



DUTCH
SAFETY BOARD

Mid-air collision between two Piper Super Cubs near Oudemolen, 21 June 2019



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The Hague, October 2021

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The Dutch Safety Board

When accidents or disasters happen, the Dutch Safety Board investigates how it was possible for these to occur, with the aim of learning lessons for the future and, ultimately, improving safety in the Netherlands. The Safety Board is independent and is free to decide which incidents to investigate. In particular, it focuses on situations in which people's personal safety is dependent on third parties, such as the government or companies. In certain cases the Board is under an obligation to carry out an investigation. Its investigations do not address issues of blame or liability.

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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.

CONTENTS

Summary	5
Abbreviations.....	6
1 Introduction	7
2 Factual Information.....	8
2.1 History of the flight.....	8
2.2 Damage to aircraft.....	10
2.3 Regulatory framework	12
3 Analysis	13
3.1 Technical analysis.....	13
3.2 The mid-air collision	13
3.3 The new formation manoeuvre	14
3.4 Formation flying: training and regulation	16
4 Conclusion.....	18
Appendix A	19
Appendix B.....	21

On 21 June 2019, at approximately 11.20 hours local time, two aircraft collided while practicing formation flying at 500 feet above mean sea level nearby the village of Oudemolen (Noord-Brabant). The formation leader was a PA-18-125 Super Cub (PH-RED) and the wingman was a PA-18-95 Super Cub (PH-VCY). The formation team was practicing a familiar formation display with the addition of a new manoeuvre.

The mid-air collision had severely damaged PH-VCY, causing the aircraft to become uncontrollable and to crash. The pilot and passenger of PH-VCY were fatally injured. PH-RED was substantially damaged; however, the pilot was able to make an emergency landing in a field nearby. The pilot of PH-RED suffered minor injuries, the passenger remained unharmed.

The Dutch Safety Board investigated the mid-air collision to answer the following questions. What was the cause of the mid-air collision? And, to what extent were technical and operational factors contributing to the accident?

The investigation revealed that during the rejoin of the new formation manoeuvre, the wingman (PH-VCY) closed in from behind at the right side with a higher airspeed, before colliding with leader (PH-RED). It was determined that technical factors did not contribute to the cause of the accident. Both pilots had a valid pilot licence, display authorization and medical certificate.

The formation team practiced a new formation manoeuvre that had the inherent risk for the pilots of not being able to adequately keep each other in sight during the rejoin phase of the manoeuvre. Even though the hazard of losing sight was recognized by the two pilots who were proficient in formation flying, the mitigating measure consisting of a fixed altitude separation of 100 feet was not effective to ensure the safety of the formation during the rejoin. Even with an applied altitude separation as a measure to avoid a mid-air collision, the new formation manoeuvre was by its design unsafe to perform.

ABBREVIATIONS

AMSL	Above Mean Sea Level
EHSE	Breda International Airport (Seppe)
ELT	Emergency Locator Transmitter
KNMI	Royal Netherlands Meteorological Institute
KNVvL	Royal Netherlands Aeronautical Association
Mph	1 mile per hour (mph = 1,609 metres per hour)
PPL	Private Pilot License
QNH	Altimeter pressure setting
SEP	Single Engine Piston
SERA	Standardised European Rules of the Air
VFR	Visual Flight Rules

1 INTRODUCTION

On 21 June 2019, at approximately 11.20 hours local time, two aircraft collided while practicing formation flying at 500 feet above mean sea level nearby the village of Oudemolen (Noord-Brabant). The formation leader was a PA-18-125 Super Cub (PH-RED) and the wingman was a PA-18-95 Super Cub (PH-VCY). The mid-air collision had severely damaged PH-VCY, causing the aircraft to become uncontrollable and to crash. The pilot and passenger of PH-VCY were fatally injured. PH-RED was substantially damaged, however, the pilot was able to make an emergency landing in a field nearby. The pilot of PH-RED suffered minor injuries, the passenger remained unharmed.

The formation team performed formation displays for about two years prior to the date of the accident. During the flying season, the team alternating practiced two familiar formation displays. On the day of the accident flight, the formation team had added a new formation manoeuvre to the display that was practiced for the second time.

The purpose of this accident investigation was to determine the cause of the mid-air collision and the operational and technical contributing factors. This investigation is a shortened report following the guidelines of the ICAO Annex 13, Standards and Recommended Practices, for aircraft accident investigation. The investigation consisted of interviews, examination of the aeroplanes' wreckages and analyses of surveillance camera video images.

Chapter 2 provides the factual information. The analysis in Chapter 3 consists of four themes: 1) the technical analysis; 2) the mid-air collision; 3) the new formation manoeuvre; and 4) formation training and regulation. The conclusion follows in Chapter 4.

2 FACTUAL INFORMATION

2.1 History of the flight

2.1.1 Flight preparation

The pilots prepared for the formation practice flight at Breda International Airport (hereafter Seppe Airfield). The pilot of PH-RED (hereafter: RED) was the formation leader and the pilot of PH-VCY (hereafter: VCY) was the wingman. Both RED and VCY had a passenger in the rear seat of the aircraft. The passenger of VCY was one of the coaches¹ of the formation team. The exercise was planned to take place between 500 and 1,500 feet AMSL in VFR airspace² just north east of the village of Oudemolen.

The pilots prepared to rehearse a familiar formation display with the addition of a new manoeuvre. This new manoeuvre was planned to be the first manoeuvre of the show. The new manoeuvre consisted of a formation split up from a line abreast position, followed by an opposite 360 degrees turn of both aircraft and finishing with a rejoin. The planned airspeed of the manoeuvre was 90 mph. On the previous formation flight, the new manoeuvre was practiced two times to gain proficiency and to determine its feasibility. The pilots had recognized that it was difficult to adequately keep each other in sight during the rejoin of the manoeuvre.

The flight briefing included the particulars of how the planned new manoeuvre had to be flown. Also, abnormal procedures such as losing sight of each other and emergency procedures were briefed. Furthermore, the leader and the wingman, completed a so-called walk-through³ of the planned exercise twice.

2.1.2 The formation exercise and mid-air collision

The start-up of the engines, taxi-out and take-off were accomplished as intended. The flight from Seppe Airfield towards the holding area of the exercise, just west of the village of Fijnaart, was uneventful. At the holding area, RED (leader) made a radio call to inform VCY (wingman) to start the display. The formation proceeded from the holding area towards the reference point and display line at an altitude of 500 feet AMSL. When approaching the reference point, the leader directed the formation to split up. The two aircraft started their opposite 360° level turn with approximately 50° angle of bank (see Figure 1).

¹ The coach was a former pilot who was experienced with formation flying. As he was becoming of age, he was not in possession of a pilot license anymore.

² [LVNL, AIP Netherlands, Airspace Classification and Description, Class G, April 2021.](#)

³ A formation walk-through means that the formation members simulate flying the exercise by walking through the manoeuvres on the ground. They will point out to each other where events such as position and altitude changes, and when radio calls are made.

After the 360° turn, which took approximately 25 seconds, the wingman rejoined as intended. Following the rejoin, the pilots continued with the planned manoeuvres of the exercise. After the first exercise was completed, which took approximately ten minutes, the formation leader instructed the wingman to fly separately to the holding area for a rejoin.

The formation rejoined at the holding area and proceeded inbound towards the reference point to perform the display for a second time. At the reference point, the leader directed the formation to split-up, after which both aircraft started their opposite turns. This time, however, after 360° of level turn, the two aircraft collided (see Figure 1).

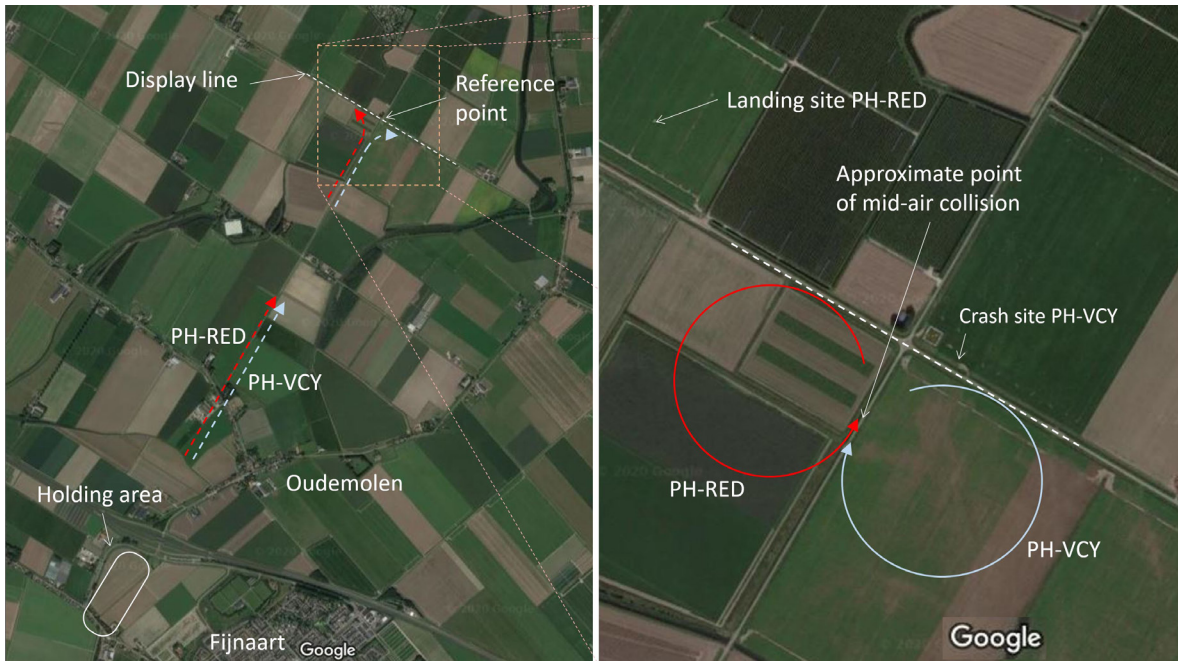


Figure 1: Location of the formation exercise and crash location of PH-RED (leader) and PH-VCY (wingman) near the village of Oudemolen. (Source map: Google Maps; modified by Dutch Safety Board)

Immediately after the collision, VCY spiraled uncontrollably down and crashed on an embankment of a ditch, fatally injuring the pilot and passenger. RED was still controllable after the collision, but its forward visibility was blocked by the tail section of VCY which was stuck on its nose section. The pilot of RED made a left hand descending turn and landed the aircraft in a field nearby.

2.2 Damage to aircraft

After the accident, both aircraft were recovered and examined. The examination consisted of a technical assessment of the flight control systems and the engines, and an assessment of the damages that resulted from the mid-air collision. The technical examination did not reveal any technical abnormalities. The damages on both aircraft as a result of the mid-air collision are described below.

2.2.1 Damage due to mid-air collision

The examination showed that RED's right hand elevator had a distinct dent and was deformed. The horizontal tail section and the aft fuselage were twisted to the left as a result of the collision. Furthermore, RED's left wing tip had a large indent just behind the left wing light. The construction inside of the wing tip was damaged and the wing's bottom skin cover was punctured. RED's left wing tip damage area had scrapes indicating that the movement off collision was from behind, moving forward and to the right (see Figure 2).



Figure 2: PH-RED's damage pattern right elevator and left wing tip. (Source: Dutch Safety Board)

The cockpit windscreen of RED was broken and for the major part missing. The windscreen frame was deformed at the lower left section. RED's propeller showed several indents on the leading edge of the propeller blade (see Figure 3).



Figure 3: PH-RED's damaged windscreen and PH-VCY's horizontal stabiliser blocking PH-RED's windscreen. (Source: Dutch Safety Board)

The examination of VCY showed that the right wing was structurally damaged and partly disconnected from the fuselage. The right wing tip was substantially damaged and deformed. Furthermore, the tail section was cut off from the aft fuselage on approximately a 45° angle (see Figure 4). The other damages to VCY were caused by the crash.



Figure 4: Wreckage of PH-VCY, damaged right wing (lower left corner) and the cut-off angle rear fuselage. (Source: Dutch Safety Board)

2.2.2 Emergency Locator Transmitter

Both aircraft were equipped with a KANNAD 406 AF-COMPACT Emergency Locator Transmitter (ELT). The ELT of RED was activated and the emergency signal was received by the Rescue Coordination Centre. The signal of the ELT of VCY was not received by the Rescue Coordination Centre. Due to the impact with the ground, the antenna connector had become disconnected from the receptacle on the ELT housing, preventing the ELT from transmitting its signals.

2.3 Regulatory framework

2.3.1 VFR airspace and formation flights

Airspace regulation concerning formation flights in VFR uncontrolled airspace in the Netherlands is governed by national and European regulation. The regulation "Besluit luchtverkeer 2014"⁴ states among others that pilots need to be extra vigilant during aerobatic, i.e., formation manoeuvring, and that they need to maintain adequate distance from gatherings of people and housing or build up areas. The regulation (EU) No 923/2012, Standardised European Rules of the Air (SERA)^{5, 6} states that, formation flights in VFR airspace are allowed to be conducted at a minimum altitude of 500 feet above the ground over sparsely populated areas. As a basic principle, formation flights are allowed in VFR uncontrolled airspace if the pilots in command of the participating aircraft make prior arrangements for the conduct of the flight.

2.3.2 Regulation concerning air display authorization

Restrictions for the conduct of formation flight air displays as part of an organized air show are governed by the regulation "Regelgeving Luchtvaartvertoningen."⁷ Article 18 of this regulation specifies among others that participants need to have a valid display authorization, as issued by the Royal Netherlands Aeronautical Association (KNVvL) Examining Institute. The procedures for the issuance of a display authorization for formation flying are stipulated in the document "Rules and Regulations for Display Pilots and Display Authorisation Evaluators."⁸

4 [Wetten.Overheid.nl, Besluit luchtverkeer 2014, Artikel 13. Kunstvluchten, 2020.](https://www.wetten.overheid.nl/BWBR0028143)

5 [EASA, Easy Access Rules for Standardised European Rules of the Air \(SERA\), SERA.5005, Visual flight rules \(f\), 2020.](https://www.easa.europa.eu/en/air-traffic/sera)

6 [EASA, Easy Access Rules for Standardised European Rules of the Air \(SERA\), SERA.3135 Formation flights, 2020.](https://www.easa.europa.eu/en/air-traffic/sera)

7 [Wetten.Overheid.nl, Regeling luchtvaartvertoningen \(Par 5, Art 34\), \(valid period: 01-04-2019 t/m 01-07-2019\), 2021.](https://www.wetten.overheid.nl/BWBR0028143)

8 [KEI, Reglement, Rules and Regulations for Display Pilots and Display Authorization Evaluators, 2017.](https://www.knvvl.nl/nl/overheidsinstellingen/rijksaeroverheidsvereniging/overheidsinstellingen/rijksaeroverheidsvereniging)

3.1 Technical analysis

The technical examination revealed that there were no technical deficiencies found on neither RED (leader) nor on VCY (wingman) that could have been a contributing factor to the accident. The weight and centre of gravity of RED and VCY were within limits. Both aircraft had a valid certificate of airworthiness and were maintained according to their maintenance program.

Furthermore, the assessment of the mid-air collision damage revealed that the propeller of RED had marked indents on the leading edge of the propeller blade. Further, it was found that the steel tubes of VCY's aft fuselage frame showed distinct cut and shear marks. And, that the entire aft tail section of VCY was cut at approximately 45 degree angle (see Figure 5). This implies that VCY had crossed in close proximity in front of RED, whereby the propeller of RED had cut off the aft tail section of VCY.

3.2 The mid-air collision

During the rejoin phase of the second attempt of the new manoeuvre, the leader had rolled out of the turn and was flying wings level. The wingman approached from behind on the right side and had a slightly right banked attitude. At that moment, the wingman was flying slightly higher than the leader and had a higher airspeed than the leader: it was closing in. Just before the collision, the wingman sharply rolled to the left. Then, the wingman collided with the leader.

The mid-air collision consisted of three distinct events (Figure 5). The sequence of the parts is based on the statement of the passenger in the leader's aircraft, and the described damage pattern as a result of the mid-air collision.

The first event of the mid-air collision was that the wingman with its right wing tip struck the leader's right side of the horizontal tail first. Then, the wingman moved forward and to the left. The second event was the wingman with its right wing tip striking the leader's upper side of the left wing tip. The third event was the wingman crossing the nose and propeller of the leader within close proximity with a right angle of bank between 90° and 180°. This crossing caused the tail section of wingman's aircraft to be cut off (see Figure 6).

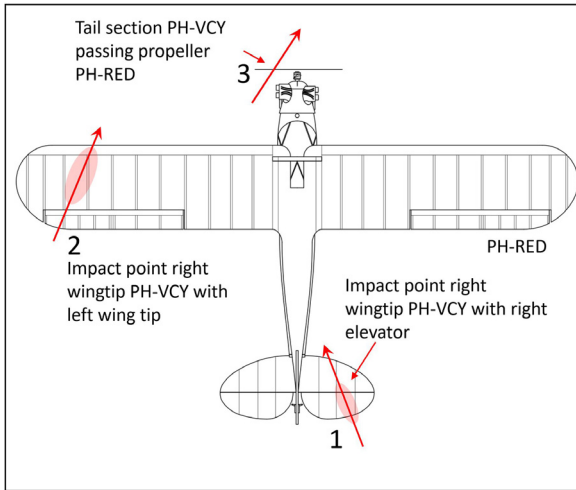


Figure 5: PH-RED's (leader) damage pattern and PH-VCY's (wingman) direction of movement. (Source: Kaboldy, Wikipedia Commons, modified by the Dutch Safety Board)

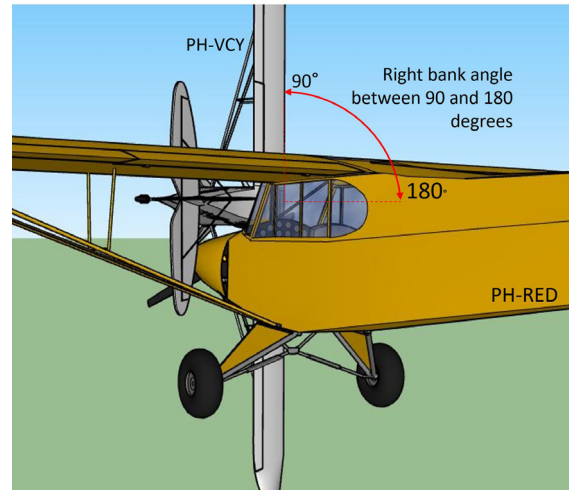


Figure 6: Propeller PH-RED (leader) cuts of tail section of PH-VCY (wingman). (Source: Dutch Safety Board)

3.3 The new formation manoeuvre

3.3.1 The risk of the new manoeuvre

The new manoeuvre starts with a formation split up from a line abreast position, followed by two opposite 360° level turns, finishing with a rejoin in a line abreast formation. The objective of the exercise is to fly the manoeuvre symmetrically. However, during the end phase of the rejoin the wingman is to be slightly aft and closing in from behind in a controlled manner (see Figure 7). The intended separation between the leader and the wingman in the line abreast formation is the width of one wingspan, which is approximately 11 meters. The 360° turn is flown with approximately 50° angle of bank. The manoeuvre progresses fairly quickly: it takes approximately 25 seconds to complete the 360° turn. The fact that both aircraft had different types of engines and thus a different performance, did not hamper the ability of the aircraft to perform the manoeuvres symmetrically.

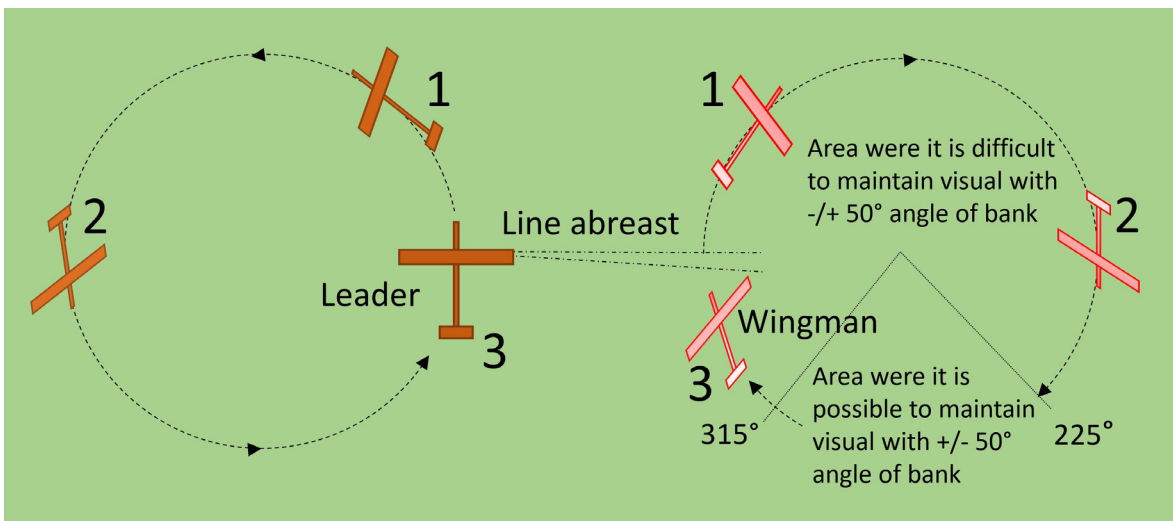


Figure 7: Geometry of the 360 degree opposite turn and rejoin manoeuvre. (Source: Dutch Safety Board)

Flying the two opposite 360° turns, poses a difficulty for the pilots to keep each other in sight. After the split-up, pilots will quickly lose sight of each other, because they are turning away from each other (see Figure 7). In this stage of the manoeuvre this is not a concern, because the distance between the aircraft is increasing. Further into the turn, the difficulty of maintaining visual is caused by the high wing of the aircraft; blocking the view to the inside of the turn.

It is reasonable to assume from a theoretical standpoint that while continuing the turn, pilots are able to regain visual contact once they have turned approximately 225° and maintain visual contact until approximately 315° into the turn. After this point, which is during the last 45° of the turn, it will become increasingly difficult to keep each other in sight because of the 50° angle of bank. In other words, during the end phase of the manoeuvre, both aircraft were turning with their bellies towards each other, which made it almost impossible for both pilots to keep each other in sight. And, because of the steep bank angle, it was for the wingman increasingly more difficult to judge the closure during the rejoin.

3.3.2 Mitigation of the risk of losing sight

During the previous formation flight, the pilots and coach had noticed that for the wingman, it was difficult to keep the leader in sight during the end-phase of the manoeuvre. On the second rejoin attempt of this flight, the wingman had to break out from the formation to avoid colliding with the leader. Therefore, the pilots identified the difficulty to keep each other in sight during the rejoin as a flight safety hazard.

To eliminate the hazard of losing sight and mid-air collision, the pilots decided that in case the wingman did not have the leader in sight, he was to maintain a separation of 100 feet of altitude above the leader. In general, however, an altitude separation of 100 feet does not assure separation at all times because of the two following factors. First, pilots may unintentionally deviate from their assigned altitude during an exercise and it is considered unavoidable for these deviations to occur. An error margin, therefore, has to be taken into account to compensate for normal flying inaccuracies. From best practice, it is considered appropriate for pilots to reckon with an altitude error margin of approximately 100 feet. Second, the altitude indication on the altimeter may deviate to a certain extent from the actual altitude. This altitude indication error is caused by the technical design of barometric altimeters and is allowed as long as it remains within established operational tolerances.^{9, 10, 11, 12}

The pilots had decided that the exercise on the day of the accident was to determine if the execution of the new manoeuvre could be performed safely. Depending on the outcome, they would either continue or discontinue flying the new manoeuvre. They had practiced the manoeuvre and rejoin three times before the accident; one of these

9 The technical design of the altimeters of certified aircraft allows for an altitude error of maximum 25 feet up to 1,500 feet.

10 Scheduled maintenance was performed on the altimeters of both aircraft on 9 April 2019; both altimeters were tested and found serviceable.

11 Both altimeters were examined after the crash. PH-RED's altimeter was found to be functioning within limits. PH-VCY's altimeter was not functioning anymore: it was internally broken as a result of the crash.

12 The altimeter settings as found after the crash were: PH-RED: 1018 hPa and PH-VCY: 1017 hPa.

attempts led to a break out situation. It is concluded that the pilots had devised a new manoeuvre with an inherent risk of not being able to adequately keep each other in sight during a critical phase of the manoeuvre. Furthermore, the mitigating measure in case of losing sight was ineffective to guarantee separation between the aircraft and the safety of flight.

3.3.3 Environmental conditions

It could not be determined if the wingman had visual contact or did not have visual contact with the leader while rejoining. Whatever the case, it is worthwhile to mention that, besides the above mentioned difficulty because of the geometry of the new manoeuvre, environmental conditions may have affected the wingman's ability to visually acquire the leader.

The reported weather conditions were suitable for formation flying: with more than 10 kilometres visibility and the lowest overcast was a few to scattered at 1,500 feet. Video images taken from the area at the time of the accident, show that the cloud condition was frequently changing between clear skies and overcast; creating shaded areas on the ground. Additionally, the aircraft of the leader was painted in a military camouflage pattern with colours varying from dark green to dark brown, designed to mislead the human eye. Against a background of green farmland with crops, the visibility of the leader's aircraft was possibly affected.

The contrast between the colour of an object and the background determines how the object can be detected by the eye, i.e., light coloured aircraft against a dark background would be relatively easy to detect. In contrast, dark aircraft against a background such as dark vegetation and scattered buildings would make detection harder. Moments before the mid-air collision, the background condition for the wingman, was dark and shaded due to passing clouds overhead.

3.4 Formation flying: training and regulation

The pilots had gained proficiency in developing, training and performing the formation display with the two Piper Super Cubs as of 2016. They were initially supported by two coaches, who had gained experience as pilots in a formation team based at Seppe Airport that performed air displays between 1990 and 2015. One coach retired from assisting the team around the beginning of 2019; the other coach was still active in assisting the team. During the flying season, the pilots discussed or practiced the exercises more or less on a weekly basis. The pilots were in possession of a valid display authorization. Noted is that such an authorization is not required for a formation training flight.

The pilots almost always planned the formation training flight in the same location –the sparsely populated area just north of the village of Oudemolen. Besides, the formation flight was coordinated between the pilots and executed between 500 and 1,500 feet AMSL.

The Dutch¹³ and European¹⁴ airspace regulation allowed for the formation training flight to be performed in the lower VFR uncontrolled airspace structure such as in the vicinity of the village of Oudemolen.

13 [Wetten.Overheid.nl, Regeling Luchtruim, Besluit luchtverkeer 2014, Artikel 13, Kunstvluchten, 2018.](https://www.wetten.overheid.nl/BWBR00282014-00013)

14 [EASA, Easy Access Rules for Standardised European Rules of the Air \(SERA\), SERA 3135 Formation Flights, 2012.](https://www.easa.europa.eu/en/air-traffic/air-traffic-rules/easa-3135-formation-flights)

4 CONCLUSION

The investigation revealed that during the rejoin of the new formation manoeuvre, the wingman (PH-VCY) closed in from behind at the right side with a higher airspeed, before colliding with the leader (PH-RED). It was determined that technical factors did not contribute to the cause of the accident. Both pilots had a valid pilot licence, display authorization and medical certificate.

The formation team practiced a new formation manoeuvre that had the inherent risk for the pilots of not being able to adequately keep each other in sight during the rejoin phase of the manoeuvre. Even though the hazard of losing sight was recognized by the two pilots, who were proficient in formation flying, the mitigating measure consisting of a fixed altitude separation of 100 feet was not effective to ensure the safety of the formation during the rejoin. Even with an applied altitude separation as a measure to avoid a mid-air collision, the new formation manoeuvre was by its design unsafe to perform.

General details

Identification number	2019052
Classification	Accident
Date, time of occurrence	21 June 2019, 11.20 hours
Location of occurrence	1 nautical mile northeast of the village of Oudemolen

	Aircraft 1 (leader)	Aircraft 2 (wingman)
Aircraft manufacturer	Piper Aircraft Corporation	Piper Aircraft Corporation
Aircraft model	PA-18-125 Super Cub	PA-18-95 Super Cub
Aircraft registration	PH-RED	PH-VCY
Serial number	18-568	18-3785
Operator	Privately owned	Privately owned
Type of operation	Formation flight	
Departure/Destination	Breda International Airport, EHSE	
Damage to aircraft	Substantial	Destroyed
Flight crew	1	1
Passengers	1	1
Injuries	Pilot: minor injuries, passenger: unharmed	Pilot and passenger: fatal

Flight crew details

	Aircraft 1 (leader)	Aircraft 2 (wingman)
Pilot	Age 56 Valid PPL rating SEP Land Valid medical certificate Total flying hours: 457 Valid display authorization	Age 55 Valid PPL rating SEP Land Valid medical certificate Total flying hours: approx. 1,200 Valid display authorization

Weather conditions

KNMI reported weather conditions at the time of the accident

Visibility more than 10 kilometres, wind at 500 feet was 240° at 12 knots, ceiling and cloud base were few to scattered varying between 1,500 and 3,500 feet, and tops of clouds at 8,000 feet.

RESPONSES TO THE DRAFT REPORT

In accordance with the Dutch Safety Board Act, a draft version (without recommendations) 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:

- The pilot in command and owner of PH-RED
- The passenger of PH-RED
- The owner of PH-VCY
- Relatives
- European Union Aviation Safety Agency
- National Transportation Safety Board
- Human Environment and Transport Inspectorate
- Ministry of Infrastructure and Water Management

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 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.
- Not adopted responses: the reason for this decision is explained in the table.
- Adopted responses; they are also listed in the table.



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