No. 22

Finnair DC-3, OY-LCA, accident near Mariehamn Airport, Finland, on 8 November 1963. Report released by the Ministry of Communications and Public Works of Finland on 29 January 1964.

1. Investigation

1.1 History of the flight

Flight AY 217 was on a scheduled domestic flight from Helsinki to Mariehamn with an intermediate stop at Turku. The flight to Turku was routine and the aircraft took off from Turku at 1620 GMT, with a crew of three and 21 passengers plus one former Finnair pilot* who was in the cockpit without ticket or permit. The flight from Turku to Mariehamn was carried out at an altitude of 2 000 ft and nothing abnormal was reported by the aircraft. The approach to the Mariehamn NDB (MAR) was made from the East-North-East and at 1657 hours the aircraft reported over the NDB on the inbound track to runway 20. During the final approach the aircraft which was flying strictly on the inbound track struck trees in a nearly horizontal attitude 1 470 metres before the threshold of the runway. Upon impact the aircraft flipped over on its back around its longitudinal axis and caught fire immediately. The accident occurred at 1659 hours.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	19	1*
Non fatal	1	2	
None			

1.3 Damage to Aircraft

The aircraft was destroyed by the impact and the subsequent fire.

1.4 Other Damage

None reported.

1.5 Crew Information

The pilot-in-command, age 30, held a valid airline pilot licence with instrument and type ratings. He had flown a total of 7 228 hours including 2 772 hours as pilot-in-command of DC-3 aircraft.

The co-pilot, age 26, held a valid commercial pilot's licence with instrument and type ratings; he had flown a total of 1 078 hours.

The stewardess was also properly certificated.

No adverse remarks were made regarding the physical and mental state of the crew, or its behaviour during the days prior to the accident.

1.6 Aircraft Information

The aircraft's certificate of airworthiness was valid until 30 April 1964. It had flown a total of 30 672 hours, including 476 hours since the last major overhaul. All inspections, repairs and maintenance had been performed in accordance with instructions and approved procedures. However, the maintenance record of the pilot-in-command's altimeter had an entry regarding the replacement of the "toothed sector and hand axis", and it was found that the toothed wheel was replaced but not the toothed sector. It was not possible to establish whether the counterweight of the toothed sector had been the object of any manipulation.

The aircraft's weight and centre of gravity were within the prescribed limits.

The type of fuel used was not mentioned in the report.

1.7 Meteorological Information

Before taking off from Turku the following weather information was available to the crew: Turku and Mariehamn: Horizontal visibility 600 m, fog, vertical visibility 200 ft; Stockholm/Arlanda: Horizontal visibility 10 km, clouds 4/8 at 210 m, 8/8 at 3 000 m.

In flight the crew received for Mariehamn the following information from the ATC at 1637 hours: Surface wind 180/6 kt, vertical visibility 200 ft, horizontal visibility 600 m, fog, QNH 989 mb; at 1657 hours: Surface wind 180/3 kt, QNH 989 mb. This was acknowledged by the crew and information on the approach lights was requested. The air traffic controller confirmed that the approach lights were on, but that he could not see them because the visibility was somewhat poorer.

1.8 Aids to Navigation

There were two radio beacons located on the extended center line of runway 20 for aid on approach and landing: the NDB "MAR" (392 kc/s) and the locator "S" respectively located at 6 800 m and at 1 420 m from the runway threshold. It is known that the signals emitted by these low frequency beacons are not always very clearly received at long distance because of other transmitters working on the same or adjacent frequencies and of atmospheric phenomena. However it was not established if this had any bearing on the accident since the aircraft was close to the beacons.

There is no GCA at Mariehamn and although the installation of ILS equipment started two years before the accident, it had not been completed because of land acquisition problems.

1.9 Communications

These were normal until the time of the accident.

1.10 Aerodrome and Ground Facilities

Mariehamn Airport has low intensity runway and threshold lights and a line of low intensity approach lights which begins 1 020 m before the threshold of runway 20. At the beginning of the line of approach lights there is a flashing light, which is located amongst trees approximately at the break off point of the obstacle clearance surface.

1.11 Flight Recorders

Not mentioned in the report.

1.12 Wreckage

No details or diagrams on the distribution of the wreckage were provided in the report.

1.13 Fire

Fire commenced immediately after contact with the ground and destroyed the entire fuselage except the rear section, which had broken off on impact. - No information on fire fighting is provided in the report.

1.14 Survival Aspects

When the Air Traffic Controller did not receive any reply from the aircraft to his radio calls, he immediately initiated search operations. The fire brigade and other rescue services were alerted between 1705 and 1708 hours. The arrival at the scene of the accident was hampered by the fog and the lack of appropriate service roads towards the approach line.

As a result of the impact the seats in the cabin were torn from the cabin floor and were packed together against the cockpit wall. The frames of the seats were partly bent but did not break and the seat belts probably resisted. The acceleration forces at impact were estimated to be arount 12 g.

1.15 Tests and Research

The engines and their accessories were dismantled and investigated at Kuorevesi with help from the Finnish Air Force. The instruments were checked first at the Airport, and then at the Air Force Depot and particular care was taken in checking the altimeters.

It was found that the pilot-in-command's and the co-pilot's altimeter settings were respectively 988.3 mb and 988.4 mb. The QNH transmitted to the aircraft two minutes before the accident was 989 mb. This would account only for a maximum error of about 20 ft. When the pilot-in-command's altimeter was opened at the Air Force Depot the counterweight of the toothed sector and its screw were found loose and the aneroid capsule was dented. It was determined that the damage to the aneroid capsule had been probably caused by overpressure when the extinguishers exploded in the fire subsequent to the accident. Also the screws, which are normally locked by lac or paint, were not locked.

1.16 Weather minima at Mariehamn Airport

The instrument approach chart for Mariehamn Airport, published in January 1962 by the Department of Civil Aviation, gave an obstacle clearance limit (OCL) of 566 feet (amsl) for the approach to runway 20, when using the two NDB approach procedures.

The landing minimum on the instrument approach charts for Mariehamn Airport, used by Finnair and approved by the DCA, is 316 feet (asml), which is 250 feet below the OCL. The "planning minima" approved for Mariehamn are vertical visibility 150 ft above the aerodrome and horizontal visibility 700 m.

2. Analysis and conclusions

2.1 Analysis

No evidence of malfunction or failure were found in the aircraft, controls, engines or systems. Under the prevailing weather conditions there was no risk of icing at 2 000 ft and nothing indicated that carburetor icing might have occurred during the approach.

The weather information available to the crew at Turku indicated for Mariehamn an horizontal visibility of 600 m, i.e. 100 m below the company's "planning minima". The decision of the pilot-in-command to carry out the flight was probably influenced by his knowledge of the route and of the weather inconstancy at Mariehamn under the prevailing meteorological conditions. However when the pilot-in-command was informed over "MAR" NDB that the visibility had worsened, he should have discontinued the approach. At the time of the accident the aerodrome and the approach sector to runway 20 were covered by a comparatively thick fog, although a few minutes after the accident stars were visible from the ground and the weather improved for about one hour. It was concluded that the pilots had no visual reference to the ground during the final approach and that the low intensity runway and approach lights were hidden by the hill located before the beginning of the approach lights. Also the flashing light at the beginning of the approach lights was located amongst trees and could not be seen from faraway, especially at low altitude. Finally no obstruction light existed at the time on the highest point of the obstacle profile.

In trying to explain why the aircraft was too low during the final approach it was considered that the pilots might have misjudged their altitude or position or both.

The normal practice amongst the Finnair crews is for the pilot-in-command to monitor continuously the altitude and for the co-pilot to be mainly responsible for the look out.

It was considered that the pilot-in-command's altimeter might have begun to work incorrectly during the flight. It is highly probable that the counterweight was already loose during the flight. Although the tests had shown that the absence of the counterweight does not, by itself, occasioned any important errors in the altimeter values, it is possible that the counterweight or its screw, by getting wedged in the altimeter mechanism during the flight could have occasioned an operational disturbance of the altimeter. As a result the pilot-in-command might have had a false idea of his altitude. If the pilot tried to keep the minimum altitude, as it is normally done when approaching to a locator beacon, a sudden error in the altimeter indication of about 130-140 feet in the dangerous direction would be enough to occasion the impact against the trees in the condition in question.

The use of the reserve static system could also have occasioned an error in the altimeter indication of nearly the same magnitude. The control lever of the system was found after the accident, in the lower position i.e. "reserve static" but it was impossible to ascertain whether it was in that position prior to or as a result of the accident. The State Institute for Technical Research could only establish that the control lever was bent as a result of some blow it had received.

The Board did not find any reason why the pilot should have shifted over to reserve static system. The pre-flight checks include the checking of this lever in its upper position ("pilot-static system") at take-off. There is a possibility that the reserve static system had been tried during the flight and that the lever was forgotten in that position, but this does not seem probable. The magnitude of the error occasioned by the use of the reserve static system is variable to a certain degree and highly dependent on the flying speed. Therefore any pilot who would have tried the reserve static system before beginning the approach would have carefully shifted over to the normal system again, especially in the prevailing weather conditions.

Another reason, which might have given the pilot an erroneous conception of his altitude, would have been the correction of a known altimeter error in the wrong direction by mistake. As reported by another pilot, the pilot-in-command's altimeter of the subject aircraft indicated about 50 feet too much on the day prior to the accident (the maximum error permissible is 65 feet). If error had been the same on the day of the accident and if the pilot had mentally performed the correction in the wrong direction, there would have been an error of 100 feet. In this case the error would have been in the dangerous direction.

However, an error of this magnitude would not have been sufficient by itself to occasion an impact with the trees at the place in question. But if the pilot deliberately or unconsciously had flown some 30 or 40 feet below the minimum permitted an impact against the trees would then have been the result. Even a conscientious pilot could deliberately go that much below the minimum as there would still remain a margin of about 100 feet provided that the pilot is aware of the value of the altimeter's error and had taken it into account in the right way.

The Board considered it obvious that the pilot-in-command had an erroneous conception of his altitude. He was flying almost exactly horizontally when he struck the trees, awaiting to be passing the locator "S" on final approach, and to see the line of approach lights appear. It is not likely that he consciously flew at the altitude at which he was actually flying, as he was perfectly aware of the circumstances and the obstacle heights in the approach sector.

It is also possible that the pilot-in-command of the aircraft had an erroneous conception of the aircraft's position and that, assuming that he had already passed the locator, he went below the minimum altitude permissible in order to be able to see the line of approach lights or the runway lights.

After the accident, Finnair pilots stated that with the radio compass tuned to the locator "S" frequency sometimes wrong indications were obtained. As a result a pilot might believe having passed the locator on final approach though he, in reality, would not have passed it yet.

The wrong indication of the radio compass is a specific deficiency of the system in question, especially appearing when the aircraft is far away from the locator.

The reports of the Finnair pilots mostly concerned cases of this kind. But, when the aircraft is near the locator, errors of some importance are scarcely possible. This was confirmed by experts from the State Institute of Technical Research and The Board of Posts and Telegraphs. The Board therefore considered that there was no evidence to prove that the pilot of the aircraft, believed having already passed the locator. The almost horizontal flight path of the aircraft at impact gives no support whatever for such a hypothesis.

In the opinion of his superiors as well as of his subordinates the pilot-in-command of the fatal flight was an extremely conscientious and careful pilot. It is therefore very unlikely that he consciously and deliberately flew 130 to 140 feet below the minimum permissible altitude, endangering the safety of the flight.

2.2 Conclusions

Findings

The crew were properly certificated.

The certificate of airworthiness of the aircraft was valid. The maintenance of the aircraft had been performed in accordance with instructions and approved procedures, however, a discrepancy was found in the maintenance record of the pilot-in-command's altimeter.

The aircraft's weight and center of gravity were within the prescribed limits at the time of take-off from Turku.

The weather at Mariehamn was below the company prescribed minima.

The counterweight of the toothed sector and its screw were found loose in the pilot-in-command's altimeter. The aircraft flew into trees in the final approach to runway 20 when making an NDB approach procedure, probably because of a wrong altitude indication.

Cause or
Probable cause(s)

The Board considered that the ultimate cause of the accident was the pilot's misconception of his altitude. It was impossible to determine whether this was due to a wrong indication of the altimeter or to human error. The defect, found in the pilot-in-command's altimeter, was regarded however as sufficient to have brought a wrong indication of the altitude which the pilot could not foresee. The cause of the accident was therefore established as follows:

As a result of a wrong indication of the aircraft's pilot's altimeter during an instrument approach carried out in weather conditions worse than the weather minima approved for runway 20 at Mariehamn, the aircraft came below the safe flying altitude and hit trees on the approach line.

3. Recommendations

The improvement of landing aids at airports should be started urgently. It should urgently be endeavoured to acquire ILS and GCA radar equipment for facilitation of aeronautical activity in Finland;

The weather minima related to NDB procedures for Finnish aerodromes should be revised taking into consideration the OCL values recommended by ICAO;

The concept "Planning minima", which does not appear in the recommendations of ICAO should be entirely abolished;

When determining the length of the line of approach lights the terrain and obstruction profile of the corresponding approach sector should be taken into consideration so that the lights cannot be hidden by the obstruction of terrain profile even in the case of an aircraft flying at a low altitude. All aerodromes should be equipped with lines of high intensity approach lights;

In overhaul and repair of altimeters and other similar aeronautical instruments, the possibility of fixing screws in frame and mechanism becoming loose should be taken into consideration;

Improvement of the fastening of seats and the endurance of seat belts at reasonable costs should be examined;

During approach pilots should follow uniform working procedures to ensure a continuous utilisation of both altimeters and speed indicators and comparison of their readings;

All air traffic control units should be equipped with sound recorders for recording radiotelephone conversations with aircraft and orders given in connexion with alarm and rescue activity;

Meteorological observations and weather data should be brought to a degree of accuracy higher than they are at several meteorological stations at present;

The possibility of increasing the number of ATC personnel at small airports, where the traffic frequency is relatively small, should be considered;

In the immediate vicinity of the center lines of approach and climbing sectors of runways at airports, catastrophy and service roads to a length of at least 1,5 - 2 km from the end of the runway should be built;

Alarm sirens at airports should be modified to work automatically;

Rescue service training should be intensified by arranging joint exercises for participants from different administrations;

The station service procedures at airports should be revised so that embarcation of outsiders should be rendered impossible;

Authorities supervising air traffic and airline operators should intensify their supervising activities and adopt methods such to ensure the observance of air service regulations and prescribed weather minima.

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