigilant. The local pilots highlighted the appreciation for the service and flexibility of the tower controllers working at Rotterdam The Hague Airport. Generally, there is satisfaction with the way traffic information is provided by LVNL.
Pilots' experiences indicated that conflicting traffic is not always detected in time and sometimes not at all. Pilots from both flying clubs mention the position of the sun. At midday, during a ROMEO departure, the pilot often looks directly into the sun. The pilots indicated that the vertical separation between the HOTEL departure and arrival routes feels more logical.

Umbrella organisations representing pilots
The Dutch Safety Board discussed the topic of stakeholder consultation with representatives of Royal Netherlands Aeronautical Association (KNVvL) and Aircraft Owners & Pilots Association (AOPA) separately.

KNVvL has previously been involved in some discussions on change proposals regarding airspace structures and flight routes, but not at the level of aerodromes (or CTRs). Experience shows that, as with the case of the establishment of a CTR at Lelystad Airport, stakeholders are involved at a late stage. At that stage, the plan is often almost definitive, which makes is hard to still influence the process and design. The formal role of the KNVvL in the stakeholder consultation for airspace or flight route changes is not very clear.

31 Dutch Safety Board, *Airproxes near Lelystad Airport*, February 2022, Chapter 2.2.10.
32 Dutch Safety Board, *Airproxes near Lelystad Airport*, February 2022, Chapter 3.4.2.

The representative of AOPA indicated that their association is involved in discussions on airspace design, for example on the airspace revision (in Dutch: *Luchtruimherziening*) and crossing of the Schiphol CTR. Overall, VFR routes and procedures appear to be the final item of the design. When it comes to the design, AOPA is involved at a late stage. AOPA does not need to be involved in every change proposal; sometimes discussions take place with local users, which in view of AOPA is sufficient.

2.8 'See and avoid' principle

Physical factors
Pilots of VFR-flights are responsible for avoiding collisions with other traffic and obstacles by applying the 'see and avoid' principle. This includes class C airspace and class D airspace. This principle has limitations such as physical obstructions in the cockpit resulting from aircraft design aspects (see Section 2.2) or the presence of front seat occupants and physical limits to human perception as shown in studies.[33],[34] For example, motion or contrast is needed to attract the eyes' attention. The Dutch Safety Board published an investigation report of a near mid-air collision in 2015 involving a turboprop aircraft and a microlight aircraft near Lelystad Airport.[35] One factor identified was the mutual constant relative position of both aircraft, which caused no movement of the conflicting aircraft in the eyes of the pilots. This adversely affected a timely detection of the other aircraft.

Windshield deterioration and distortion can also play a role, as well as when another aircraft - still at a far distance as a dark object - can inadvertently be perceived as one of the spots (for instance insects) on the windshield.

An additional example: an approaching aircraft on a steady head-on course will be observed as a small, stationary target until a short time before the (near) collision because of the high closing speed. At the time the size of the target triggers the pilot, the target can already be close, leaving little or no time for the pilot to take avoidance action. When the speeds of converging aircraft differ while manoeuvring, such as climbing or descending, and the faster aircraft is above the slower one, the view of each aircraft can be obstructed until impact.[36]

Atmospheric factors
Besides the limitations of the human visual system, vision is influenced by atmospheric conditions. Glare can contribute to a reduction of the visual effectiveness of the pilot. For instance, when flying into the direction of the position of the sun, the glare of the sun will make it hard to see other aircraft and makes scanning uncomfortable.[37]

33 Australian Transport Safety Bureau, *Limitations of the See-and-Avoid Principle,* 1991, reprinted 2004. (https://www.atsb.gov.au/publications/2009/see-and-avoid/)
34 Collision avoidance – methods to reduce the risk, Safety promotion leaflet GA1, EGAST (https://www.easa.europa.eu/sites/default/files/dfu/EGAST_Leaflet_Collision-Avoidance.pdf)
35 Dutch Safety Board, Final report "Near mid-air collision near Lelystad airport', September 2018.
36 Morris, C., Midair collisions: Limitations of the see-and-avoid concept in civil aviation, 2005. (https://www.researchgate.net/publication/7907700)
37 Civil Aviation Authority, Safety Sense Leaflet Collision Avoidance, 2013. (https://publicapps.caa.co.uk/docs/33/20130121SSL13.pdf)

Furthermore, moisture in the air can limit the visibility[38] significantly, in particular when the weather is sunny or when a temperature inversion in the atmosphere is present.

A safety study of the Australian Transport Safety Board (ATSB) (see footnote 33) particularly mentions that " … although many collisions are averted by 'see and avoid', the concept is a flawed and unreliable method of collision avoidance".

2.9 The ambient workplace recording

Commission Implementing Regulation (EU) 2020/469 mandates that Air Traffic Services units shall be equipped with devices that record background communication and the aural environment at air traffic controller's, or the flight information service officer's, or the Aerodrome Flight Information Service (AFIS) officer's work stations. The EU-regulation further states that such recordings shall only be used for the investigation of accidents and incidents subject to mandatory reporting. For Air Traffic Services (ATS) providers within the EU it is mandatory to preserve the recording at least 24 hours[39].

LVNL has implemented the ambient workplace recording as of 27 January 2022. This includes the control tower of Rotterdam The Hague Airport. Based upon an internal protocol, it preserved the ambient workplace recording for 30 days. It is important to note that LVNL recognises the possible safety benefit of the recordings and therefore has decided to go beyond the mandatory regulatory period of at least 24 hours. LVNL considers this longer period necessary because its process of occurrence investigation takes some time and only when the initial information of an occurrence is gathered and analysed, it can be determined whether it is justified to read out the recording for the investigation. Since February 2024 the recording of the ambient workplace has been reduced to 72 hours due to privacy[40] concerns.

The Dutch Safety Board was notified by one of the pilots about the serious incident two days after the event had occurred. The Dutch Safety Board requested LVNL to secure the recording of the ambient workspace recorder for investigation purposes and LVNL complied with the request. The audio recording of the ambient workplace recorder of Rotterdam Tower was of good quality and covered the period that both VFR flights were in the Rotterdam CTR.

For the Dutch Safety Board and other Safety Investigation Authorities (SIA's) it is of utmost importance to use as much information and source data as possible for a safety investigation. An ambient workplace recording provides accurate and factual information regarding the interaction between air traffic control staff. Also possible background noises and disturbances are audible.

38 The measured visibility – as indicated in a METAR - can be significantly higher than the pilot is able to see because of the effect of moisture in the air.
39 ICAO annex 11 - Air Traffic Services - recommends to retain the recorded information for at least the last 24 hours of operation.
40 The employees' council wishes to further reduce this to 24 hours in accordance with the legal basis.

It is possible that not all Air Traffic Services providers within the European Union (EU) have adopted a longer retention period similar to LVNL. There is a risk that important recordings may not be available for safety investigations, since SIA's often receive notifications of occurrences more than 24 hours after the event. This is later than the required retention period of 24 hours to preserve the ambient workplace recordings. This is a structural deficiency for safety investigation.

Data recorded in the ambient workspace may be crucial for the investigation and the identification of safety improvements. It makes sense to increase the time to preserve the ambient workplace recording for the purpose of accident and incident investigation to 30 days on EU level. A similar prescribed rentention period exists for other important Air Traffic Services data recorders, such as radio telephony communications, communications with other Air Traffic Services units, surveillance data and paper/ electronic flight progress data.[41]

41 See Commission Implementing Regulation (EU) 2020/469, ATS.OR.455 Retention of recorded information and data.

3 ANALYSIS

3.1 Limitations of 'see and avoid'

Visibility and clouds
VFR pilots have a responsibility to avoid a collision, which is based on the 'see and avoid' principle. As the visibility during the event was 10 km or more without significant clouds (see METAR in Section 2.3), the minimum required 5,000 metres visibility and 1,000 feet vertical distance from clouds were met for VFR operations in class C airspace. Though adequate visual metereorological conditions prevailed, the involved pilots did not establish timely visual contact. The minimum recorded distance between both aircraft - as determined by radar - was 250 feet vertically and 200 meters horizontally (see Section 2.1, Figure 3). This recording was after the evasive action and hence the minimum distance was possibly less.

Relative position of conflicting traffic affecting detection
For the largest part of the ROMEO arrival and departure routes (both situated adjacent to the highway) the phrase 'opposite traffic' applies, as the opposite aircraft will be more or less in the field of vision in front of the aircraft (indicative between 11 - 13 o'clock position).
However, this does not apply to the crossing near point OSCAR where the two flight paths intersect at a 90-degree angle. At the time of the incident, the relative position of D-EBTO developed towards an approximate 45 degrees angle to the left side for N98825. The relative position of N98825 developed towards an approximate 45 degrees angle to the right for D-EBTO, see figure 2. At the time of the incident, the actual relative positions no longer corresponded to 'opposite'.

Whilst still looking for the opposite traffic, it is conceivable that the position of approximate 45 degrees to the left (9 – 10 o'clock position) contributed to the fact that the pilot of N98825 never saw D-EBTO. Also, his traffic detection and warning device on board gave no aircraft proximity warning. This could not be confirmed by the investigation. Due to missing evidence, the reason(s) why no alarm might have been generated or observed by the pilot of N98825, remained unknown (see Section 2.2). As evidenced by radar data, the transponder of D-EBTO operated correctly in altitude mode. The pilot of the D-EBTO stated that the Traffic Collision Avoidance System (TCAS I) generated a traffic warning indicating the relative position of the conflicting traffic, which helped him – though in a late stage - to establish visual contact and initiate an evasive manoeuvre. Onboard anti-collision equipment functioned as a safety net. As required by procedure it was likely that the landing lights of both aircraft were on, but this could not be confirmed by evidence.

Other factors affecting detection
Home based pilots of both flying clubs at Rotterdam The Hague Airport recognised that the direction of the ROMEO departure at that time of the day is into the sun. Sun light and no or little relative motion conditions prevailed in the final stage of conflict when both aircraft came into close proximity of each other. It is unknown what other factors may have been present as well and which of them most contributed to the situation that both pilots did not observe the other aircraft timely. In general it can be said that 'see and avoid' as a safety barrier is sensitive to failure.

3.2 Limited effectiveness of traffic information

VFR flights receive traffic information from Air Traffic Control (ATC) to promote that VFR pilots timely see other traffic in order to avoid collisions. Once visual contact is confirmed by the pilot(s) operating in class C airspace, this may relieve ATC.

The pilot of D-EBTO reported waypoint ROMEO at 13.16 hrs after having checked in on the tower frequency ten minutes earlier. Less than two minutes later, the tower controller informed D-EBTO for the first time about opposite traffic on the ROMEO departure route at the same altitude as D-EBTO. The other involved aircraft, N98825, had just received a clearance for take-off from Runway 06. Approximately half a minute later, N98825 also received its first information about the opposite inbound traffic on the ROMEO arrival route. The pilot of N98825 acknowledged the received information and reported to keep a close lookout.

Around the time of the incident, the traffic load in the CTR of Rotterdam The Hague Airport was relatively low. The traffic information was given to N98825 shortly after take-off. From the perspective of the tower controller, this made sense. Air traffic and the associated radio frequency load can quickly increase. So, it is understandable that an air traffic controller will not wait for a later possibility to provide information, as there might not be time later on due to other traffic.

From the perspective of the pilots, however, the timing of the provided traffic information in this case can be perceived as ineffective. Given the mutual distance at 6 NM (11 km), the initial traffic information messages were given too early for the pilots to see each other, since this was physically hardly possible. It could only serve for awareness. At the moment the traffic information would have been more functional and necessary, it was not provided. As the relatieve position of both aircraft changed (no longer opposite), the necessary moment would have been when D-EBTO turned westward to cross the flightpath of N98825 about 20 seconds later, where both aircraft would near the crossing at about the same time. Hence, in this case traffic information appeared to be an ineffective barrier to timely detect other traffic and to help the pilot avoid a collision.

Information from Rotterdam The Hague Airport home based VFR pilots indicate that - although traffic information is often provided – the subsequent non-detection of other traffic is not uncommon. This is also confirmed by studies addressing the functioning of 'see and avoid', see Section 2.8.

3.3 The safety of VFR procedures in the CTR of EHRD

Adherence to procedures and instructions impairing safety
It is commonly known that non-adherence to procedures and short cuts of procedures may impair safety. Radar information confirmed that both the departing and the arriving aircraft followed the prescribed VFR routes as depicted in the visual approach chart. Both pilots further complied with the prescribed altitude of 1,500 feet for the ROMEO departure and ROMEO arrival, as also instructed by ATC. As indicated in the applicable VFR flight procedures and regulations (see section 2.5.1), the pilot of D-EBTO was required to maintain 1,500 feet until his evasive manoeuvre, as pilots in controlled airspace are expected to adhere to instructions (and procedures).

Both flights neared the crossing point at the same moment. This, however, resulted in a risk for a mid-air collision since none of the pilots had visual contact with the other. After D-EBTO turned westward, the TCAS detected that it would cross the track of the N98825 thereby providing an audible alert and indicating the relative position of the conflicting traffic (N98825). At a late stage, only the pilot of D-EBTO saw the other aircraft and made an evasive action. As getting the other aircraft in sight occurred in a late stage of conflict, the adherence to the procedures and instructions impaired flight safety rather than securing it.

Increased risk for collision
As collision risk incidents near point OSCAR depend on the coincidence that two aircraft approach the crossing at the same time, the total number of airproxes reported to the Dutch Safety Board is relatively low for the Rotterdam CTR. But when they occur, this event in 2022 and the previous events in 2014 and 2020 have shown that safety was seriously impaired as mid-air collisions are almost always fatal. As demonstrated by the event in 2020, a Cessna 172 and a helicopter (Lifeliner) flew opposite towards each other with a relative ground speed of 222 knots (411 km/h), which strongly reduced the time for detection and evasion. In particular when VFR flights near each other with a relative high speed, flight safety is impaired as it undermines 'see and avoid'.

Only when Runway 06 is in use, simultaneous flights following the ROMEO arrival and ROMEO departure procedures pose by design a potential risk for collision, as the prescribed flight paths cross each other at the same altitude. The investigation revealed that there is no mechanism in the operational procedures of ATC to prevent that two aircraft near the crossing at the same time. This also applies for the MIKE procedures. Unlike the events in 2014 and 2022, where both the arriving and departing aircraft followed a standard procedure, the event in 2020 showed that a serious incident can also occur when one of the two involved aircraft is flying 'a direct route' and only the other aircraft is following a standard procedure. The crucial commonallity of the three occurrences is that (potential) conflicting traffic in class C airspace – in these cases arriving and departing VFR flights – was cleared by ATC in such a way that there was a real risk for mid-air collisions. With reference to the above, the Dutch Safety Board is of the opinion that this is a structural safety problem.

Further, the Operations Manual contains no additional information or note for the air traffic controller addressing the substantial difference in risk for collisions for VFR flights between using Runway 24 or Runway 06. According to LVNL, air traffic controllers know this and therefore there is no need to include this in the manual. However, by explicitly including this in the Operations Manual, the importance for safety could be emphasised.

Responsibilities
Not only VFR pilots but also an ATS provider has a responsibility in class C airspace to avoid collisions, as VFR flights are not exempted in the regulatory framework for this (see Section 2.4). In fact, in the event of 2022 both VFR flights adhered to the prescribed procedures and ATC instructions. As it was still uncertain whether visual contact would be (timely) established, the risk for a mid-air collision resulting from compliance with standard procedures and ATC instructions further developed. This situation in particular required additional intervention by ATC to aid in preventing a collision, but the safety problem – though unintentionally organized[42] - was left to the pilots.

Though the pilot of D-EBTO did not mention the specific reason during flight, it is noteworthy that he proactively suggested and requested twice to descend to 1,000 feet and once to hold prior to pass the crossing – a measure that could have prevented the incident as no other traffic was in the vicinity and where the highest obstacle along the ROMEO routes (502 feet and more to the south) was not a problem.
These requests were rejected by ATC. The instructor tower controller indicated that, in principle, published routes and prescribed altitudes must be adhered to. The ambient workplace recording revealed that there were no anomalies in the performance of tasks by the trainee air traffic tower controller and that he acted in accordance with what LVNL expected him to do.

In Section 2.4 it is mentioned that LVNL states that '*the pilots of D-EBTO and N98825 were responsible for their separation* ' and that '*VFR pilots are supposed to have the other traffic in sight*. This indicates that LVNL is of the opinion that – apart from providing traffic information and including obstacle clearances during route design - LVNL had no responsibility at all with respect to distances between VFR traffic. This, however, is not in line with the regulatory framework as laid down in Commission Implementing Regulation (EU) 2017/373 for Air Traffic Services. The Dutch Safety Board agrees with LVNL that ATS has no formal responsibility to separate VFR traffic from other VFR traffic, but this should not be confused with its overarching responsibility to prevent collisions.

42 The safety problem meant here: no visual contact yet between the two flights (limitations 'see and avoid'), standard procedures prescribed a crossing at same altitude (embedded risk), no mechanism preventing that aircraft pass the crossing at the same moment (embedded risk).

Underlying factors
From the interview with tower controllers at Rotterdam The Hague airport, it emerged that frequent VFR flights occur within the CTR and that, according to the air traffic controllers, the 'see and avoid' principle has consistently been effective. In their perception, everyday practice also demonstrates that this principle works well in almost all cases. The Dutch Safety Board can agree that most VFR flights in the CTR are uneventful in relation to airproxes.

However, the effectiveness of 'see and avoid' is not always really challenged as many traffic situations can afford that 'see and avoid' is not, or less, functioning. The home based pilots of Rotterdam The Hague Airport also stated that conflicting traffic is not always detected in time or sometimes not at all. Additionally, since decades safety studies have shown that 'see and avoid' is an unreliable tool. Therefore, the number of uneventful VFR movements within the Rotterdam CTR is not automatically a proper indication of the effectiveness of 'see and avoid'. The limitations of 'see and avoid' are common knowledge within aviation based on aforementioned publications, but the investigation showed that LVNL being an Air Traffic Services Provider has not incorporated this knowledge as a principle for the design of the ROMEO and MIKE procedures and for handling VFR operations in daily practise.

LVNL indicated that when any of the VFR pilots would have requested traffic avoidance, it would have found a solution. However, from the perspective of a VFR pilot there is no reason to request traffic avoidance for a (predictive) standard route for which a clearance has been received and where good visibility conditions prevailed. That none of the pilots requested traffic avoidance did not relieve the Air Traffic Services provider (LVNL) of its responsibility to prevent collisions.

Responding to VFR airprox events
The serious incident with D-EBTO and N98825 (2022) and the two previous serious incidents (2014 and 2020) indicated a safety risk for arriving and departing VFR traffic when flying in the same 'pizza slice' of the CTR. As shown by the serious incident with the Lifeliner helicopter (in 2020), VFR traffic on a 'direct instruction' could also be involved. But five of the six involved aircraft flew a published ROMEO or MIKE procedure. The crucial commonallity of all three occurrences is that – when Runway 06 is in use - in class C airspace arriving and departing VFR flights had received clearances or instructions in such a way that there was a real risk for a mid-air collision.
Despite the seriousness of the events in the CTR of Rotterdam The Hague airport, it appeared that the incidents were not a reason for LVNL to improve the ROMEO and MIKE procedures for safety reasons, also because LVNL considers separation between VFR flights solely as a responsibility for VFR pilots. Consequently, the risk for a mid-air collision of VFR traffic remains.

The Dutch Safety Board appreciates the internal recommendation of LVNL, which was made following the serious incident in 2020 and which which aims to better control the workload of the Rotterdam tower controller. However, as shown by the event with D-EBTO and N98825 in 2022, despite that there was not much traffic (workload) at that time, the serious incident could still occur.

In response to the airprox events that occurred in the CTR of Lelystad airport (see 2.6), the LVNL has taken successful measures to restore safety, as it separated arriving and departing traffic in the same sector ('pizza slice') and hence reduced airprox events. In this case, LVNL has shown good safety management as it acted on identified safety risks. LVNL also demonstrated that such changes to procedures can be made and introduced on short notice.

Factors during the design process
Although the design history of the ROMEO and MIKE procedures could not be determined, overall it can be stated that effective and timely involvement of stakeholders is important. Especially for VFR procedures, where less design criteria exist. Consultation of users and stakeholders makes the most sense at the design stage of the process, as later in the process - when the draft and regulations are ready in draft form - the scope for making changes is much smaller.

Commission Implementing Regulation (EU) 2020/469 makes maintenance and periodic review of flight routes mandatory. According to the Ministry of Infrastructure and Water Management, this will be installed with LVNL. In the case of monitoring VFR routes, this means that within the LVNL organisation a system will have to be set up for collecting incidents and investigating the underlying causes. This is essential as the underlying incident shows that procedural aspects and the allocation of responsibilities may be a contributing factor to risks in VFR procedures.
This will require the LVNL to not only attribute incidents to VFR pilots, indicating that 'see and avoid' is their responsibility. LVNL will also have to critically review its own performance and contribution to avoiding collisions between VFR traffic in controlled airspace (class C and D). The Ministry of Infrastructure and Water Management will need to conduct the appropriate oversight on this.

4 CONCLUSIONS

The safety problem

In particular when Runway 06 is in use, a risk for a mid-air collision exists for VFR flights even when pilots adhere to standard procedures and/or instructions. As there is no mechanism in the ATC procedures preventing aircraft crossing routes of other VFR traffic at te same time and at the same altitude, simultaneous arrival and departure flights following the ROMEO procedures or following the MIKE procedures in the Rotterdam CTR are inherently unsafe. This can also be in combination with traffic flying a 'direct route'. The crucial commonality between the current near mid-air collision and the two previous near mid-air collisions, is that in class C airspace arriving and departing VFR flights in the same sector ('pizza slice') were cleared or instructed such a way that there was a real risk for mid-air collisions.

The airprox between D-EBTO and N98825 occurred as both flights neared the crossing point of the VFR routes near point OSCAR at the same moment at the same prescribed altitude. Despite the provision of traffic information by Air Traffic Control (ATC), this created an increasing risk for a mid-air collision as long as the pilots had not established visual contact.

In a late stage of conflict the pilot of D-EBTO detected the conflicting aircraft after having received a traffic advisory from his traffic collision and avoidance system (TCAS). This safety net contributed to a successful evasive action.

Failing safety barriers and responsibilities

To fullfill the responsibility for VFR pilots to avoid collisions, they need to have the other traffic in sight. As outlined in studies, 'see and avoid' is sensitive to failure and therefore an unreliable safety barrier.

The provision of traffic information by ATC to promote visual contact in this case was not effective and thus not supporting 'see and avoid'.

The limitations of 'see and avoid' are common knowledge within aviation, but the investigation showed that LVNL has not incorporated this knowledge as a principle for the design of the ROMEO and MIKE procedures and for handling VFR operations in daily practise.

Pilots themselves as well as the Air Traffic Service (ATS) provider have a responsibility in preventing a (mid-air) collision in class C airspace between VFR traffic, as laid down in the regulatory framework. Though visual contact between D-EBTO and the N98825 remained uncertain, ATC did not aid in solving the upcoming risk for a collision.

Since LVNL considered separation between VFR traffic solely as a responsibility for VFR pilots, despite the serious air proximity events in 2014, 2020 and 2022, LVNL apparently did not see reasons to improve the ROMEO and MIKE procedures to address the risk of mid-air collisions. The non-responsibility for providing separation between VFR traffic, however, should not be confused with its overarching responsibillty for preventing collisions in class C airspace.

The use of ambient workplace recordings

The current EU requirement for Air Traffic Services providers to preserve the ambient workplace recording at least 24 hours, is a structural safety deficiency for safety investigations. As this legal retention period is very short, there is a risk that crucial factual information may not be available for the purpose of safety investigation and identification of safety improvements.

5 RECOMMENDATIONS

To Air traffic Control Netherlands (LVNL):

For safety reasons:

1. Secure on short notice and in consultation with stakeholders that arriving VFR traffic and departing VFR traffic in the CTR of Rotterdam The Hague Airport, have under all circumstances no crossing flight paths at the same altitude.
2. Include the objectives of Commission Implementing Regulation (EU) 2017/373 ATS. TR.100 for VFR operations in class C and D airspace in LVNL policy for procedures and/or training in order to prevent collisions between VFR traffic.

To the International Civil Aviation Organisation and to the European Union Aviation Safety Agency:

3. For the purpose of accident and incident investigation, amend the retention period of background communication and aural environment recordings in air traffic services from 24 hours of operation to 30 days (ICAO annex 11, Commission Implementing Regulation (EU) 2020/469, ATS.OR.460).

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:

- Pilot of D-EBTO
- Pilot of N98825
- Air Traffic Control the Netherlands (LVNL)
- Air traffic tower controller trainee
- Air traffic tower controller instructor
- Air traffic control pro/atmp department
- Air traffic control operational expert
- Ministry of Infrastructure and Water Management
- European Aviation Safety Agency (EASA)
- German Federal Bureau of Aircraft accident Investigation (BFU)

To receive comments on the draft report from the involved parties normally only happens once. In particular the comment from the Ministry of Infrastructure and Water Management – addressing the responsibility of air traffic control for VFR operations - had changed the moral of the report significantly. Therefore, the Dutch Safety Board decided that a second opportunity to reflect on the adapted draft report was necessary. The second check only applied to:

- Air Traffic Control the Netherlands (LVNL)
- Ministry of Infrastructure and Water Management

The responses received were processed in the following way:

- If the Safety Board decided to adopt responses, they were amended into the final version of the report.
- If the Safety Board did not adopt responses, an explanation is given of why it decided to do so.

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 (https://www.safetyboard.nl).

APPENDIX B

Approval process for VFR procedures

The minister of Infrastructure and Water Management and minister of Defence have a joint responsibility within the Amsterdam FIR regarding aviation safety and sustainability. Before airspace changes are laid down in national regulations and publications, joint decision-making and coordination must take place. For this, a specified process has been implemented in 2011 and updated several times. [43]

The process is used to guide in the design, approval and implementation of all types of airspace changes. Depending on the extent or complexity of the change, different steps are taken. For more complex changes, stakeholder consultations need to be done as part of the approval process. At all times, the amendment must be adopted by the competent authority (minister or state secretary) before publication.

According to the published process, umbrella organisations such as the Royal Netherlands Aeronautical Association (KNVvL) and Aircraft Owners & Pilots Association (AOPA) Netherlands may be the initiator of an airspace change request. These organisations are also important stakeholders with an operational interest and need to be consulted before a change is approved. Both organisations represent users of VFR procedures and routes. The level and timing of the stakeholder participation depends amongst others on the complexity of the change.

For civil aviation, the Department of Flight Procedures and Airspace Advice (VLA) and the National Supervisory Authority (NSA) within the Human Environment and Transport Inspectorate (ILT) primarily have a supervisory role in the airspace and flight procedures modification process. The VLA conducts a technical operational assessment of the design provided by the initiator. In some cases, a safety analysis by the initiator is part of the design. For VFR routes and procedures, the VLA department conducts an assessment based on the limited criteria currently in place (see Section 2.5.2). The assessment is mainly based on expertise. Additionally, the VLA department may request additional clarifications or analyses from the initiator. They may also require or conduct a validation flight. The VLA department does not have a working relationship with parties like AOPA or KNVvL. Only after approval by the VLA department, the design can proceed.

43 In Dutch: *Wijzigingsproces Luchtruim en vliegprocedures*. On 15 March 2023 version 4.0 of this procedure has been approved. See also https://www.rijksoverheid.nl/documenten/publicaties/2023/05/25/wijzigingsproces-luchtruim-en-vliegprocedures

As of 27 January 2022, European Union (EU) regulations require that Member States shall ensure that maintenance and periodic review of flight procedures for aerodromes and airspace under their authority are conducted.[44] The maintenance aspect, or day-to-day monitoring, of flight procedures around the aerodrome, falls under the responsibility of the aerodrome.[45] The periodic review, carried out at least every five years, will be conducted by LVNL.[46] If a modification arises from the periodic review, it will go through the modification process described above.

An occurrence, either accident or incident, may be a trigger to initiate a review of a flight procedure. Monitoring of occurrences and the establishment of underlying factors is essential for this. In the first instance, the EASA-certified aerodromes and LVNL have the responsibility to act on reported occurrences where necessary. The ILT's unit that analyses aviation incidents (ABL) registers and analyses aviation occurrences. The ABL usually does not investigate incidents, but primarily looks at trends.

This process described above has not been used for the VFR procedures in the Rotterdam CTR, as the procedures had been implemented before this consultation was established. In addition, occurrences in recent years did not trigger a review of the procedures, see also Section 2.6, and no periodic review did take place yet.

44 Commission Implementing Regulation (EU) No 2020/469, Article 3. Applicable as of 27 January 2022.
45 Commission Regulation (EU) No 139/2014, ADR.OR.B.025.a.1.iii and/or ADR.OR.C.005.b.2.
46 The Aviation Act will be amended to officially assign this task to LVNL.

APPENDIX C

Regulations (EU) 2017/373 and (EU) 2020/469

Commission Implementing 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

Annex IV – Part-ATS Specific requirements for providers of Air Traffic Services

ATS.TR.100 Objectives of the air traffic services (ATS)

The objectives of the air traffic services shall be to:

a. prevent collisions between aircraft;
b. prevent collisions between aircraft on the manoeuvring area and obstructions on that area;
c. expedite and maintain an orderly flow of air traffic;
d. provide advice and information useful for the safe and efficient conduct of flights;
e. notify appropriate organisations regarding aircraft in need of search and rescue aid, and assist such organisations as required.

ATS.TR.235 ATC clearances

Commission Implementing Regulation (EU) 2020/469

a. (a) ATC clearances shall be based solely on the requirements for providing air traffic control service.
    1. Clearances shall be issued solely for expediting and separating air traffic and be based on known traffic conditions which affect safety in aircraft operation. Such traffic conditions include not only aircraft in the air and on the manoeuvring area over which control is being exercised, but also any vehicular traffic or other obstructions not permanently installed on the manoeuvring area in use.
    2. Air traffic control units shall issue such ATC clearances as necessary to prevent collisions and to expedite and maintain an orderly flow of air traffic.
    3. ATC clearances shall be issued early enough to ensure that they are transmitted to the aircraft in sufficient time for it to comply with them.
    4. When the pilot-in-command of an aircraft informs an air traffic control unit that an ATC clearance is not satisfactory, the air traffic control unit shall issue an amended clearance, if practicable.

5. When vectoring or assigning a direct routing not included in the flight plan, which takes an IFR flight off published ATS route or instrument procedure, an air traffic controller providing ATS surveillance service shall issue clearances such that the prescribed obstacle clearance exists at all times until the aircraft reaches the point where the pilot re-joins the flight plan route, or joins a published ATS route or instrument procedure.

b. (…)

APPENDIX D

4 VFR flight procedures and regulations

for visual approach chart and visual traffic circuits see AD 2.EHRD-VAC.1, AD 2.EHRD-VAC.2 and AD 2.EHRD-VAC.3.

4.1 General

4. All VFR flights within the Rotterdam CTR shall submit a flight plan (see ENR 1.10).
5. Prior permission is required from Rotterdam TWR for all VFR operations in the CTR.
6. The use of RWY 06/24 is restricted to aircraft maintaining two-way radio contact with TWR.
7. Pilots shall adhere to the approach or departure route as indicated on the charts, unless otherwise instructed by ATC.
8. Pilots shall strictly adhere to the circuits as indicated on the charts, unless otherwise instructed by ATC.
9. Noise abatement has been included in the procedures.
10. Built-up areas shall be avoided as much as possible.
11. Marked areas shall be avoided.
12. Standard circuit altitude is 1000 FT AMSL for inbound VFR traffic. Standard altitude for VFR training circuit is 500 FT AMSL.
13. IFR areas: VFR flights within the CTR may be instructed by ATC to stay clear of the specified IFR areas. These areas are indicated on the chart.
14. VFR reporting points positions:

VFR reporting point	Position
FOXTROT	515428N 0043258E
HOTEL	515818N 0040736E
MIKE	515954N 0043905E
OSCAR	515656N 0043150E
PAPA	515626N 0042802E
ROMEO	515125N 0043550E
SIERRA	515822N 0041903E
TANGO	515824N 0042347E
WHISKEY	515820N 0041323E

4.2 Visual departure procedures

Pilots must have obtained start-up clearance from ATC before starting engines. A request for start-up shall be made to Rotterdam Delivery; clearance for start-up will either be issued immediately or at a specified time depending on traffic. A request for start-up includes:

- aircraft identification (e.g. PHSPY).
- position (e.g. opposite tower).
- ATIS information (e.g. information J).
- flight rules (e.g. VFR).
- destination (e.g. Hilversum).
- request start-up.

1. **MIKE Departure**: after take-off follow the VFR route via OSCAR (or ABM OSCAR) to MIKE while climbing to 1000 FT AMSL and keep 500 M to the right-hand side of the railway.
2. **ROMEO Departure**: after take-off follow the VFR route via OSCAR (or ABM OSCAR) and FOXTROT to ROMEO while climbing to 1500 FT AMSL and keep 500 M to the right-hand side of the highway.
3. **HOTEL Departure** (ATC discretion only): after take-off follow the VFR route via TANGO, SIERRA to WHISKEY in the direction HOTEL while climbing to 1000 FT AMSL. (This VFR route coincides with RTM VOR radial 271).
4. For other directions. Departure instructions will be given.

4.3 Visual approach procedures

1. Contact Rotterdam TWR 2 minutes before reaching the CTR boundary for permission to enter the CTR.
2. **MIKE Arrival**: enter the CTR via MIKE at 1000 FT AMSL; follow the VFR route via OSCAR (or ABM OSCAR) to PAPA and keep 500 M to the right-hand side of the railway.
3. **ROMEO Arrival**: enter the CTR via ROMEO at 1500 FT AMSL; follow the VFR route via OSCAR (or ABM OSCAR) to PAPA and keep 500 M to the right-hand side of the highway.
4. **HOTEL Arrival** (ATC discretion only): enter the CTR via WHISKEY at 1500 FT AMSL; follow the VFR route via SIERRA to TANGO. (This VFR route coincides with RTM VOR radial 271).
5. Pilots may be instructed to hold over ROMEO, FOXTROT, ABM MIKE, ABM OSCAR, WHISKEY, SIERRA or TANGO.
6. When instructed to approach via ABM PAPA the following applies for RWY 06/24:
    1. Join the circuit as instructed by ATC.
    2. Maintain 1000 FT AMSL (MIKE Arrival) or 1500 FT AMSL (ROMEO Arrival).
    3. After passing ABM PAPA cross the runway in the middle and join the downwind leg as instructed by ATC.
7. In case of an overshoot enter the relevant traffic circuit and inform ATC.

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