= American Airlines Flight 191 =

American Airlines Flight 191 was a regularly scheduled passenger flight operated by American Airlines from O 'Hare International Airport in Chicago to Los Angeles International Airport . A McDonnell Douglas DC @-@ 10 @-@ 10 used for this flight on May 25 , 1979 , crashed moments after takeoff from Chicago . All 258 passengers and 13 crew on board were killed , along with 2 people on the ground . It is the deadliest aviation accident to have occurred in the United States .

Investigators found that as the jet was beginning its takeoff rotation , engine number one , on the left wing , separated and flipped over the top of the wing . As the engine separated from the aircraft , it severed hydraulic fluid lines that locked the wing leading edge slats in place , and it damaged a three @-@ foot section of the left wing 's leading edge . Air loads on the wing resulted in an uncommanded retraction of the outboard slats . As the jet began to climb , the damaged left wing , with no engine , produced far less lift stalled than the right wing , with its slats still deployed and its engine running at full takeoff speed . The extremely disrupted and unbalanced aerodynamics of the aircraft caused it to roll to the left until it was partially inverted , reaching a bank angle of 112 degrees , before crashing in an open field by a trailer park near the end of the runway . The engine separation was attributed to damage to the pylon rigging structure holding the engine to the wing , caused by faulty maintenance procedures at American Airlines .

While maintenance issues and not the actual design of the aircraft were ultimately found responsible for the crash , the accident and subsequent grounding of all DC @-@ 10s by the Federal Aviation Administration added to an already unfavorable reputation of the DC @-@ 10 aircraft in the eyes of the public , caused by several other incidents and accidents involving the type . The investigation also revealed other DC @-@ 10s with damage caused by the same faulty maintenance procedure . The faulty procedure was banned , and the aircraft type went on to have a long passenger career . It has since found a second career as a cargo airplane .

= = Background = =

= = = Aircraft = = =

The aircraft involved was a McDonnell Douglas DC @-@ 10 @-@ 10 registered N110AA . It had been delivered on February 25 , 1972 , and at the time of the crash had logged just under 20 @,@ 000 hours of flight over seven years . The jet was powered by three General Electric CF6 @-@ 6D engines . A review of the aircraft 's flight logs and maintenance records showed that no mechanical discrepancies were noted for May 11 , 1979 . On the day of the accident , in violation of standard procedure , the records were not removed from the aircraft , and were destroyed in the accident .

= = = Flight crew = = =

Captain Walter Lux , 53 , had been flying the DC @-@ 10 since its introduction eight years earlier . He had logged around 22 @,@ 000 flying hours , of which about 3 @,@ 000 were in a DC @-@ 10 . He was also qualified to pilot 17 other aircraft , including the DC @-@ 6 , DC @-@ 7 , and Boeing 727 . First Officer James Dillard , 49 , and Flight Engineer Alfred Udovich , 56 , were also highly experienced : 9 @,@ 275 hours and 15 @,@ 000 hours respectively , and between them they had 1 @,@ 830 hours flying experience in the DC @-@ 10 .

= = Accident = =

The weather was clear , with a northeast wind at 22 knots (25 mph ; 41 km / h) . At 2 : 50 CDT , Flight 191 pushed back from gate K5 and was cleared to taxi to runway 32R . Maintenance crews present at the gate did not notice anything unusual during pushback , engine start , or taxi .

Everything looked normal as the flight began its takeoff roll at 3 : 02 .

Just as the aircraft hit takeoff speed , the number one engine and its pylon assembly separated from the left wing , ripping away a 3 @-@ foot (0 @.@ 91 m) section of the leading edge with it . The combined unit flipped over the top of the wing and landed on the runway . Robert Graham , supervisor of maintenance for American Airlines , stated : " As the aircraft got closer , I noticed what appeared to be vapor or smoke of some type coming from the leading edge of the wing and the No. 1 engine pylon . I noticed that the No. 1 engine was bouncing up and down quite a bit and just about the time the aircraft got opposite my position and started rotation , the engine came off , went up over the top of the wing , and rolled back down onto the runway ... Before going over the wing , the engine went forward and up just as if it had lift and was actually climbing . It didn 't strike the top of the wing on its way , rather it followed the clear path of the airflow of the wing , up and over the top of it , then down below the tail . The aircraft continued a fairly normal climb until it started a turn to the left . And at that point , I thought he was going to come back to the airport . "

It is not known what was said in the cockpit in the 50 seconds leading up to final impact , as the cockpit voice recorder lost power when the engine detached . The only crash @-@ related audio collected by the recorder is a thumping noise (likely the sound of the engine separating) , followed by First Officer Dillard exclaiming " Damn ! " , at which point the recording ends . This may also explain why Air Traffic Control was unsuccessful in their attempts to radio the crew and inform them that they had lost an engine . This loss of power did , however , prove useful in the subsequent investigation , serving as a marker of exactly what circuit in the DC @-@ 10 's labyrinthine electrical system had failed .

In addition to the engine 's failure , several related systems failed . The number one hydraulic system , powered by the number one engine , failed but continued to operate via motor pumps that mechanically connected it to hydraulic system three . Hydraulic system three was also damaged and began leaking fluid but maintained pressure and operation up until impact . Hydraulic system two was undamaged . The number one electrical bus , whose generator was attached to the number one engine , failed , causing several electrical systems to go offline , most notably the captain 's instruments , his stick shaker , and the slat disagreement sensors . While a switch in the overhead panel would have allowed the captain to restore power to his instruments , it was not used . It might have been possible for the flight engineer to reach the backup power switch (as part of an abnormal situation checklist ? not as part of their take @-@ off emergency procedure) in an effort to restore electrical power to the number one electrical bus . That would have worked only if electrical faults were no longer present in the number one electrical system . Furthermore , to reach the switch the flight engineer would have needed to rotate his seat , release his safety belt , and stand up . Since the aircraft never got higher than 350 feet (110 m) above ground and was in the air for only 50 seconds between when the engine separated and when it crashed , there was not sufficient time to take such an action . In any event , the first officer was flying the airplane and his instruments continued to function normally . As the wings and engines were not visible from the cockpit , the crew likely had no idea that an engine had fallen off , only that one had failed .

Since it was no longer possible to abort the takeoff at this point , the crew followed the standard operating procedure for an " engine out " climb . This procedure is to climb at the takeoff safety airspeed (V2) and attitude (angle) , as directed by the flight director . The partial electrical power failure (produced by the separation of the left No. 1 engine) meant that neither the stall warning or slat retraction indicator were operative . The crew was therefore unaware that the slats on the left wing were retracting . This retraction significantly raised the stall speed of the left wing . By following the takeoff safety airspeed , the left wing stalled while the right wing was still producing lift , so the aircraft banked sharply and uncontrollably to the left . Later , in simulator recreations of the accident , it was determined that by climbing at a higher airspeed the crash could have been averted .

The aircraft climbed to about 325 feet (99 m) above ground level while spewing a white mist trail of fuel and hydraulic fluid from the left wing . The first officer had followed the flight director and raised the nose to 14 degrees , which reduced the airspeed from 165 knots (190 mph ; 306 km / h) to the takeoff safety airspeed (V2) of 153 knots (176 mph ; 283 km / h) , the speed at which the aircraft could safely climb after sustaining an engine failure . However , the engine separation had severed the hydraulic fluid lines that controlled the leading edge slats on the left wing and locked them in

place , causing the outboard slats (immediately left of the No. 1 engine) to retract under air load . The retraction of the slats raised the stall speed of the left wing to approximately 159 knots (183 mph ; 294 km / h) , 6 knots (6 @.@ 9 mph ; 11 km / h) higher than the prescribed takeoff safety airspeed (V2) of 153 knots (176 mph ; 283 km / h) . As a result , the left wing entered a full aerodynamic stall . At 325 feet (99 m) above ground level , the resulting asymmetric lift caused the aircraft to commence rolling rapidly to the left and to enter a steep dive from which it could not recover , despite maximum opposite control inputs by the first officer . The aircraft continued rolling until it was partially inverted at a 112 @-@ degree bank angle , right wing over left wing . It then slammed into a field approximately 4 @,@ 600 ft (1 @,@ 400 m) from the end of the runway . Large sections of aircraft debris were hurled by the force of the impact into an adjacent trailer park , destroying five trailers and several cars . The DC @-@ 10 had also crashed into an old aircraft hangar located at the edge of the airport at the former site of Ravenswood Airport , which was used for storage . The nearly full fuel load ignited in a huge fireball almost immediately . The aircraft was almost completely destroyed , with no significant pieces of the fuselage remaining . The only sizable components left were the landing gear , the two engines that were still attached to the aircraft at impact , the engine that separated from the aircraft , and the tail section .

A fireman assisting at the scene of the crash later stated , " We didn 't see one body intact , just trunks , hands , arms , heads , and parts of legs . And we can 't tell whether they were male or female , or whether they were adult or child , because they were all charred . " Another first responder on the scene stated , " It was too hot to touch anybody and I really couldn 't tell if they were men or women . Bodies were scattered all over the field . "

In addition to the 271 people on board the aircraft , two employees at a nearby repair garage were killed and two more severely burned . At 273 victims , this was the deadliest accident in US aviation history . Of the victims , only about a dozen bodies were found intact . Three additional residents were injured from falling aircraft debris . The crash scene was in a field northwest of the intersection of Touhy Avenue (Illinois Route 72) and Mount Prospect Road on the border of the suburbs of Des Plaines and Mount Prospect , Illinois .

= = Investigation = =

The National Transportation Safety Board was responsible for investigating the crash and determining what caused the engine to separate from the aircraft and the reason why the aircraft was unable to remain airborne on its two remaining engines .

The loss of the engine by itself should not have been enough to cause the crash ; the aircraft should have been capable of returning to the airport using its remaining two engines . Unlike other aircraft designs , however , the DC @-@ 10 did not include a separate mechanism to lock the extended leading edge slats in place , relying instead solely on the hydraulic pressure within the system . In response to the accident , slat relief valves were mandated to prevent slat retraction in case of hydraulic line damage .

The wreckage was too severely fragmented to determine the exact position of the rudders , elevators , flaps , and slats prior to impact and examination of eyewitness photographs showed only that the right wing flaps were fully extended as the crew tried unsuccessfully to correct the steep roll they were in . The left wing flaps could not be determined from the blurry color photographs , so they were sent to a laboratory in Palo Alto , California for digital analysis , a process that was pushing the limits of 1970s technology and necessitated large , complicated , and expensive equipment . The photographs were reduced to black @-@ and @-@ white , which made it possible to distinguish the flaps from the wing itself and thus proved that they were retracted . In addition , it was also verified that the tail section of the aircraft was undamaged and the landing gear was down .

Wind tunnel and flight simulator tests were conducted to help to understand the trajectory of the aircraft after the engine detached and the left wing slats retracted . Those tests established that the damage to the wing 's leading edge and retraction of the slats increased the stall speed of the left wing from 124 knots (143 mph) to 159 knots (183 mph) .

The DC @-@ 10 incorporates two warning devices that might have alerted the pilots to the

impending stall : the slat disagreement warning light , which should have illuminated after the uncommanded retraction of the slats , and the stick shaker on the captain 's control column , which activates close to the stall speed . Both of these warning devices were powered by an electric generator driven by the number one engine . Both systems became inoperative after the loss of that engine . The first officer 's control column was not equipped with a stick shaker ; the device was offered by McDonnell Douglas as an option for the first officer , but American Airlines chose not to have it installed on its DC @-@ 10 fleet . Stick shakers for both pilots became mandatory in response to this accident .

= = = Engine separation = = =

Witnesses were in universal agreement that the aircraft had not struck any foreign objects on the runway and no pieces of the wing or other aircraft components were found with the engine , proving that nothing had broken off and hit it . The engine separation thus could only have come from an internal failure . From an examination of the detached engine the NTSB concluded that the pylon attachment had separated as the result of damage incurred before the crash . Investigators looked at the aircraft 's maintenance history and found that its most recent service was eight weeks before the crash , during which this particular engine had been removed from the aircraft for repairs . The pylon , the rigging holding the engine onto the wing , had been damaged during the procedure . The procedure recommended by McDonnell @-@ Douglas called for the engine to be removed from the pylon before detaching the pylon itself , but American Airlines , along with Continental Airlines and United Airlines , had begun to use a procedure that saved approximately 200 man @-@ hours per aircraft and " more importantly from a safety standpoint , it would reduce the number of disconnects (of systems such as hydraulic and fuel lines , electrical cables , and wiring) from 72 to 27 . " The new procedure involved mechanics removing the engine and pylon as a single unit . A large forklift was used to support the engine while it was being detached from the wing ? a procedure that was found to be extremely difficult to execute successfully , due to difficulties with holding the engine assembly straight while it was being removed .

The field service representative from McDonnell @-@ Douglas said the company would " not encourage this procedure due to the element of risk " and had so advised American Airlines . McDonnell @-@ Douglas , however , " does not have the authority to either approve or disapprove the maintenance procedures of its customers . "

The accident investigation also concluded that the design of the pylon and adjacent surfaces made the parts difficult to service and prone to damage by maintenance crews . There were two different approaches to the one @-@ step procedure : using an overhead hoist or using a forklift . United Airlines used the hoist ; American and Continental Airlines used the forklift . Inspection of the DC @-@ 10 fleets of the three airlines showed that while United Airlines ' hoist approach seemed to work , there were several DC @-@ 10s at both Continental and American with severe and potentially fatal damage to their pylon mounts .

The forklift method had some setbacks : If the forklift was incorrectly positioned , as with the procedure used by American , the engine would rock like a see @-@ saw and jam against the pylon attachment points . The forklift operator was guided only by hand and voice signals ; the positioning had to be perfect or damage could result . The maintenance work on N110AA did not go smoothly . Aircraft mechanics started to disconnect the engine and pylon , but there was a shift change halfway through . When work was resumed , the pylon was jammed on the wing and the forklift had to be repositioned .

After the crash , an examination of the pylon attachment points on the engine revealed damage to the wing 's pylon mounting bracket that matched the shape of the pylon 's rear attachment fitting . This meant that the pylon attachment fitting had struck the mounting bracket . This was important evidence because the only way the pylon fitting could strike the wing 's mounting bracket in the observed manner was if the bolts that held the pylon to the wing were removed and if the engine was being supported by something other than the aircraft . Hence investigators were able to determine that the observed damage to the rear pylon mount existed before the crash , rather than

being caused by it .

The damage was not enough to cause an immediate failure . However , a fatigue crack developed and expanded slightly with each takeoff and landing over eight weeks until Flight 191 , when the damaged rear pylon mount reached the breaking point and failed . Without this fitting in place , the engine , at full takeoff thrust , rotated upward on its still @-@ attached forward pylon mount . The structure surrounding the forward pylon mount then overloaded and failed , and the engine broke off .

= = Media reaction = =

The disaster and investigations received widespread coverage in the media , assisted by new news gathering technologies . The impact on the public was increased by the dramatic effect of an amateur photo taken of the aircraft rolling that was published on the front page of the Chicago Tribune on the Sunday two days after the crash .

There were some early reports that a collision with a small aircraft had been the cause of the crash . This apparently was the result of the discovery of small @-@ aircraft parts among the wreckage at the crash site . National Transportation Safety Board vice @-@ chairman Elwood T. Driver , in a press briefing , was photographed holding a broken bolt and nut , implying these parts were a cause of the accident . The small @-@ plane parts were subsequently determined to have been on the ground at the time of the crash , at the former general aviation Ravenswood Airport , a facility that had been out of service for a few years . An owner there had been selling used aircraft parts from a remaining hangar building .

The crash of Flight 191 brought strong criticism from the media regarding the DC @-@ 10 's safety and design . The DC @-@ 10 had been involved in two accidents related to the design of its cargo doors , American Airlines Flight 96 (1972) and Turkish Airlines Flight 981 (1974) . The separation of engine one from its mount , the widespread publication of the dramatic images of the airplane missing its engine seconds before the crash , and a second photo of the fireball resulting from the impact , raised widespread concerns about the safety of the DC @-@ 10 . The final blow to the airplane 's reputation was dealt two weeks after the crash , when the aircraft was grounded by the FAA . Although the aircraft itself was later exonerated , the damage in the public 's eye was already done .

= = Cause = =

The findings of the investigation by the National Transportation Safety Board were released on December 21 , 1979 :

The National Transportation Safety Board determines that the probable cause of this accident was the asymmetrical stall and the ensuing roll of the aircraft because of the uncommanded retraction of the left wing outboard leading edge slats and the loss of stall warning and slat disagreement indication systems resulting from maintenance @-@ induced damage leading to the separation of the No. 1 engine and pylon assembly at a critical point during takeoff . The separation resulted from damage by improper maintenance procedures which led to failure of the pylon structure .

Contributing to the cause of the accident were the vulnerability of the design of the pylon attach points to maintenance damage ; the vulnerability of the design of the leading edge slat system to the damage which produced asymmetry ; deficiencies in Federal Aviation Administration surveillance and reporting systems which failed to detect and prevent the use of improper maintenance procedures ; deficiencies in the practices and communications among the operators , the manufacturer , and the FAA which failed to determine and disseminate the particulars regarding previous maintenance damage incidents ; and the intolerance of prescribed operational procedures to this unique emergency .

The NTSB determined that the damage to the left wing engine pylon had occurred during an earlier engine change at the American Airlines aircraft maintenance facility in Tulsa , Oklahoma , on March 29 and 30 , 1979 .

= = DC @-@ 10s afterward = =

In response to this accident , American Airlines was fined $ 500 @,@ 000 by the U.S. government for improper maintenance procedures .

On June 6 , 1979 , two weeks after the crash , the Federal Aviation Administration suspended the type certificate for the DC @-@ 10 , thereby grounding all DC @-@ 10s under its jurisdiction . It also enacted a special air regulation banning the DC @-@ 10 from U.S. airspace , which prevented foreign DC @-@ 10s not under the jurisdiction of the FAA from flying within the country . This was done while the FAA investigated whether or not the airplane 's engine mounting and pylon design met relevant requirements . Once the FAA was satisfied that maintenance issues were primarily at fault and not the actual design of the aircraft , the type certificate was restored on July 13 and the special air regulation repealed . However , the type certificate was amended , stating that " ... removal of the engine and pylon as a unit will immediately render the aircraft unairworthy . "

The crash of another DC @-@ 10 at the end of November , Air New Zealand Flight 901 , exactly six months after Flight 191 , added to the DC @-@ 10 's negative reputation . The crash of Flight 901 , an Antarctic sightseeing flight which hit a mountain , was caused by several human and environmental factors not related to the airworthiness of the DC @-@ 10 , and the aircraft was later completely exonerated in that accident .

Yet another DC @-@ 10 , performing Western Airlines Flight 2605 , crashed in Mexico City after a red @-@ eye flight from Los Angeles barely 5 months after the crash of American Airlines flight 191 . The Western Airlines DC @-@ 10 's crash , however , was due to low visibility and an attempt to land on a closed runway .

Ironically , the crash of yet another DC @-@ 10 , United Airlines Flight 232 , ten years later restored some of the aircraft 's reputation . Despite losing an engine and all flight controls and crash @-@ landing in a huge fireball (which was caught on video by a local news crew) , 185 people survived the accident . Experts praised the DC @-@ 10 's sturdy construction as partly responsible for the high number of survivors , though the efforts of the crew were primarily responsible .

Despite initial safety concerns , the DC @-@ 10 continued to serve with passenger airlines for over 30 years after the crash of Flight 191 . In the end , it was newer , more fuel @-@ efficient twin @-@ engined airplanes from Boeing and Airbus and not safety concerns that ultimately ended the passenger career of the DC @-@ 10 . Many retired passenger DC @-@ 10s have since been converted to all @-@ cargo use . DC @-@ 10 freighters , along with its derivative , the MD @-@ 11 , form the backbone of the FedEx Express fleet . The DC @-@ 10s have been upgraded with the glass cockpit from the MD @-@ 11 , thereby turning them into MD @-@ 10s . American Airlines retired its last DC @-@ 10s in 2000 after 29 years of service . In February 2014 , Biman Bangladesh Airlines operated the final DC @-@ 10 passenger flights .

= = Notable victims = =

Some notable victims in the crash of Flight 191 were :

Itzhak Bentov , Israeli biomedical inventor (the cardiac catheter) and New Age author (Stalking the Wild Pendulum and A Cosmic Book) .

Sheila Charisse , the daughter @-@ in @-@ law of movie actress Cyd Charisse .

Leonard Stogel , music business manager / promoter / producer / executive for California Jam and California Jam II , Sweathog , The Cowsills , Sam the Sham , Tommy James & The Shondells , Redbone , Gentle Giant , and other musical groups . Coincidentally , Stogel 's parents had earlier perished on American Airlines Flight 1 .

Several people connected to Playboy magazine :

Several members of the American Booksellers Association who were on their way to their annual convention at the Los Angeles Convention Center , where they were to have a joint party organized by Playboy founder Hugh Hefner . This included Judith Bennett , author of the book Sex Signs : Every Woman 's Astrological and Psychological Guide to Love , Health , Men and More .

Victoria Haider , magazine editor for Playboy magazine (and sometimes editor of Harlan Ellison) .
Judith Wax and her husband , Sheldon Wax . Judith Wax frequently contributed to Playboy (Sheldon was its managing editor) , notably the annual " Christmas cards " piece that " presented " short satirical poems to various public figures . In her 1979 book , Starting in the Middle , she had written about her fear of flying on page 191 .
Robert Walton Vaughan , Professor of Chemical Engineering , California Institute of Technology , leading researcher in nuclear magnetic resonance and catalysis .
John B. Wear , Jr . , M.D. , Professor & Chairman of Urology , University of Wisconsin Medical School .

= = Memorial = =

For 32 years there was no permanent memorial to the victims . Funding was obtained for a memorial in 2009 , through a two @-@ year effort by the 6th grade class of Decatur Classical School in Chicago . The memorial , a 2 @-@ foot (0 @.@ 6 m) concave wall with interlocking bricks displaying the names of the crash victims , was formally dedicated in a ceremony on October 15 , 2011 . The memorial is located in a park two miles east of the crash site .
A now @-@ faded banner reading " In Remembrance of American Airlines Flight 191 May 25 , 1979 " is situated on a fence at the corner of West Touhy Avenue and South Mt . Prospect Road , near the site of the crash .

= = In other media = =

The cable / satellite TV channel The National Geographic Channel produced a documentary on the crash , and an episode from Seconds from Disaster titled " Chicago Plane Crash " detailed the crash and included film of the investigation press conferences .
The Smithsonian Channel 's television series Air Disasters profiled the crash in the episode " Catastrophe at O 'Hare . "
The television series Mayday profiled the crash in the episode " Catastrophe at O 'Hare " .
After the crash and the media attention that was focused on the DC @-@ 10 , American Airlines replaced all " DC @-@ 10 LuxuryLiner " logos on the fuselage with a more generic " American Airlines LuxuryLiner " .
In the days following the crash , a man named Clarence Bean , Jr . , claimed that his pregnant girlfriend , Diane Chorba , was on the flight , but Cook County medical examiners assigned the task of identifying the crash victims later disproved this . Bean was found guilty of her murder in 2001 .
Chicago folk singer Steve Goodman wrote the song " Ballad of Flight 191 (They Know Everything About It) " in response to the crash and the subsequent investigation as the inaugural song for a series of topical songs which aired on National Public Radio in 1979 .
Chicago post @-@ hardcore punk band The Effigies wrote the song " Body Bag " about the crash . The lyrics included " Plane just left O 'Hare / On time flight one @-@ nine @-@ one / Disaster in the air / Starboard engine 's gone " (although it was the port engine that was actually lost) .
The Michael Crichton novel Airframe described the incident in detail as an example to the reader how a " good airplane (DC @-@ 10) " could be " destroyed by bad press " .