CHAPTER 10

Appendix: Extracts from the Warsaw Accident Report

From Subsection 1.1: History of the Flight

DLH 2904 flight from Frankfurt to Warsaw progressed normally until Warsaw Okecie TWR [the airport designation is EPWA] warned the crew that windshear exists on approach to RWY 11, as reported by DLH 5764, that had just landed. According to Flight Manual instructions PF used increased approach speed and with this speed touched down on RWY 11 in Okecie aerodrome. Very light touch of the runway surface with the landing gear and lack of compression of the left landing gear leg to the extent understood by the aircraft computer as the actual landing resulted in delayed deployment of spoilers and thrust reversers. Delay was about 9 seconds. Thus the braking commenced with delay and in condition of heavy rain and strong tailwind (storm front passed through aerodrome area at that time) aircraft did not stop on runway.

In effect of the crash one crew member and one of the passengers lost their lives. The aircraft sustained damage caused by fire.

....

[PBL Synopsis: The flight proceeds normally until the approach to Warsaw airport. The crew is warned by the tower controller that preceding aircraft had reported windshear on landing. When the aircraft was close to landing, the crew of the previous aircraft reported that they have "severe windshear" on landing.

Windshear is a condition whereupon the airspeed suddenly changes. The wind direction or speed or both has changed suddenly, and the momentum of the aircraft continues its dynamic path through the changed airstream. A change in airspeed, though, means that the lift from the wings, holding the aircraft to its flight path suddenly changes along with the airspeed - and when the airspeed is suddenly lower, the lift is suddenly less. On approach to the runway, the aircraft is close to the ground and the crew has to react to such a loss of airspeed quickly by increasing the thrust from the engines and adjusting the pitch to cope with the new airspeed condition - and it might not be enough. Aircraft have descended too quickly into the ground before the runway and lives have been lost in previous windshear-related accidents. Pilots of aircraft warned of windshear conditions often choose a higher approach speed, so they have reserves of airspeed in case of a sudden loss. But, if the expected windshear and accompanying airspeed loss doesn't materialise, the aircraft is landing faster, and the lift from the wings keeps it more buoyant over the runway surface, and the aircraft might have difficulty stopping. As in this case.

End of PBL Synopsis]

> *.... DLH 2904 passed MM*[1] *at 278 feet with CAS*[2] *= 147 kts and GS*[3] *= 168 kts and continued approach with landing configuration (landing gear down, full flaps [35°], manual control of thrust and of aircraft flight control surfaces) until touchdown.*
>
> *During DLH 2904 approach to RWY 11*[4] *(magnetic course 113°) atmospheric front passed from west to east over Okecie area, preceding the approaching aircraft.*

1 the Middle Marker, an electronic "milestone" for an instrument landing system, very close in - at EPWA it is 0.6 nautical miles from the touchdown zone on the runway. See for example the ILS RWY 11 approach chart in [1].

2 Calibrated Air Speed, the airspeed as measured by the pitot-static system, corrected for aerodynamic effects associated with the positioning of the instruments on the aircraft body

3 Ground Speed, the speed of the aircraft over the ground. A vector is a mathematical item with a *direction* and a *length*. By elementary dynamics, the ground velocity will be the vector sum of the air velocity of the aircraft and the wind velocity. The (calibrated) air speed is the length of the air velocity of the aircraft, and the ground speed is the length of the ground velocity.

4 Runway 11; runways are designated with numbers from 01 to 36, according to the magnetic heading to which they are oriented, in increments of 10°. So Runway 11 lies somewhere between 106°N magnetic and115°N magnetic.

On final approach (in the area of MM) DFDR[1] and QAR[2] recorded temporary (duration about 15 seconds) decrease of CAS = 154 kts by 12 kts.

The aircraft passed the altitude of 50 feet with CAS = 158.8 kts, i.e. about 20 kts greater than V_LS recommended according to its weight[3]. GS was 172.0 kts. The aircraft made his first contact with RWY 11 by its right landing gear assembly at the distance of 770 metres from RWY 11 threshold[4].

As it was recorded, the left landing gear touched runway 9 seconds later, at the distance of 1525 metres from RWY 11 threshold, by CAS of 136 kts and GS of 154 kts.

Already after first contact of the right landing gear assembly with the runway pilot attempted to use wheel brakes, and while they failed to work, demanded the right-seat pilot to assist.

Only at the recorded moment, when the left landing gear touched the runway, automatic systems of the aircraft Airbus A320 depending on oleo strut (shockabsorber) compression unlocked the use of ground spoilers and engine thrust reversers. The systems began to operate, the spoilers deployed to full angle (50°), thrust reverser system began to work and N1 of the engines came to 71%, but the wheel brakes, depending on wheel rotation being equivalent of circumferential speed of 72 kts began to operate after about 4 seconds.

Rollout of the aircraft progressed in conditions of heavy rain and with a layer of water on the runway. Aircraft was decelerated according to possibilities in actual conditions, but on the distance of last 180 metres of

1 the Digital Flight Data Recorder records all necessary parameters of the flight, the status of the aircraft and engines. Up to about 200 parameters are recorded nowadays. The DFDR is intended for accident and incident investigation.

2 the Quick Access Recorder records a smaller number of parameters than the DFDR, and the data may be downloaded easily and routinely at the end of each flight. It is intended for flight quality control, not for accident investigation.

3 V_LS is the landing speed. It is calculated from the Operating Manual, and also using calculating instruments on board. It varies with the weight of the aircraft, which itself varies by the weight of the occupants and their baggage, and the weight of the fuel still on board.

4 The threshold is the beginning of the runway.

runway deceleration decreased by about 30%. Residual length of the runway (left from the moment when braking systems had begun to work) was to small to enable the aircraft to stop on the runway. Seeing the approaching end of runway, and the obstacle behind it, the pilot managed only to deviate the aircraft to the right. The aircraft rolled over the end of runway with the speed GS = 72 kts and having passed next 90 metres collided by its left wing with the embankment, slipped over it destroying LLZ aerial located on the embankment, and stopped right behind the embankment. In effect of this movement the landing gear of the aircraft and the left engine were also destroyed.

Evacuation of passengers, organised by 4 persons cabin crew in conditions of commencing aircraft file, contributed to rescue of 63 passengers of 64 on board. As far as 2-person cockpit crew is concerned, the left-seat pilot survived (injured), the other one, seated in the right seat was killed outright. Aerodrome fire service extinguished the fire of the aircraft.

From Subsection 1.12.1: Place Information

Place of the accident was the embankment located 90 metres behind the end of RWY 11 and 60 metres from the concrete surface (see Appendix 2.4 Plan of RWY11 end). The aircraft rolled out behind the end of runway, hit the embankment mentioned earlier, destroying the LLZ aerial mounted on the embankment, and came to stop on the other side of the embankment. In effect of this movement the landing gear of the aircraft and the left engine were also destroyed. Traces found on the runway surface at the end of it and on the ground along the way of aircraft allow to state that at the moment of collision with the embankment the aircraft was inclined by about 45° to the right and at the final stage the declination increased, but the direction of movement was not changed. Traces on the asphalt part of the runway are dark coloured, indicating braking and steering action, but on the part covered with concrete - light, denoting the cleaning action of water compressed to high pressure under the tyres.

From Subsection 1.13: Medical and anatomopathological information

Autopsy of the body of the pilot in command (PNF), who being seated in the right seat checked the left seat pilot (PF), indicates that he was killed at the impact due to collision with cockpit interior elements. It was confirmed by extensive damage to the internal organs, namely: rupture of pericardial sac and of the main artery wall, rupture of internal membrane of aorta, performation of the lungs with broken ribs. Presence of the carbon oxide haemoglobin or alcohol in the blood of the pilot was not stated. During examination of stomach contents and kidney neither drugs nor medicines affecting the capacity or capability to perform pilot duties were discovered.

In the blood of the not survived passenger 22.6% of carbon oxide haemoglobin was found, and in the opinion of who performed the autopsy intoxication with carbon oxide in the environment of the high temperature was the cause of the death.

From Subsection 1.14: Fire

In the collision of the aircraft with the embankment and with LLZ aerial located on it the fuel tanks of the aircraft were broken and the fuel began to spill on the left side of fuselage. It was ignited, most probably because of contact with hot parts of the damaged left engine or with the electrical system of the aerial. It caused the fire of the left wing. The fire spread onto area of about 600 square metres. Shortly the fire penetrated into passenger cabin, creating the smoke at first, and later filling the whole cabin. When, in three minutes from the emergency call, five Aerodrome Fire Service cars came to the spot, they managed to extinguish the external fire and the passengers remaining in the area of danger and blocking access for fire service, were successfully evacuated for the safe distance.

From Subsection 1.15: Survival Aspects

The passenger seated in the utmost left place in "business" class sustained the fracture of the first lumbar vertebra and of both hands what made him most probably unable to leave the seat by his own, but the temporary loss of consciousness in effect of the impact did not allow him to draw the attention of other passengers and cabin attendants to himself. It is not unlikely that the promptly growing smoke in the cabin caused him to loose the consciousness or led to its degradation to the same effect.

From Subsection 1.17: Aquaplaning

Aquaplaning that affected Lufthansa D-AIPN during rollout aroused in various stages of the rollout, probably from the beginning. It could be caused at the same time by:

- uneven layer of water up to several millimetres covering the surface of the runway,
- high touchdown speed,
- considerable wear of three of four tyres of main landing gear.

On the basis of analysis of both traces on the runway surface and the character of damage to the tyres it had to be assumed that at the final part of the runway covered with the concrete, aquaplaning was in the fully developed form as sliding of blocked wheels on the water steam cushion. It caused the radical decrease of the coefficient of friction, what was confirmed by record of braking progress as found in the flight data recorder.

This subject was worked up by the company "Consulting Lotniczy AVI-APOL", Poznan.

From Section 2: Analysis

From Subsection 2.2.3: Approach

.... some events of essential significance for further progress of the flight occurred at the approach phase, as follows:

a) DLH 2904 crew three times heard the warning of windshear in RWY 11 approach area.

b) The crew complied with only one of the recommendations given in A320 OAM, Section "Supplementary Procedures - Adverse Weather", page 5.24/18, namely: they increased the speed by 20 kts.

c) The crew switched off the weather radar; the radar could help to evaluate the situation properly.

d) The crew did not turn to account the wind display on EFIS and did not consider the discrepancy between these data and the information on the wind given by air traffic services. They neither did take into account that tailwind component displayed on EFIS exceeds the value defined by OAM as acceptable for this aircraft.

e) The crew did not analyse whether by the increased approach speed RWY 11 would provide enough distance to enable them to suppress the increased kinetic energy of the aircraft.

f) The crew used FULL flaps configuration, which on this aircraft disabled the braking system until recorded touchdown.

From Subsection 2.2.4: Flare out

This phase falls within the period .... (DFDR time 1722 to 1724) and contains the segment from the pass over RWY 11 threshold to the first recorded contact of the aircraft (right landing gear assembly) with RWY 11 surface. It is to be noted, that especially in the case of this phase, it's boundaries are conventionally assumed.

The selected parameters for characteristic points of this phase are as below:

[...parameters omitted]

It is to be noted, that the pilot kept - because of the windshear - not only increased speed, but also increased thrust down to relatively very low altitude, and consequently the aircraft - after passing over the threshold - occurred to be distinctly above the ILS glide path. Throttles were moved back to "idle" at the point E on the altitude of 6 feet. This caused significant extension of the flare-out phase. Point F is only apparent end of this phase, caused by casual (in the counteraction against crosswind) contact of the aircraft with the ground in considerable right bank (3.21°); this contact was strong enough to compress this one oleo strut as much as was needed for oleo switch to come on. If the aircraft approached the ground without this bank, the oleo switch would come on at considerably greater distance. It is of importance that this first, in a way forced contact with the ground occurred at the distance as far as 770 m from RWY 11 threshold and the bounce of the right landing gear brought to the crew the false impression, that both gears had the contact with the runway. Further actions of the crew confirm this assumption.

The crew did not draw the right conclusions from the course of flare-out phase and did not appraise their own chances in the real situation - with that speed and that point of touchdown.

From Subsection 2.2.5: Touchdown

This phase falls within the period .... (DFDR time 1714 to 1733) and envelops the segment from the first recorded signal of contact of the right landing gear with the runway to the moment of recorded the last leg (in this particular case of the left main landing gear) being in full contact with the runway.

The selected parameters at characteristic points of this phase are as below:

[...parameters omitted]

By the aircraft weight 58 tons the touchdown with the speed near to earlier calculated V_LS = 130 kts should be expected. In fact the first recorded casual - and in a way forced - contact with the ground occurred at the point F by CAS = 151.5 kts and GS = 170.0 kts.

Full recorded touchdown occurred only at the point I with the speed CAS = 136.0 kts, because only by this speed such decrease of the residual lift was possible, that the weight of the aircraft could cause the oleo struts to compress sufficiently for oleo switches to close (provided nearly ideally symmetrical compression of both main landing gear legs is achieved). It was confirmed by the analysis 460.169 carried out by AEROSPATIALE AVIONS. Again at this phase of flight the crew did not appraise the situation properly and attempted to brake only instead of initiating go-around.

From Subsection 2.2.6: Rollout and stop

This phase falls within the period .... (DFDR time 1733 to 1758) and encompasses the segment from the recorded contact of left main landing gear (the last one) with the runway surface to the full stop of the aircraft.

The selected parameters at characteristic points of this phase are as below:

[... parameters omitted]

The remaining runway length available at the moment of the recorded contact of both main landing gears with the runway surface was 1275 m.

Airbus A320 automatic systems dependent on compression of oleo struts armed all three braking systems only at the moment of recorded contact of the left main landing gear assembly with the runway (15:33:57). Systems began to work, spoilers were deployed to FULL (50°), reverser systems went into operation and N1 of the engines come to 71%, but wheel brakes, dependent on the rotation gain to circumferential speed of 72 kts began to operate about 4 seconds later.

Rollout, as well as the whole landing and final approach progressed in the heavy rain and with the presence of the layer of water on the runway. Aquaplaning, that occurred during the rollout phase considerably degradated the braking effectivity. Deceleration of the aircraft was in accordance with it's abilities in those circumstances, but on the last 180 metres decreased by about 30%. The runway length remaining at the moment of beginning of brake system action was insufficient to stop the aircraft on the runway.

Seeing the approaching end of runway and the obstacle behind it pilot struggled to deviate the aircraft to the right. Aircraft began to turn right, *but it's centre of gravity movement path did not bend. The aircraft rolled over the end of runway with the speed GS = 72 kts and after passing next 90 metres collided with the embankment, slipped over it damaging the LLZ aerial located on the top of the embankment, and stopped just behind the embankment. In effect of this movement the landing gear of the aircraft and the left engine were also destroyed.*

Subsection 2.2.7: Landing distance required

This section analyses the landing distance required for the aircraft's ground speed and the weather conditions (standing water on the runway) and concludes that it was longer than the available runway length.

Bibliography

[1] EPWA Instrument Charts. Available at https://yinlei.org/x-plane10/jep/EPWA.pdf , accessed 2017-06-19.

[2] Main Commission Aircraft Accident Investigation Warsaw, *Report on the Accident to Airbus A320-211 Aircraft in Warsaw*, March 1994. Available from https://rvs-bi.de/publications/compendium/incidents_and_accidents/warsaw_a320.html