

No. 27

United Air Lines, Inc., DC-7, N 6328C, and United States Air Force,
F-100F, 56-3755, collided near Las Vegas, Nevada, on 21 April 1958.
Civil Aeronautics Board (USA) Aircraft Accident Report SA-332,
File No. 1-0066, released 19 August 1958.

Circumstances

United Airlines Flight 736 departed Los Angeles International Airport at 0737 hours Pacific standard time with 42 passengers and 5 crew aboard. It was a scheduled passenger flight to New York, which was proceeding normally in accordance with an IFR flight plan along Victor Airway 16 to Ontario, California, and Victor Airway 8 to Denver. The aircraft was cleared to a cruising altitude of 21 000 ft msl and advised to climb in VFR weather conditions. At 0735 the flight reported to Aeronautical Radio that it was over Ontario at 12 000 ft and was climbing in VFR conditions. Then at 0811 it reported over Daggett at its cruising altitude of 21 000 ft and estimated that it would reach Las Vegas (omni range station) at 0831. This was the last position report made by the flight.

At approximately 0745 hours that morning F-100F, 56-3755, took off from Nellis Air Force Base, Las Vegas, Nevada on an instrument training flight carrying an instructor and a trainee pilot. The flight was in accordance with a VFR local flight plan filed with Nellis Operations and the local traffic control tower. At approximately 0823, 755 called Nellis VFR Control and reported that it was "inbound on KRAM" (a local commercial radio broadcast station). The flight requested an altitude assignment from which it would conduct a simulated ADF instrument jet penetration utilizing KRAM. The VFR controller assigned 755, 28 000 ft and advised it to report over the radio station. At approximately 0828, the flight reported that it was over KRAM requesting a penetration. The VFR controller cleared it for

an immediate penetration and requested that it report the penetration turn. 755 then reported leaving 28 000 ft. There were no other reports from the flight in connection with this procedure.

At 0830 the offices of Aeronautical Radio at Los Angeles, Denver and Salt Lake City heard an emergency message from the United flight. . . . "United 736, Mayday, midair collision, over Las Vegas."

At the same time, as nearly as can be determined, there was an unrecorded emergency transmission from the F-100F. This message was heard by the VFR controller and by the two pilots of another F-100F. All were agreed that the first portion of the emergency transmission was "Mayday, Mayday, this is 755." The last part of the message was either, "We've had a flameout" or "We're bailing out."

The aircraft collided at 21 000 ft over a position later determined to be about 9 miles southwest of the Las Vegas VOR station, on Victor Airway 8, approximately 1-3/4 miles to the right (southeast) of the centreline. Both aircraft fell out of control and crashed killing the 47 persons on board the DC-7 and both pilots of the F-100F.

Investigation and Evidence

Weather conditions in the Las Vegas area at the time of the accident were clear with visibility more than 35 miles. Winds at 21 000 ft were from 300 degrees at 45 kts.

Eyewitness evidence indicated that the aircraft approached each other quartering head-on, with the DC-7 flying northeast and the F-100F flying south or southeast.

The main portion of the DC-7 wreckage was located approximately 2.6 miles northeast of the estimated collision position. Investigation revealed that the aircraft was in a relatively flat attitude at ground impact with a high sink velocity relative to its forward motion. On impact it broke into numerous pieces along a heading of 160°. The wide separation between the ground marks made by each powerplant confirmed observations of eyewitnesses who stated that they separated in flight. Similarly, the wide distribution of many major wreckage pieces showed that a general disintegration of the aircraft occurred before the ground impact. Examination of the pieces of structure provided clear evidence that the inflight breakup of the aircraft after collision resulted from airloads which exceeded the design strength of the structure. There was no indication of structural failure prior to the collision.

The F-100F main wreckage site was located 5.4 miles south-southwest of the DC-7 site. The aircraft had contacted the ground on a northerly heading and, similar to the DC-7, it struck the ground in a relatively flat attitude with extremely high sink velocity as compared to forward motion. The impact, and fire which followed, caused major destruction of the structure. As near as could be determined from the evidence, at ground impact the landing gear and flaps were up and the speed brakes were closed. There was no evidence to indicate structural failure of the F-100F prior to the inflight collision.

Much of the wreckage after documentation as to location and identification was removed from the scene to a location on Nellis Air Force Base where certain areas from both aircraft were reconstructed and minutely examined.

Most important to these objectives were the right outboard wing sections of both aircraft and the right horizontal tail of the F-100F. These components were widely separated from the main wreckage areas and bore clear evidence of inflight contact which separated the wing sections as a result of and at the time of the collision. Examination showed these components were the only major ones directly involved in the inflight contact sequence.

Analysis indicated that initial contact occurred between the leading edge of the DC-7 right wing (at station 574) and the leading edge of the F-100F right wing 132 inches outboard of the aircraft centre-line. The two wings progressively penetrated one another until the outboard portion of each was severed; in the case of the DC-7 the wing was severed along a swath line 34 degrees aft and outboard, and in the instance of the F-100F along a swath line 12 degrees aft and inboard. A second cut in the DC-7 wing, located about 24 inches inboard of the first, was made by the right horizontal tail of the F-100F which penetrated rearward until the cutting object, the outboard portion of the tail, was destroyed. This entire collision sequence occurred in less than 1/100 of a second.

A vector diagram, using the 34-degree fracture line in the DC-7 wing, estimated true airspeeds of the DC-7 and F-100F of 312 and 444 kts, respectively, and assuming a small angle of descent for the F-100F, indicated that at impact the aircraft were on quartering head-on courses about 122 degrees apart with a closure speed of about 665 kts. Believing the DC-7 was flying a magnetic heading to follow Victor Airway 8 and was in nearly straight and level flight, at collision the heading of the DC-7 was 23 degrees magnetic and the heading of the F-100F was 145 degrees magnetic. This heading for the F-100F seems reasonable because the aircraft was to the right of the desired 170-degree track and a normal correction to track procedure

required a heading of 140 degrees. Because of its position, right of track, it would seem probable that the flight approached KRAM from the basic instrument practice area located east of the facility. Because of unknown factors, any estimate of the amount of turn required to the outbound heading cannot be determined or reasonably estimated.

The swath cut through the DC-7 wing by the F-100F wing was approximately 2 ft wide, and the edges were nearly perpendicular to the plane of the DC-7 wing. For a wing 8 inches thick and swept more than 45 degrees at the leading edge to have cut a 24-inch vertical swath through the DC-7 wing it would have been necessary for the F-100F wing to have contacted the DC-7 wing at a considerable angle of attack relative to the collision course and for the aircraft to have been rolled beyond a 90-degree bank. Paint scrape marks on the bottom of the F-100F right wing showed that it was the bottom side of the F-100F wing which made the contact, indicating that the F-100F was banked to the left. The distance between the swaths cut by the F-100F wing and tail surface indicated that the aircraft was in approximately a 15-degree negative angle of attack attitude at the instant of collision. The F-100F was also in a 12-degree nose-down attitude relative to the DC-7. An approximate 4-degree angle of descent would have been normal during the penetration.

From the angles of bank, descent, and attack indicated, as well as eye-witness information obtained, it was the Board's view that a last second evasive manoeuvre was initiated by the F-100F instructor intending to avoid the DC-7 by diving to the left, down, and under the aircraft. The F-100F passed the nose of the DC-7, narrowly missing its No. 4 propeller. Then the aircraft collided in the attitudes described.

To the Board the 15-degree negative angle of attack seemed extreme even under the circumstances. Because of this

it is noteworthy that the angle would be reduced one degree for each degree that the DC-7 was yawed to its left. It would also be reduced by a greater speed than was estimated for the aircraft. Of the two possibilities, it was believed most likely that one of the pilots of the DC-7 saw the F-100F in the last seconds before collision and initiated a desperate evasive manoeuvre to avoid it.

Since the F-100F evasive manoeuvre was not initiated in time to be successful it can be assumed that the course of the F-100F was not altered appreciably during the manoeuvre. The two aircraft may then be backed apart from the point of collision for a reasonable distance along their courses at impact so that their relative locations to one another may be established and the possibilities of the pilots having sighted each other evaluated. The vector diagram indicates that the DC-7 was approaching the F-100F on a bearing 24 degrees to the right of the nose of the F-100F and it would have been at nearly eye level. This location falls directly behind the opaque canopy ring of the F-100F and, assuming no head movement, would make sighting the DC-7 at more than a mile nearly impossible and at more than one-half mile very difficult since at that distance the eyes of only one of the pilots would be in a position to see the DC-7 clearly.

The relative angle of approach of the F-100F to the DC-7 was from 34 degrees to the left and approximately 5 degrees above the horizon. This angle of approach falls behind the corner post between the captain's clear vision window and side window. The captain would have been able to see the F-100F approach with only one eye but if his head were two or three inches to the left of normal he could not have seen the aircraft at all until it was much too late to avoid the collision. The approach of the F-100F should have been unobscured to the copilot of the DC-7 through the captain's front windshield. The flight engineer on the DC-7 had no opportunity to observe the approach since

his location in the cockpit was too high and too far aft to permit any upward visibility.

Nellis Training Procedures

Nellis instrument training procedures required that before a flight entered the 25-mile instrument practice area the pilot must secure a clearance and altitude assignment. This was accomplished through "Nellis VFR Control" which simulates an approach control. VFR control was incorporated to relieve the workload of the control tower, to provide separation between Nellis aircraft, and to give the trainee pilots practice in radio procedures. The VRF controller normally gave altitude assignments, 19 000 ft or higher, with 1 000 ft vertical separation.

The VFR control did not, however, perform an air traffic control function except for Nellis aircraft and its use did not relieve the instructor pilot of visual separation responsibilities required of all pilots by the Civil Air Regulations, restated in Air Force Regulations in equal or stricter requirements. It was stated that the VFR controller did not have knowledge of any air traffic other than the Nellis instrument training flights described. There were no procedures to alert the jets of other traffic known to Air Traffic Control. It was stated that such advisory service was beyond the capability of the Base and ATC facilities.

At the time of the accident seven jet penetrations were used for the Nellis Air Force Base. Three were published in the USAF Pilot's Handbook, and the other four were unpublished procedures. Although all seven procedures were formulated according to standard criteria for instrument approaches the latter four were approved through a local letter of agreement dated 10 May 1957, entered into between the Base and the Civil Aeronautics Administration. The KRAM penetration was one of the unpublished procedures. A review of the specified penetration track showed that it was nearly all within the lateral limits of Victor Airway 8.

For the KRAM penetration procedure the pilot would obtain permission to enter the instrument area and receive an altitude assignment. The flight should then "track in" on the commercial broadcast station. This inbound track would be one which requires less than a 45-degree turn to the penetration heading of 170 degrees after passing over the radio facility. If the inbound track required a greater than 45-degree turn, a right turn to intercept the outbound track was necessary. According to the established training procedures the speed of the aircraft should be 300 knots indicated airspeed. After overheading the radio station approval for the penetration is obtained with permission to leave the assigned altitude. When approved, the pilot should report leaving the altitude. At this time the "speed brakes" of the F-100 are extended and a descent is established holding 300 knots indicated airspeed. If necessary and when the ADF indications are stable, the pilot is expected to correct to a 170-degree outbound track from KRAM. Normally the descent is continued until one-half of the initial altitude plus 3 000 feet has been reached, in this instance 17 000 feet. At this altitude a right penetration turn is required to a heading of 35 degrees. The descent is continued throughout the turn and until a minimum altitude is reached on the 35-degree heading. The aircraft is again turned, if necessary, to establish a 35-degree inbound track to the runways at Nellis Air Force Base. At the proper time, and if remaining fuel permits, the penetration is followed by a simulated missed-approach procedure and/or another penetration.

United Air Lines Flights

The manager of United Air Lines flight operations stated that United pilots are instructed to plan their flights on airways, including the 1500 series, and on authorized high-altitude off-airways routes. Below 18 000 ft and in controlled airspace the pilots are permitted to plan a flight and file it according to a VFR or an IFR flight plan unless weather conditions permit only an IFR flight. Above 18 000 ft the flight must be planned and

flown according to an IFR flight plan although VFR restrictions may be requested during climb and/or descent and when necessary. A flight over a high-altitude off-airways route must adhere to visual flight rules and only an IFR flight plan may be filed.

The witness said that the planning and operating of a flight above 18 000 ft according to IFR regardless of weather was to obtain as much air traffic control separation as possible. The witness stated that United understood that Civil Air Regulations and Air Traffic Control procedures did not preclude VFR flights in controlled airspace and during VFR weather conditions VFR and IFR flights would be intermixed. He said it was clear that in VFR weather an IFR flight received separation only from other like flights. Because of this, he said, it was United policy to require continued pilot vigilance for other traffic in VFR weather and, according to Civil Air Regulations, it was the pilot's responsibility to maintain visual separation regardless of flight plan or clearance. The witness furnished United company material and operation procedures reflecting this policy and said that cockpit vigilance was a subject of continuing emphasis.

Conclusion

The accident, which appears to have occurred under the most adverse conditions contemplated under VFR insofar as the opportunity for the pilots to see and avoid is concerned, raises the question whether the long established visual flight rules are adequate in uncontrolled operations. It is clear that, under certain conditions of speed and angle of convergence, insufficient opportunity exists for pilots to observe other aircraft and take avoidance action. As aircraft speeds and traffic density increase, this problem will be aggravated. To this end the Board has promulgated regulations under which a positive control service has been initiated by the CAA on certain transcontinental routes between 17 000 and 22 000 ft.

It is essential that positive control be extended to altitudes as high as 35 000 ft and on additional routes as rapidly as practicable. While the problem of aircraft speeds and traffic density is serious, and growing more so, it is not sufficient cause to discard the see and be seen rule in entirety. Alternatives to this fundamental rule in VFR operations either do not exist as yet or are so extreme that they would penalize the expeditious flow of traffic to the point where U. S. aviation in general would be stifled. The practical consequences of immediate implementation of full positive control for such operations regardless of weather would be the grounding of a great majority of current aircraft operations. Therefore, until technological advances are made which will ensure separation of aircraft without reliance on the vigilance of the pilot, the Board will continue to retain visual flight rules with whatever refinements circumstances and the state of the art permit. The necessity for this position has been agreed by all major users of the airspace, both civil and military.

From a review of the operating procedures used at Nellis and all the evidence and testimony obtained during the investigation, the Board views critically some of the procedures which relate to this accident. Generally, the policies and procedures indicate full cognizance of the collision hazards inherent in the particular training performed and equipment flown. Air Force Regulation 55-19 contains numerous provisions in this regard. Through establishment of the local flying area and mission subdivisions, arrival and departure corridors, scheduling and altitude requirements, an effective segregation of aircraft operations is facilitated in most of the training phases.

It is the Board's view, however, that in the instrument training phase and in particular the VFR practice KRAM penetrations, insufficient attention was given the segregation of military training operations from other users of the airway.

It is apparent that simulated instrument approaches must be practiced and must utilize radio facilities which, in most cases, are located to form the airway structure. Nevertheless, penetration procedures intended for training manoeuvres to be flown mostly in VFR weather conditions should be those which create the least collision exposure. The KRAM penetration selected in this case, however, required a flight course which was almost wholly on Victor Airway 8 where most air traffic could reasonably be expected. The Board is of the opinion that, when it was determined no outlying facility could be established or used as provided in AFR 55-19, it was incumbent upon the military to establish procedures providing minimum collision exposure according to the intent of this requirement. The KRAM penetration did not fulfil this obligation.

The Board is well aware of the importance of the military mission, and there is no question as to the military right to use controlled airspace. Although such airspace is frequently described as "civil airways", except for portions specifically reserved, all airspace is open to all users, civil, and military. The Board requires that users must operate in accordance with the rules governing the airspace and expects such airspace to be used in a manner which takes fullest account of limitations of pilot capacity to maintain visual separation and which provide the best environment for visual separation.

In view of testimony of CAA witnesses, there is no doubt that the Administrator was cognizant of the extent and nature of the training activities at Nellis Air Force Base. The penetration agreement was approved by personnel of CAA and it was known by the nature of the training mission that the procedures agreed upon would be used primarily during VFR weather conditions for training. The CAA was also fully aware that the procedures, of necessity, had

been established on the navigational aids in the Las Vegas terminal area where several airways intersect and over which there is considerable traffic flow. Furthermore, the CAA was aware of the difficulty in maintaining visual separation created by the speed and rate of descent of the F-100 series aircraft.

The Board believes that the CAA exercised poor judgment in failing to take any action with respect to conditions that existed on the airway structure which impaired visual collision avoidance and created unnecessary collision exposure. When the CAA agreed that the penetrations were necessary to the Nellis Training Program and that they would be established in the Las Vegas terminal area, it was reasonable to expect that the CAA would have made certain that such procedures would create minimum conflict with other traffic on the airways when used as a VFR procedure. As pointed out, Section 60.46 of the Civil Air Regulations is part of the instrument rules and, therefore, the CAA is not required by this regulation to consider VFR use of the penetration procedure as a factor for approval. However, the absence of such regulatory responsibility in this instance does not, in our opinion, excuse the Administrator for failing to take some action to reduce a known collision exposure in visual flight conditions.

Under Title III of the Civil Aeronautics Act the Administrator is directed, among other things, to encourage and foster the development of civil aeronautics and air commerce; to designate civil airways and to acquire, establish, operate and maintain air navigation facilities along such civil airways and at landing areas; and to make provision for the control and protection of air traffic moving in air commerce. The Administrator in performing these functions is directed by Section 2 of the Act to regulate air commerce "in such manner as to best promote its development and safety."

We do not feel this was done in this case. The record is clear that the Administrator was cognizant of the extent and nature of the training activities at Nellis Air Force Base and that the penetration procedures approved by him would be used primarily during VFR weather conditions for training. Yet, no action of any kind was taken by the Administrator, even after he had received complaints from United Air Lines. The record shows that the Administrator did not approach the Military in an effort to reach a voluntary agreement to alleviate the situation, nor was any attempt made to relocate the airway or to provide additional facilities for the jet penetration procedures. It was not until after the accident that a joint CAA-Military survey team was created to review Military activities throughout the country and to reexamine the jet penetration procedures used by Nellis Air Force Base. The Board recognizes the possibility that voluntary action by the Administrator might have met with resistance on the part of the Military. The fact remains, however, that no attempt at voluntary action was taken by the Administrator, nor did he advise the Board that he deemed himself powerless to act and, therefore, that regulatory action was required by the Board.

The Administrator, with his large staff of safety technicians stationed throughout the country, is familiar with all of the safety aspects of civil aviation as problems arise on the local level and therefore, has a working knowledge of these problems on a day-to-day basis. The Board believes that where the Administrator is aware of the existence of a potentially unsafe situation in which he believes himself powerless to act, he should immediately bring this to the attention of the Board. The Administrator's statutory duty under Section 301 of the Act to "cooperate with the Board in the administration and enforcement of this Act" clearly requires him to bring

such matters to the Board's attention. This was not done.

Many of the actions initiated by the CAA and operational procedures effected by Nellis following the accident could reasonably have been taken before it occurred. The record indicates that when United Air Lines reported "near misses" on the airways near Las Vegas there were conferences but no other indicated corrective measures. It is the Board's conclusion that the incidents showed the need for and should have furnished the impetus for some of the later steps. All of the actions, in essence, reduce the collision exposure, take greater cognizance of other users, and utilize as much IFR Air Traffic Control service as can be obtained.

The testimony of various witnesses indicated that United Air Lines was aware of the general flying activity from Nellis Air Force Base. It was indicated that the company knew there was extensive flying training from the Base and that F-100 series aircraft were being used. It is also reasonable to assume that United knew that jet penetrations would be flown and this activity would normally involve some use of the established navigational aids. Nevertheless, the Board does not believe that from this information United should have suspected that the KRAM penetration with its unwarranted collision exposure would be selected and used regularly and frequently as a VFR training manoeuvre.

United had experienced numerous "near miss" incidents on the airway in the vicinity of Las Vegas. These, according to the United operations manager, were of major concern to United and were promptly reported to the CAA. The Board believes that United's action was proper and it was reasonable for the company to expect that appropriate corrective action would be taken by the CAA.

Probable Cause

The probable cause of this collision was a high rate of near head-on closure at high altitude; human and cockpit limitations; and the failure of Nellis Air

Force Base and the Civil Aeronautics Administration to take every measure to reduce a known collision exposure.