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Swiss Transportation Safety Investigation Board STSB

Summary Report

A summary investigation, in accordance with Article 45 of the Ordinance on the Safety Investigation of Transport Incidents from 17 December 2014 (OSITI), as amended 1 February 2015 (SR 742.161), was carried out with regards to the following serious incident. This report was prepared to ensure that lessons can be learned from the incident in question.

Location	Stadlerberg (ZH); extension of runway 14 centreline at a distance 5 NM from the landing runway threshold		
Coordinates	676 330 / 265 950 (Swiss Grid 1903) N 47° 32' 23'' / E 008° 27' 09'' (WGS[1] 84)	**Altitude**	approx. 3000 ft AMSL[2]
Date and time	29 September 2018, 16:57 UTC (LT = UTC + 2 h)		

Type of serious incident	Near miss
Air traffic control	Final approach control (Zurich Final)
Airspace	Control Zone (CTR) Zürich, class D airspace
Closest point of approach	0 m horizontal, approx. 10 m vertical
Prescribed minimum separation	3.0 NM between IFR[3]/IFR traffic, none between IFR/VFR[4] and VFR/VFR
Airprox category	ICAO[5] Category A

Aircraft 1	Airbus A319	HB-IPT
Owner	Wells Fargo Bank Northwest, National Association, 299 South Main Street, 5th Floor, Salt Lake City, UT 84111, USA	
Operator	Swiss International Air Lines Ltd., Malzgasse 15, 4052 Basel, Switzerland	
Relevant equipment	Traffic Alert and Collision Avoidance System (TCAS)	

Type of operation	Commercial flight
Flight rules	IFR
Departure airport	Berlin Tegel airport (EDDT)
Destination airport	Zürich airport (LSZH)
Flight phase	Approach

[1] WGS: World Geodetic System The WGS 84 standard was adopted for aviation by the International Civil Aviation Organization – ICAO in 1989.

[2] AMSL: Above Mean Sea Level

[3] IFR: Instrument Flight Rules

[4] VFR: Visual Flight Rules

[5] ICAO: International Civil Aviation Organization

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Commander	German national, born 1980			
Licence	Airline Transport Pilot Licence Aeroplane (ATPL(A)) according to the European Aviation Safety Agency (EASA), issued by the Federal Office of Civil Aviation (FOCA)			
Flying hours	**Total**	7738 h	**during the last 90 days**	250:27 h
	on the aircraft type	1968 h	**during the last 90 days**	250:27 h
First Officer	German national, born 1985			
Licence	ATPL(A) according to EASA, issued by the FOCA			
Flying hours	**Total**	2715 h	**during the last 90 days**	205 h
	on the aircraft type	2500 h	**during the last 90 days**	205 h
Aircraft 2	Drone		no registration	

Factual information

History of the serious incident

An Airbus A319 commercial aircraft, registration HB-IPT, was on its final approach on the runway 14 Instrument Landing System (ILS) at Zurich airport (LSZH) after an uneventful flight with flight number LX 981 from Berlin Tegel airport (EDDT). 5 crew members and 103 passengers were on board the aircraft. At a distance of approximately 5 NM from the threshold of runway 14, which corresponds approximately to a position over the Stadlerberg, and at an altitude of approximately 3000 ft AMSL, the First Officer established visual contact with an object in the flight direction which initially resembled a gathering of three birds. On closer approach the flight crew realised that it was a large silver-coloured drone, which in their view was significantly larger than drones which are generally commercially available. Due to the high closing speed, the flight crew had no time to change the aircraft heading to avoid a collision. The drone was an estimated distance of approximately 10 m above the A319 as the latter passed below. The flight crew reported this immediately in English language to the air traffic controller, stating that the A319 had almost struck the drone. The air traffic controller immediately informed the flight crew of the subsequent aircraft on approach on ILS 14. However, this aircraft was unable to establish visual contact with the drone when overflying the Stadlerberg approximately 2 minutes later.

Despite the airport authority and local police being informed immediately, neither the drone nor its pilot could be traced.

Meteorological information

At the time of the dangerous proximity, the north of Switzerland was experiencing extensive cloud cover with a thickness of just under 100 m with a cloud base at approximately 4900 ft AMSL. The visibility below the cloud base was some 20 km. The wind speed was 14 knots from the north-east. These conditions are known locally as a typical Bise with high fog clouds.

Drone incidents in the airspace around Zurich

Reports of dangerous proximity incidents involving aircraft and drones in controlled airspace around Zurich airport have been increasing steadily for quite some time. Some of the incidents involving drones in the vicinity of Zurich airport reported to the Swiss Transportation Safety Investigation Board (STSB) in 2018 are described below (cf. also Figure 1):

- On 28 June 2018 at 16:30 an Embraer ERJ-190 commercial aircraft with flight number 2L 8645 was approaching Zurich after a flight from Nischni Nowgorod (UWGG). As the aircraft was aligned with the ILS 14 at a distance of some 4 NM from the threshold of runway 14, the cockpit crew saw what they thought was a bird at the same altitude and to

the left of the direction of flight. As they continued to close, the crew realised that it was unmistakably a drone. The quadrocopter[6] drone flew very close alongside on the left and passed slightly below the ERJ-190.

- On 22 August 2018 at 09:50 an Airbus A321 commercial aircraft took off from runway 16 at Zurich bound for Malaga (LEMG) with flight number LX 2110. Shortly after lift-off the crew established visual contact with a drone at the same altitude at an estimated 50 m to the right of the aircraft. The crew assessed the risk of collision as high. The A321 was at that time climbing between the end of runway 16 and the municipality of Glattbrugg at an altitude of 2500 ft AMSL.
- On 6 October 2018 at 10:30 an Airbus A220 commercial aircraft was approaching Zurich on flight number LX 915 from Dresden (EDDC). After the A220 was aligned on the Localizer (LOC) centreline of runway 14, the cockpit crew established visual contact with a stationary drone flying to the right at an estimated distance of 100 m at the same altitude. The A220 was at that time at an altitude of approximately 4000 ft AMSL to the east of Tiengen in Germany, at a distance of approximately 12 NM from the threshold of runway 14.
- On 18 November 2018 an Airbus A340-300 commercial aircraft was flying towards the runway 14 ILS at Zurich on flight number LX 161 after a long-haul flight from Narita (RJAA). When lining up on the LOC 14 centreline at a distance of 11 NM from the threshold of runway 14, at 14:15 the three-man cockpit crew identified a quadrocopter drone, which flew past the A340 to the right at the same altitude of approximately 4500 ft AMSL and at a horizontal distance of approximately 50 m.
- On 7 December 2018 a member of the flight crew of a Boeing B777 on flight number LX 93 returning from Sao Paulo (SBGR) on the final approach to runway 28 at Zurich at 11:30 established visual contact with a white drone. At that time the B777 was only approximately 5 NM from the threshold of runway 28 at an altitude of approximately 3000 ft AMSL. The closest point of approach with the drone, which was flying slightly below the B777, was estimated by the flight crew member as 300 to 500 m.

All the above near-misses or dangerous proximity incidents between a commercial aircraft and a drone took place in controlled airspace, either in the Zurich CTR or the Zurich Terminal Control Area (TMA).

Collisions between manned aircraft and drones

Several collisions involving manned aircraft and drones worldwide have already been reported to date.

- On 21 September 2017 an American military UH-60M helicopter collided with a DJI Phantom 4 drone. A main rotor blade and some plastic panels of the helicopter were slightly damaged. Various components of the destroyed drone remained embedded in the plastic panels of the helicopter. Although the flight crew of the UH-60M were able to establish visual contact with the drone before the collision, there was not enough time for evasive action. The American investigation authorities published an investigation report into the serious incident (NTSB DCA17IA202B).
- On 15 October 2017 a Beechcraft King Air twin-engined business aircraft with 8 people on board on approach to Quebec Airport, Canada (SYQB) collided with a plate-sized drone. The aircraft was slightly damaged. Although the flight crew were able to establish visual contact with the drone before the collision, there was not enough time for evasive action. The Canadian investigation authorities published an investigation report into the serious incident (TSB A17Q0162).

[6] A quadrocopter has four rotors or propellers acting vertically downwards to generate lift and also forward motion by tilting the rotor planes.

- On 14 August 2018 a Robinson R44 helicopter on a spraying mission near the city of Petah-Tiqwa in Israel collided with a DJI Phantom 4 drone. The drone was trapped in the helicopter's spray system, which is located below the helicopter and which remained undamaged. The helicopter pilot recognized the drone only shortly before it hit the helicopter at a distance of about 10 m. The Israeli investigating authority published an investigation report into the serious incident (Israel Ministry of Transport No. 81-18).

To date the STSB has recorded two collision incidents in Switzerland involving manned aircraft and drones.

- On 9 March 2018 damage to the starboard inner slat of an Airbus A340 commercial aircraft was discovered after landing in Zurich (LSZH), the pattern of which was consistent with a collision with an unidentified flying object. A forensic examination revealed the presence in the dented slat of plastic particles of the type used in drones. The possibility of a bird strike could be ruled out.
- On 25 May 2018 a Guimbal Cabri G2 helicopter collided with a drone above the Valle Versasca, damaging the main rotor. The pilot was able to land the helicopter subsequently at Locarno Airport (LSZL). The STSB published a summary report on this accident.

Studies on drones

As a consequence of the rapid increase in drone numbers worldwide for both commercial and private use, international aviation authorities feel compelled to lay down new conditions for the operation of drones. It has been estimated that in Europe alone, a total of some 400,000 drones will be flown for commercial purposes by 2050 (today 10,000), with another approximately 7 million for private use (today approximately 1.5 million). The American Federal Aviation Administration (FAA) assumes that the number of commercial drones in the USA will increase tenfold to a total of approximately 500,000 in the next 3 years.

Studies have shown that establishing visual contact with a drone from the cockpit of an aircraft is very difficult, especially in view of the small size of the drone. In tests, pilots of single-engined aircraft have only established visual contact with a drone at a very late stage, despite knowing its position. At that stage, pilots only had a few seconds for any possible evasive action.

In 2017 several American universities conducted a study in conjunction with the FAA to evaluate the severity of a collision between an aircraft and a drone (ASSURE[7] UAS[8] Airborne Collision Severity Evaluation). Numerical simulations were used to determine the damage caused to various parts of an aircraft by a colliding drone, for example the windscreen, engines or leading edges of the wings or tail unit. The following conclusions could be drawn:

- The relative speed between the aircraft and the drone and also the mass of the drone were both identified as key factors affecting the severity of a collision. A collision with a drone having a mass of 1.2 kg at low flight speeds of 100 knots, such as is attained on final approach with many aircraft types, is sufficient to cause permanent deformation of parts of the aircraft. At speeds approaching 250 knots, parts of the drone can penetrate the outer skin of the aircraft and parts of the aircraft primary structure can fail.
- Compared to a bird strike, the extent of the damage caused by a drone of the same mass is significantly larger. Since a bird body behaves similarly to a viscous fluid in a high-speed impact, its density is the sole governing parameter for the extent of the damage to the target structure. Drones, on the other hand, possess high structural stiffness due to the combination of their structural geometry and the hard materials often used, such as metals and fibre-reinforced composites. This stiffness determines and therefore increases the degree of damage to the target structure.

[7] ASSURE: Alliance for System Safety of UAS through Research Excellence

[8] UAS: Unmanned Aerial System

- The study concluded by finding that in several of the impact scenarios examined involving drones weighing 1.2 or 1.8 kg respectively and a commercial or business aircraft, there was a danger of parts of the aircraft primary structure failing.

Operation of drones in Switzerland

The operation of drones is regulated in the Ordinance on Special Category Aircraft (OSCA) 748.941[9]. Drones with a weight of more than 30 kg always require a special licence from the FOCA. For lighter drones with a weight between 0.5 and 30 kg, operation is subject to the following restrictions, among others:

- No operation within a radius of 5 km of civil and military aerodromes and heliports[10];
- Maximum height of 150 m above ground inside a Control Zone (CTR);
- Operation only with direct visual contact with the drone.

The airspace structure around Zurich airport and the associated restrictions on the operation of drones are shown in Figure 1.

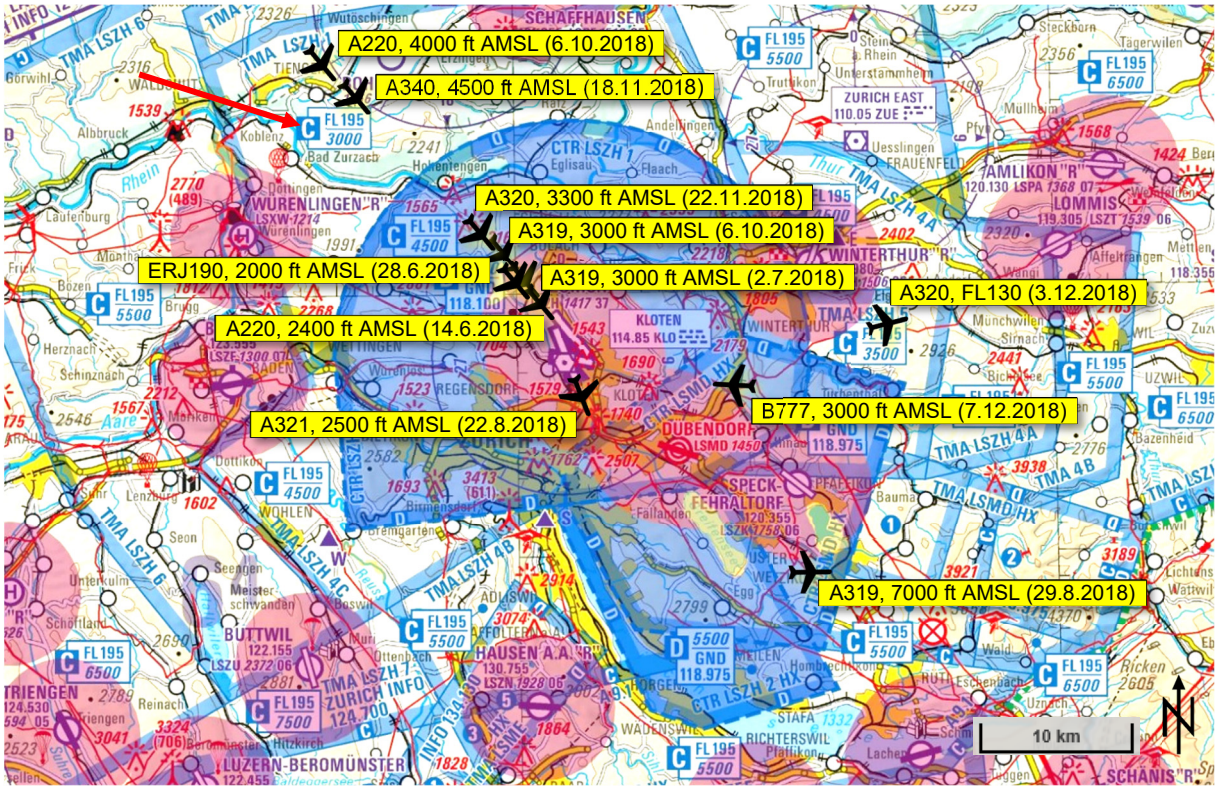

Figure 1: Geographical positions of eleven of the dangerous proximity incidents reported to the STSB in 2018 in the Zurich area (aircraft type, altitude, date) entered on the aeronautical chart of Switzerland, with the restricted areas for drones superimposed: Zones within a radius of 5 km around aerodromes (red circular areas) and CTR Zurich (blue areas). The TMA Zurich sectors are shown as blue shaded lines with their upper and lower limits (e.g. TMA Sector 1, red arrow). Source of the base map: Swiss Federal Office of Topography.

[9] Drones up to a weight of 30 kg can be assigned to the "unmanned aircraft up to 30 kg" category described in section 7 of the OSCA.

[10] The radii around aerodromes and heliports and other restrictions are shown in the interactive drone map of Switzerland.

Analysis

Despite good visibility, the flight crew of the Airbus A319 did not detect the drone until a late stage, so no evasive action was possible. This confirms what corresponding studies have also found, namely that establishing visual contact with a drone is very difficult even with models of larger dimensions, particularly at high closing speeds. It can be concluded from this that the "see and avoid" principle is fundamentally impracticable for collision avoidance. In the present case the drone was flying at an altitude typically adopted by aircraft on their final approach to runway 14 at Zurich. A proximity hazard incident resulted. Since the drone was not fitted with a transponder and therefore did not appear on either the Traffic Alert and Collision Avoidance System (TCAS) of the A319 nor on the radar screens of air traffic control, detection and avoidance in good time was not possible.

However, airspaces exist in which both manned aircraft and drones may be present simultaneously; partly in airspaces in which clearance by air traffic control is necessary, for example in a TMA. The two aircraft proximity hazards to the north-west of Zurich airport along the ILS 14 centreline in the region of Tiengen (cf. Figure 1, 06/10/2018 and 18/11/2018) occurred in Sector 1 of the Zurich TMA, which is classed as Class C airspace and has a base of 3000 ft AMSL. Drone flying at this location was permitted under the valid legislatory provisions, provided that the drone operation took place with direct visual contact with the drone in accordance with the OSCA. This condition represented a natural limit to operations at the time, since the attitude and flight path of model aircraft have to be controlled directly by pilots and the pilot of a model aircraft must be able to detect the attitude of a model aircraft visually in order to do this. However, due to the stability systems available today which are widely used in drones, this requirement ceases to apply and consequently neither does the associated spatial limitation.

The TMAs are not shown on the interactive drone map of Switzerland. The operation of drones in these airspaces is therefore not excluded (see Figure 1).

The sole method of avoiding collisions between manned aircraft and drones in these airspaces at the moment is the see-and-avoid principle. Due to the difficulties described in the above section, only drone pilots have the possibility of directly influencing the collision risk. They can select areas for flying where no aircraft are expected, or steer the drone away when an aircraft is sighted approaching the drone flying area. In conjunction with Zurich Airport, the Zurich cantonal police and Skyguide, the FOCA is drawing the attention of all drone operators to this danger with the "Don't fly drones near airports!" publicity campaign in all the Swiss national languages *("In der Nähe von Flugplätzen fliege ich meine Drohne nicht! ")*. A technology based on "detect and avoid" for early detection of drones is the objective for reducing the probability of a collision with a drone.

The report by the flight crew of the A319 to the air traffic controller in English about the proximity hazard incident with the drone was safety conscious. It made the crews of other aircraft listening in on the approach frequency aware of the drone and allowed the air traffic controller to warn other approaching aircraft about the drone.

Manned aircraft must currently only comply with appropriate design regulations regarding bird strikes. A collision with a drone is not comparable with a bird strike, as the study referred to above shows. Even at low relative speeds, drones of low mass can inflict significantly greater damage on the aircraft structure, engines or windscreen of an aircraft, not least due to the mass concentrations resulting from the design.

Conclusions

The extent of the damage caused to an aircraft by a collision with a drone can be significant. Due to the lack of implemented "detect and avoid" technologies, collision avoidance is currently only possible by means of visual identification, primarily by the drone pilot. This presents a major safety hazard.

Aviation supervisory authorities, airport operators, air traffic control authorities, airlines, police authorities and aircraft and drone manufacturers internationally are aware of the problem. As a result, efforts are under way throughout the world to develop and implement collision-reduction technologies in drones and to adapt regulations for their operation. In Switzerland the FOCA has undertaken a risk analysis together with the operators of national airports, the Skyguide air navigation services provider and airlines and is already working on corresponding measures.

For this reason, the STSB is refraining from further investigations and closing this investigation with this summary report, in accordance with Article 45(1) of the OSITI.

The definitive version of this report is the original in the German language.

Bern, 21 August 2020 Swiss Transportation Safety Investigation Board