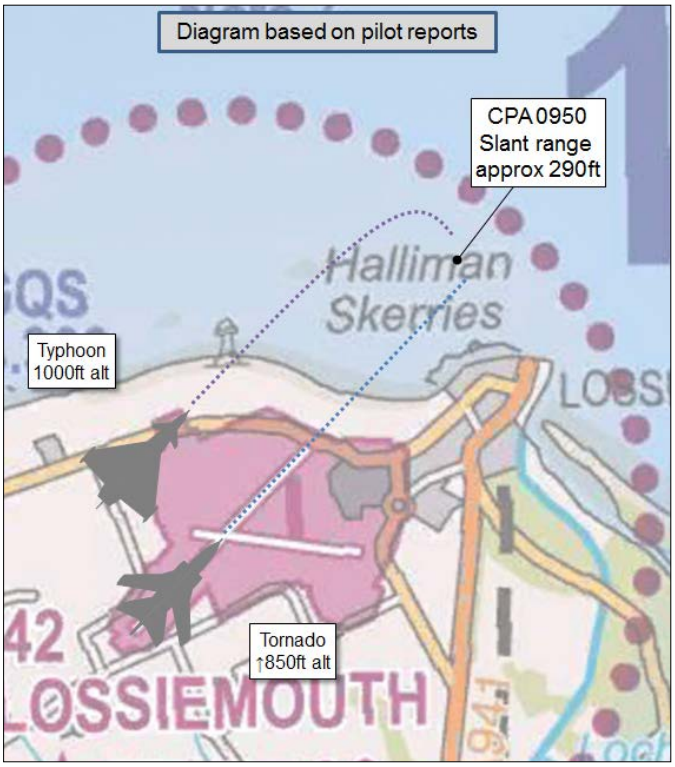
AIRPROX REPORT No 2016171

Date: 17 Aug 2016 Time: 0950Z Position: 5744N 00318W Location: Lossiemouth

PART A: SUMMARY OF INFORMATION REPORTED TO UKAB

Recorded	Aircraft 1	Aircraft 2
Aircraft	Tornado	Typhoon
Operator	HQ Air (Ops)	HQ Air (Ops)
Airspace	Lossiemouth ATZ	Lossiemouth ATZ
Class	G	G
Rules	IFR	VFR
Service	Aerodrome	Aerodrome
Provider	Lossiemouth	Lossiemouth
Altitude/FL	NK	NK
Transponder	A, C, S	A, C, S
Reported		
Colours	Grey	Grey
Lighting	Nav, Strobes	Nav, HISLs
Conditions	VMC	VMC
Visibility	>40km	25km
Altitude/FL	840ft	1000ft
Altimeter	QFE (1012hPa)	QFE (1012hPa)
Heading	45°	46°
Speed	275kt	290kt
ACAS/TAS	TCAS I	Not fitted
Alert	None	N/A
Separation		
Reported	200ft V	290ft (slant range taken from RAIDs)
Recorded	NK	



THE TORNADO PILOT reports that he was No4 in a formation of 4 Tornados. They were departing on SID05A in a stream of 2 pairs with 2 min separation between the pairs and 30 secs between each aircraft within the pair. The first pair departed and the second pair were given clearance to line-up and wait. At the same time he was aware that a formation of Typhoons were calling for a visual join. Take-off clearance was given, and the No3 aircraft rolled at 0949:20. At 0949:34 the Typhoon formation called initials, and at 0949:50 he commenced his take-off run. As he got airborne, the joining Typhoon formation lead called 'on the break' followed by the intentions of the other elements. At 0950:40 his Tornado pair switched frequency from tower to departures. At 0950:44 he was aware of a flash in his left 8 o'clock and he turned his head to see a Typhoon which was either canopy, or belly towards him and obviously reversing its turn away from him. At this point he was at 840ft and he stopped his climb to try and comprehend what was going on; the Typhoon stabilised into a fighting wing position[1] behind him before breaking behind into the circuit. After his pair checked in on the Departures frequency, he reported that a Typhoon had come close to him and was told that it was circuit traffic. There were no TCAS indications throughout, and even after the event he could not see the contact on TCAS.

He assessed the risk of collision as 'Medium'.

THE TYPHOON PILOT reports that he was recovering to Lossiemouth as the No4 in a formation of Typhoons. Upon initiating a gentle break in the 05RH circuit to route around Lossiemouth village (for noise abatement), he became aware of a Tornado climbing out and in close proximity on the inside of

[1] When flying in formation, fighting wing would be 2-300m behind the lead aircraft off-set to the left or right.

his turn. Assessment at the time was a separation of 300ft, with the Tornado behind and below. He immediately reversed the turn and climbed, rolling out to establish positive separation and then climbed to break into the circuit over the Tornado, whilst remaining visual. A more detailed description with timings taken from Rangeless Airborne Information Distribution System (RAIDS) follows: The formation had changed to Lossiemouth Tower at 11,000ft and were passing 10,000ft when the second Tornado pair were told to line-up and wait. The Typhoon formation was at 5000ft, 8nm from Lossiemouth, very wide downwind and positioning for initial when the Tornados were given clearance to take-off. At this point, although aware of the departing traffic, he believed that they would be well clear by the time the Typhoons reached the circuit. When the formation lead called initials, ATC responded with 'Roger', which backed up his assumption that the departing traffic was clear. Additionally an earlier flight of Tornados that they were unaware of were airborne and showing on the MIDS PPLIs [datalink system], clear of the circuit. His aircraft radar was in PASSIVE mode due to the proximity of the other members of the formation. There was limited opportunity for him to look for the Tornados due to being No4 of the formation in echelon for the run and break. The first 3 Typhoons broke starting from the runway threshold, but the No4 maintained straight-and-level at 300kts, slowly decelerating to 290kts over the deadside at 1000ft to avoid overflying Lossiemouth village. He cleared his flightpath right 2 to 3 o'clock before turning, but did not look back 4 to 5 o'clock (where the Tornado now was) until initiating the roll. The Tornados called switching frequency, a few seconds later he initiated the roll to the right (slant range on RAIDS was 500ft); 2 seconds later he reversed the turn and climbed (slant range was 410ft); 3 seconds later the pilot rolled out and checked separation (slant range 345ft). CPA occurred once the Typhoon pilot was visual and separating laterally and had started the climb with slant range at 290ft.

He assessed the risk of collision as 'Medium'.

THE LOSSIEMOUTH AERODROME CONTROLLER reports that the Tornado formation taxied, and when approaching the RW05 hold, the lead stated that the 4-ship would depart as two separate pairs, 2 minutes apart. This was acknowledged and squawks were passed, followed by a take-off clearance for the first pair. Moments later a formation of 4 Typhoons called to join the visual circuit. They were approximately 15nm SE of the airfield, and the joining clearance was given with circuit state clear. A few seconds later the Tornados were seen to be rolling on their respective streamed departure and the second pair called 'ready for departure'. They were told to hold, which they read back, then were given their respective squawks and frequencies for Hotspur. Once the first pair of Tornados were safely rolling and clear of the RW05 threshold, the second pair were given 'line-up and wait' which was read back correctly. By use of the ATM, he waited until there would be standard lateral IFR separation between the two pairs of Tornados and then gave the second Tornado pair take-off clearance and they commenced their streamed take-off runs. At the moment the take-off clearance was given, he could see on the ATM that the Typhoons were 7nm SW of the airfield and a few seconds later they called at the Initial point. The controller replied 'circuit clear' believing that the Typhoons would have situational awareness of the Tornados on the runway, having heard the 'line-up and wait' and take-off calls. Shortly afterwards the first Tornado started rolling, simultaneously the Typhoons broke into the visual circuit, albeit slightly off-set to the dead-side. The first three Typhoons seemed to break into the visual circuit between the RW05 threshold and Lossiemouth village, whilst it appeared that the 4th had opted to extend and break into the circuit after the village, possibly due to noise abatement; however, the controller didn't notice this at the time because he was concentrating on the first three. The Tornados then called switching to the Departures frequency and the Typhoons passed their respective intentions to low approach, land, low approach, and land.

He perceived the severity of the incident as 'Low'.

THE LOSSIEMOUTH SUPERVISOR reports that on reporting for duty that morning he was confronted with an issue about the serviceability of the main runway; a 'bubbling' effect had occurred overnight along a large portion of the edge of the runway. He went out to personally inspect it and assessed it as fit for Ops. He returned to the tower and fully briefed those concerned and implemented 2 hour runway inspections. The Typhoons were the first station-based aircraft to get airborne and, on their recovery, he ordered a runway inspection to determine if there had been any change. He was positioned in the ACR initially monitoring their recovery and the Tornados' departure

because there was a trainee in Departures. Shortly after the Typhoons called switching the Tower frequency he made his way up to the VCR. When he got there they had already been given clearance to join the circuit and the Tornados were at the hold. At this stage his priority was the state of the runway so he asked the VCR assistant for a report from the runway inspector. He listened on the airfield vehicle frequency to hear the response, which came back as no change, so he now switched to listening to the tower frequency. By this time the Typhoons had passed through initials and were beginning to break, he saw the first of the Tornados depart and so turned to watch the first of the Typhoons, who were now late downwind. Once all the aircraft had landed he made his way back to the ACR, where the Departures controller told him that one of the Tornado pilots had reported a Typhoon getting close behind him on climb-out. Nothing had been reported by the Typhoon pilot, so he assumed the pilot was visual with the Tornado and content with his spacing. He subsequently spoke to both pilots on the telephone and established that they were submitting DASORs.

Factual Background

The weather at Lossiemouth was recorded as follows:

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METAR EGQS 170950Z 08007KT 9999 FEW013 18/13 Q1014 BLU NOSIG=
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Portions of the tape transcript between Lossiemouth Tower, the Tornados and the Typhoons are below:

From	To	Narrative	Time
Tornado 3/4	ADC	Tower, {Tornado 3/4 c/s} ready for departure in turn	09:45.43
ADC	Tornado3/4	{Tornado 3/4 c/s} Lossie tower hold, and I've got your Hotspur details when ready	09:45.48
Tornado 3/4	ADC	Hold and go for {Tornado 3/4 c/s}	09:45.50
ADC	Tornado 3/4	{Tornado 3/4 c/s}squawk 5113 and 14. Tad is 035 and backup is 125.	09:45.54
Tornado 3/4	ADC	5113 ripple. 035 125 {Tornado 3/4 c/s}	09:46.03
Typhoon formation	ADC	Tower, good morning, {Typhoon c/s} join	09:47.11
ADC	Typhoon formation	{Typhoon c/s} Lossie tower join runway 05RH QFE 1012, circuit clear	09:47.15
Typhoon formation	ADC	05RH, 1012 {Typhoon c/s}	09:47.21
ADC	Tornado 3/4	{Tornado 3/4 c/s} line up and wait	09:47.25
Tornado 3/4	ADC	Line up and wait {Tornado 3/4 c/s}	09:47.28
Tornado 1/2	ADC	{Tornado 1/2 c/s} airborne stud 3	09:47.48
ADC	Tornado 1/2	{Tornado 1/2 c/s}	09:47.49
ADC	Tornado 3/4	{Tornado 3/4 c/s} clear for takeoff wind 080 8	09:48.36
Tornado 3/4	ADC	Takeoff {Tornado 3/4 c/s}	09:48.41
Typhoon formation	ADC	{Typhoon c/s} initials	09:49.34
ADC	Typhoon formation	{Typhoon c/s} roger	09:49.35
Typhoon formation	ADC	{Typhoon c/s} on the break 1 low approach, 2 to land, 3 low approach, 4 low approach	09:50.17
Tornado 3/4	ADC	{Tornado 3/4 c/s} stud 3	09:50.32
ADC	Tornado 3/4	{Tornado 3/4 c/s} roger, break, {Typhoon c/s} roger, wind 080/9	09:50.33

The radar replay shows the Typhoons approaching the airfield and the Tornados departing; however, the radar coverage is such that the aircraft do not show on radar at the point of confliction.

Analysis and Investigation

Military ATM

The incident involved Typhoon No4, who was the final aircraft in a 4 ship joining via initials, initiating his break, and Tornado No4, on departure. The Typhoon, in extending upwind on the deadside to adhere to noise abatement procedures and then initiating his break, came into conflict with the Tornado climbing out after take-off, reducing separation to 286ft.

Investigation of the circuit direction for RW05 revealed that historically it had been a left-hand circuit but, due to the introduction of Typhoon and efforts for standardisation of circuit patterns at Lossiemouth, the direction was changed to a right-hand circuit. This change introduced the noise abatement requirement over Lossiemouth town. During a 4 aircraft break, it is not possible for all aircraft to break before the town and so the aircraft that extend for noise abatement over Lossiemouth town are required to break further upwind and across the climb out lane. The OSI identified that extending upwind on the deadside before initiating his break was the cause of the incident; work is on-going to review circuit patterns at RAF Lossiemouth.

Whilst an Aerodrome Controller (ADC) is required to pass information concerning circuit traffic, the provision of further information is at the discretion of the controller; Regulatory Articles and higher level documents offer a degree of latitude that allows controllers to pass any further information that they deem relevant, at any point in time and at any particular stage of flight. The Occurrence Safety Investigation (OSI) team was unable to find a definition of "circuit traffic"; all those controllers consulted as part of the routine and substitution tests stated that they did not consider aircraft on the runway for departure to be "circuit traffic"; however, all controllers consulted, including BM STANEVAL staff, stated that they would call aircraft on the runway for departure to aircraft joining through Initials, in reply to the "initials" call, if they considered it to be relevant, iaw CAP413. Some also stated that they would call the departing traffic in all cases. Whilst not mandated in any publications, those consulted considered this to have formed part of their initial and continuing ATC trg; the OSI Team viewed current ATC training documents and found them to be consistent with these beliefs. RA3261 - Aerodrome Service states that an Aerodrome Service should provide "Specific Traffic Information appropriate to the stage of flight and risk of collision". It also enables units to produce orders to "detail local procedures for the integration of Air systems (AS) in the vicinity of the Aerodrome".

The OSI describes the situational awareness of the Typhoon pilot as they joined the circuit and how their mental picture was that the pair of Tornados that they had seen departing were those they heard on frequency. Without being able to ascertain why the Typhoon pilot's situational awareness remained as such whilst further calls were made from the controller to Tornado 3/4 (including a take-off clearance), it is difficult to take the investigation to suitable depth without making assumptions. Not knowing if the controller's transmissions were heard or assimilated by the Typhoon pilot is a key part of this.

A significant amount of work was conducted by the OSI team into the causal factors and produced 5 recommendations for the Occurrence Review Group (ORG). The prime recommendation from the ORG for ATC was to 'establish a RAF Lossiemouth ATC local order mandating that the ADC call all traffic on the runway for departure to aircraft calling at Initial'. BM Safety consider this to be an excellent recommendation; however, if this information is not heard or assimilated by the joining pilot, then with similar circumstances there is potential for this to happen again.

Lookout from the Typhoon pilot and the subsequent avoiding action were effective in preventing a collision; however safe separation was greatly reduced. TCAS was an ineffective barrier as it failed to operate against the Typhoon.

UKAB Secretariat

The Tornado and Typhoon pilots shared an equal responsibility for collision avoidance and not to operate in such proximity to other aircraft as to create a collision hazard[2]. An aircraft operated on or in the vicinity of an aerodrome shall conform with or avoid the pattern of traffic formed by other aircraft in operation[3].

Occurrence Investigation

RAF Lossiemouth conducted a thorough and detailed OSI and identified a number of observations and recommendations. The OSI established that the situational awareness of the Typhoon pilot was that the Tornados had already departed the circuit, this was also the opinion of the rest of the Typhoon formation. RAIDs indicated that the Typhoon passed the Tornado with a lateral separation of 2-300ft and it was likely that the Typhoon's fuselage and foreplane was obscuring the pilot's view of the Tornado.

The OSI also looked at why the Tornado's TCAS did not alert. Noting that the aircraft got airborne at 0950:20, the TCAS documentation states that there is a warm-up period of 10 seconds prior to any information being given. Therefore TCAS should have been available from 0950:30, with audio traffic advisory warning available from 0950:35 once the Tornado had passed 500ft, this was approximately 6 seconds before the Typhoon commenced his break. However, anecdotal evidence from Tornado GR aircrew revealed a variation in TCAS warm-up times across the fleet and was thought to be a possible explanation as to the lack of TCAS indications.

Comments

HQ Air Command

This incident was the subject of a thorough safety investigation at the unit. A number of barriers were either breached or weakened which all contributed in some way to the 2 aircraft coming into proximity. Historically, the visual circuit at RAF Lossiemouth was a left-hand circuit – this was changed to a right-hand circuit for noise abatement reasons but the second-order effects of this are that it is not possible for all the aircraft in a recovering 4-ship to break prior to the southern extent of Lossiemouth town, forcing at least one aircraft to delay the break to avoid overflight of the built up area. This places that aircraft in direct conflict with departing traffic.

It cannot be absolutely ascertained whether or not the Typhoon was squawking but, given that a valid transponder return was detected until approximately 1 minute prior to CPA and that a 4-ship echelon recovery demands a high degree of attention from the pilot, it is considered extremely unlikely that that pilot changed his transponder settings. The warm-up period for TCAS appears to be variable, so that may well explain why there was no alert to the Tornado crew of the Typhoon's presence. A number of recommendations have already been made and enacted, including a reversion of the circuit direction on RW05 to left-hand and a more descriptive 'warn-out' procedure stating departure intentions in detail.

This incident shows, once again, that clearance of own flight path is an essential barrier to MAC and this is what ultimately saved the day.

Summary

An Airprox was reported when a Tornado and a Typhoon flew into proximity at 0950 on Wednesday 17th August 2016. Both pilots were operating under VFR in VMC, and both were in receipt of an Aerodrome Service from Lossiemouth ADC.

[2] SERA.3205 Proximity.
[3] SERA.3225 Operation on and in the Vicinity of an Aerodrome.

PART B: SUMMARY OF THE BOARD'S DISCUSSIONS

Information available consisted of reports from the pilots of both aircraft, transcripts of the relevant RT frequencies, radar photographs/video recordings, reports from the air traffic controllers involved and reports from the appropriate ATC and operating authorities.

The Board first discussed the actions of the Tornado pilot. They quickly agreed that there was very little that he could or should have done differently in the circumstances; essentially, he would have assumed that the Typhoons knew he was there from his RT calls, and would not have expected one to break beside him. The Board were mystified also as to why his TCAS had not worked in this instance, but thought that the conclusions of the OSI report were probably correct, the TCAS had simply not warmed up in time. Some members with Tornado experience also opined that the crew would have had a fairly high cockpit workload at this time in getting airborne, changing frequency and sequencing their route with their lead aircraft, and so even if TCAS had given a visual alert, they may not have seen it anyway.

Turning to the actions of the Typhoon pilot. The Board reflected on why the Typhoon formation, and the No4 pilot specifically, had not realised that the Tornados were on the runway for departure as they broke into the circuit. Fundamentally, it was for the Typhoons to integrate with the departing Tornado traffic and the Typhoon leader was responsible for positioning his formation for the break accordingly. Acknowledging that the controller had not passed traffic information on the Tornados in any of joining calls, members thought that nevertheless it should have been apparent from their RT calls that the Tornados were on the runway and departing. That being said, the Typhoon pilots could not have known that the Tornado pair was conducting a stream 30sec departure because that was not readily apparent from the radio calls. The Board also noted that the controller had reported to the Typhoon formation on their initial call that the circuit was clear; given that the 2 Tornado pairs were in the process of conducting their stream departure at this point, many members commented that this would have been pertinent information to relay to the Typhoons so that they could plan their recovery and break. In the absence of any further information to the Typhoon formation at the 'initials' call (when the Tornado rear pair were now actually occupying the active runway) the Board thought it entirely understandable that the No4 Typhoon pilot might not have known that the Tornado pair would be departing in 30sec stream rather than as a single unit, and that there was therefore a likely confliction as he extended around Lossiemouth village at 1000ft through the departures lane. Notwithstanding, the Board recognised that it was for the Typhoon No4 pilot to ensure that he integrated with other aircraft in the circuit area, and that this required him to clear his own flight path visually before he manoeuvred for the break.

The Board then looked at the actions of the aerodrome controller, although the OSI found that in a substitution test many other controllers at Lossiemouth would also not have given Traffic Information of an aircraft on the runway for departure to joining aircraft, controller members were unanimous that it should have been called. Pilot members were completely astonished that there was not a standard procedure that aircraft occupying the runway should be called to joining formations at their initials call. ATC advisors noted that although CAP 413 identifies the circumstances in which circuit information should be passed, it is generic in nature, and controller members were adamant that every example of phraseology could not be written down - controllers were expected to use their judgement as to what was pertinent information. Nevertheless, the controller members were in agreement that an aircraft occupying the runway and cleared for take-off was pertinent information that should have been passed to aircraft joining through initials. Members wondered whether this was a specific training problem at RAF Lossiemouth in that controllers were not being taught to do this. In this respect, the Board noted that the requirement to pass Traffic Information in these circumstances had now been added to local orders.

In looking at the mid-air collision barriers pertinent to this incident, the Board assessed that the following were key contributory factors:

- **Airspace Design and Procedures** were **ineffective** because the circuit direction at Lossiemouth required extended breaks to be conducted for larger formations, which introduced a conflict with aircraft departing.

- **ATC conflict and detection** was not effective because the controller did not pass Traffic Information on the Tornado departure details to the Typhoons.

- **Flight Crew Compliance with ATC Instructions** was only **partially effective**, because ATC had not given specific Traffic Information and so instructions and/or procedures pertinent to the scenario were only partially available or were generic only.

- **Flight Crew Situational Awareness** was **ineffective** because the Typhoon No4 pilot did not know the Tornado No4 was getting airborne and departing into conflict.

- **TCAS** was **ineffective**, probably due to the Tornado system's warm-up time.

- **See and Avoid** was **partially effective**; the Typhoon pilot saw the Tornado and managed to take avoiding action, albeit late.

In determining the cause of the incident, the Board agreed that, ultimately, the Typhoon pilot had not integrated effectively with the Tornado. Contributory factors were that an extended break point had been required to avoid the Lossiemouth village, and that ATC did not inform the Typhoons about the departing Tornados on the runway. Turning to the risk, the Board noted the dynamic nature of the incident, the reducing slant range between the 2 aircraft up to CPA, and the very late sighting and manoeuvre by the Typhoon pilot. Taking all these into account, the risk was assessed as Category B, safety margins had been much reduced below the norm.

The Board were informed that the circuit pattern for RW05 was previously left-hand but had been changed with the introduction of the Typhoon to right-hand for noise abatement – this had introduced the need to extend the break for larger formations which, in this case, meant that the No4 did not have the space to break into the circuit before Lossiemouth village. The Board were heartened to hear from the military members that the circuit direction had now reverted again to a left-hand circuit so that extended breaks crossing the departures lane at the same height should be less likely.

PART C: ASSESSMENT OF CAUSE AND RISK

Cause: The Typhoon pilot did not integrate effectively with the departing Tornado.

Contributory Factors: 1. The extended break of the Typhoon around Lossiemouth village.

2. ATC did not inform the Typhoon formation of the departing Tornados on the runway.

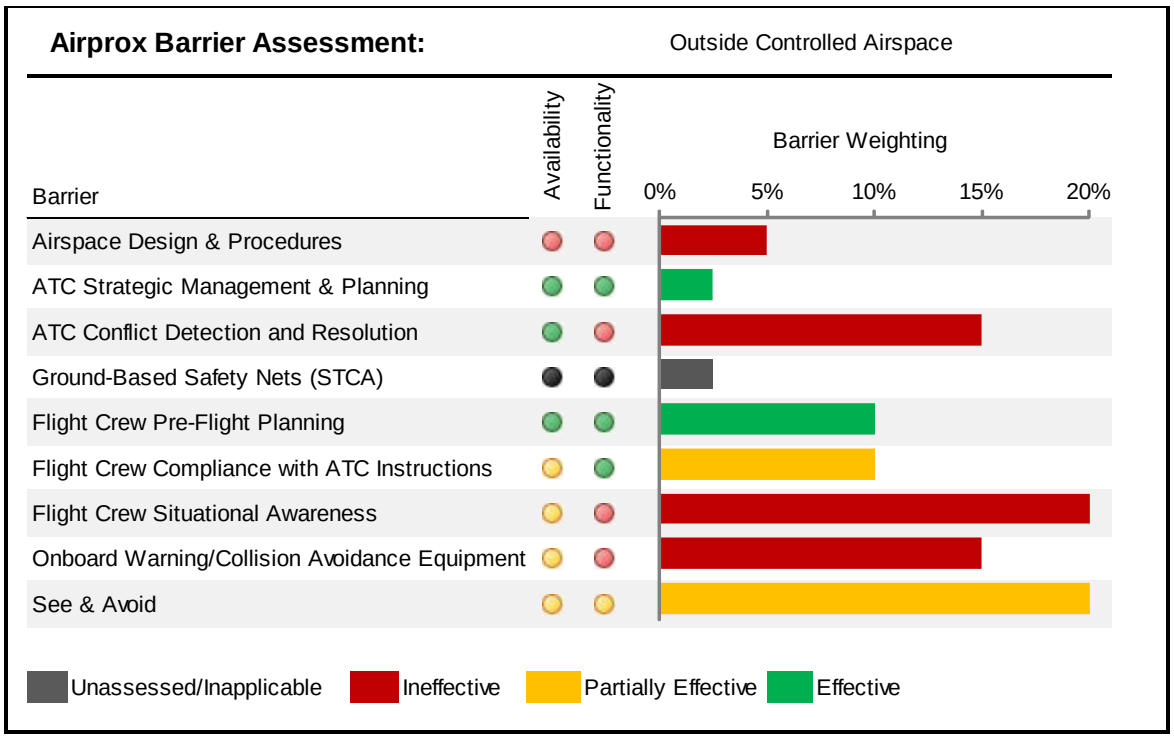
Degree of Risk: B.

Barrier assessment:

Modern safety management processes employ the concept of safety barriers that prevent contributory factors or human errors from developing into accidents. Based on work by EASA, CAA, MAA and UKAB, the following table depicts the barriers associated with preventing mid-air-collisions. The length of each bar represents the barrier's weighting or importance (out of a total of 100%) for the type of airspace in which the Airprox occurred (i.e. Controlled Airspace or Uncontrolled Airspace).[4] The colour of each bar represents the Board's assessment of the effectiveness of the associated barrier in this incident (either Fully Effective, Partially Effective, Ineffective, or

[4] Barrier weighting is subjective and is based on the judgement of a subject matter expert panel of aviators and air traffic controllers who conducted a workshop for the UKAB and CAA on barrier weighting in each designation of airspace.

Unassessed/Inapplicable). The chart thus illustrates which barriers were effective and how important they were in contributing to collision avoidance in this incident.



Barrier Effectiveness		Consequence		
		Non-functional	Partially Functional	Functional
Availability		**1**	**2**	**3**
Completely Unavailable	**1**	1	2	3
Partially Available	**2**	2	4	6
Available	**3**	3	6	9

Key:

Effective

Partially Effective (If the system was partially available but fully functional score availability as 2.5)

Ineffective

Unassessed/Inapplicable

Barrier	Availability			Functionality			Unassessed / Inapplicable
	Fully (3)	Partially (2)	Not Available (1)	Fully (3)	Partially (2)	Non Functional (1)	
Airspace Design and Procedures	Appropriate airspace design and/or procedures were available	Airspace design and/or procedures were lacking in some respects	Airspace design and/or procedures were not appropriate	Airspace design and procedures functioned as intended	Airspace design and/or procedures did not function as intended in some respects	Airspace design and/or procedures did not function as intended	The Board either did not have sufficient information to assess the barrier or the barrier did not apply; e.g. ATC Service not utilised. Note: The Board may comment on the benefits of this barrier if it had been available
ATC Strategic Management and Planning	ATM were able to man and forward plan to fully anticipate the specific scenario	ATM were only able to man or forward plan on a generic basis	ATM were not realistically able to man for or anticipate the scenario	ATM planning and manning functioned as intended	ATM planning and manning resulted in a reduction in overall capacity (e.g. bandboxed sectors during peak times)	ATM planning and manning were not effective	
ATC Conflict Detection and Resolution	ATS had fully serviceable equipment to provide full capability	ATS had a reduction in serviceable equipment that resulted in a minor loss of capability	ATS had a reduction in serviceable equipment that resulted in a major loss of capability	The controller recognised and dealt with the confliction in a timely and effective manner	The controller recognised the conflict but only partially resolved the situation	The controller was not aware of the conflict or his actions did not resolve the situation	
Ground-Based Safety Nets (STCA)	Appropriate electronic warning systems were available	Electronic warning systems is not optimally configured (e.g. too few/many alerts)	No electronic warning systems were available	Electronic warning systems functioned as intended, including outside alerting parameters, and actions were appropriate	Electronic warning systems functioned as intended but actions were not optimal	Electronic warning systems did not function as intended or information was not acted upon	
Flight Crew Pre-Flight Planning	Appropriate pre-flight operational management and planning facilities were deemed available	Limited or rudimentary pre-flight operational management and planning facilities were deemed available	Pre-flight operational management and planning facilities were not deemed available	Pre-flight preparation and planning were deemed comprehensive and appropriate	Pre-flight preparation and/or planning were deemed lacking in some respects	Pre-flight preparation and/or planning were deemed either absent or inadequate	
Flight Crew Compliance with Instructions	Specific instructions and/or procedures pertinent to the scenario were fully available	Instructions and/or procedures pertinent to the scenario were only partially available or were generic only	Instructions and/or procedures pertinent to the scenario were not available	Flight crew complied fully with ATC instructions and procedures in a timely and effective manner	Flight crew complied later than desirable or partially with ATC instructions and/or procedures	Flight crew did not comply with ATC instructions and/or procedures	
Flight Crew Situational Awareness	Specific situational awareness from either external or onboard systems was available	Only generic situational awareness was available to the Flight Crew	No systems were present to provide the Flight Crew with situational awareness relevant to the scenario	Flight Crew had appropriate awareness of specific aircraft and/or airspace in their vicinity	Flight Crew had awareness of general aircraft and/or airspace in their vicinity	Flight Crew were unaware of aircraft and/or airspace in their vicinity	
Onboard Warning/Collision Avoidance Equipment	Both aircraft were equipped with ACAS/TAS systems that were selected and serviceable	One aircraft was equipped with ACAS/TAS that was selected and serviceable and able to detect the other aircraft	Neither aircraft were fitted with ACAS/TAS or their systems were not selected on or unserviceable or systems incompatible	Equipment functioned correctly and at least one Flight Crew acted appropriately in a timely and effective manner	ACAS/TAS alerted late/ambiguously or Flight Crew delayed acting until closer than desirable	ACAS/TAS did not alert as expected, or Flight Crew did not act appropriately or at all	
See and Avoid	Both pilots were able to see the other aircraft (e.g. both clear of cloud)	One pilots visibility was uninhibited, one pilots visibility was impaired (e.g. one in cloud one clear of cloud)	Both aircraft were unable to see the other aircraft (e.g. both in cloud)	At least one pilot takes timely action/inaction	Both pilots or one pilot sees the other late and one or both are only able to take emergency avoiding action	Neither pilot sees each other in time to take action that materially affects the outcome (i.e. the non-sighting scenario)	