1. 1 Introduction
The new era of 21st century is globalised and very advanced due to the education which introduces technology and these technologies are consumed by everyone as individual and globally. This assignment will increase the understanding of aircraft functions and its failure which are related to human factor and other functions like mechanical fault or hydraulic leakage moreover what all happened on 25 May 1979 is briefly discussed in addition to it McDonnell-Douglas DC-10-10 aircraft, crashed into an open field just short of a Chicago-O’Haru International Airport, Illinois after about about 4,600 ft northwest of the
departure end of runway. The assignment has vital topics concerning the investigation of an Aircraft Accident. One of the greatest innovations of mankind; A 21st century industrial revolution that has completely transformed the way we live today. A creation that has taken the aviation industry to a whole new level, the knowledge used to make aircraft air worthy. Moreover many aspects of an crash and their study has been mentioned which consist of Briefly outline the report structure of an accident investigation. The assignmnet is purposeful coinciding with how aircraft has completely taken over other means of transporatation. This is required to identify with the relationship between aircraft. Each topic are tartan profoundly, these technological methods which are deliberate to facilitate the airline firm the accomplishment of these methods endow with more meticulous direction and information.

1.2 SYNOPSIS

Might 25, 1979, American Airlines, Inc., Flight 191, a McDonnell-Douglas DC-10-10 aircraft, collided with an open field barely shy of a trailer stop around 4,600 It northwest of the exit end of runway at Chicago-O’Hare International Airport, Illinois. the perceivability was 15 miles. Amid the take-off pivot, left motor and arch Flight 191 was taking off from runway 32H. The weather was clear and gathering and around 3 ft of the Leading edge of the left wing isolated from the aircraft and tumbled to the runway. Battle 191 kept on moving to around 325 ft over the ground and afterward started to move to one side. The aircraft kept on moving to one side until the wings were past the vertical position, and amid the move, the aircraft’s nose pitched down underneath the skyline.

- The report specified that the engine and assembly of the pylon detached precisely at the take off point. Yet the crew was by this time committed to take off.
- The rear pylon bulkhead disconnected originally followed by forward-facing two pylons.
- The bulkheads vanished its strong point due to its strength life. This caused in disinterest of pylon connection.
- Engine 1 shredded off commencing the left wing which steered loss in electrical connections becoming defective. These included the stick shaker, warning illuminations of stall slats.
- The ripping off of 1 m the leading edge slats because of the unit of Engine 1 prompted disappointment of the hydraulic framework which thusly brought about the withdrawal of the slats.
- The pilots diminished the pace of the aircraft according to crisis methods. This prompted improvement of stall.
- It was found that the engineers amid upkeep while adjusting, withdrew the whole pylon and engine as one unit and did not take after the methodology grew by FAA. This was done as an easy route to spare time, work and money.
- The engineers did not issue any gripes they defied while joining and separating the engine pylon gathering.
- One and only stick shaker was accessible in the cockpit. This ended up being a powerless point following both pilots need to have one each.
- The leading edge slats needed bolting framework and subsequently this prompted them withdrawing because of outside conditions.

1.3 Accident Board Findings’ The NTSB issued 23 findings regarding this accident.’

- Separation of engine pylon from the wing
- Loss of electrical and hydraulic power of flight controls
- Flight crew procedures
- Performance of improper maintainance procedures
- Lack of redundancy in stall warning system
- Lack of mechanical locks in high lift system’ Reference#1A’.faa.gov/

After an air accident, an investigation group is framed to find the accident site (if accessible), recuperate the destruction (if accessible) and to explore the reason for the accident and make the essential alterations to counteract future accidents of such nature. The groups included would be the investigation department under whose purview the aircraft has collided with, the aircraft manufacturer, criminal investigation authority, the motor manufacturers, the airline, and anyone else concerned with the aircraft manufacturing and maintenance.

Accidents are sure to happen due to mechanical disappointments or human mistakes however there ought to be an approach to dodge an accident happening later on and this is the reason each country has its own
particular accident, investigation and safety board. There are universal flying safety and accident investigations associations which research about how the accident happened and after that they give the discoveries and suggestions which permit to enhance the safety in aeronautics field and declines the possibilities of an accident in future. An accident or investigation report is issued by any of the investigation sheets like in this crash the accident investigation report has been issued.

The NTSB group was sent in the spot of episode for examinations. They needed to figure out the last commencement seconds before the accident regarding why the plane slammed. They are because of give the finished report to FAA- Federal Aviation Authority.

1.4 The investigation process integrates the subsequent steps that are conceded out in accidents

Aircraft Operation Accountability of repossessing information about the aeroplane and flight-crew before the occurrence.

Aircraft Systems Investigative the aircraft’s numerous systems like hydraulics system, electrical system and pneumatics also with the aircraft’s flight control systems.

Air Traffic Control Re-enactment of the communications between the pilots and the air traffic controller

Climatic Conditions Gathering of the weather figures around the aircraft’s when accident occurred.

Crew Performance Studying how the aircraft’s flight crew faced with all the circumstances prior to the occurrence concerning the aircraft.

The basic report structure of this investigation is given below:

1. General Information
   ? History of the Aircraft
   ? Injuries to the crew including passengers
   ? Damage to Aircraft
   ? Data acquired of the crew
   ? Information about the aircraft
   ? Meteorological Data

2. Research
   ’ Failure of Accident
   ’ Maintenance Procedures
   ’ Elements leading to the failure

3. Conclusions
   i. Report Findings
   ii. Sources of Failure

4. Recommendations

Teams involved in investigation:

1. National Safety Transport Board
2. FAA

1.5 Antiquity of Flight

I. At 1459 c.d.t., May 25, 1979, the flight no 191, a McDonnell Douglas DC-10 series 10 aircraft (DC-10-10) (N110AA), of the American Airlines, which taxied through the planned passenger flight was en route to Los Angeles, California along with 258 passengers and 13 crewmembers on board. The personnel in charge of maintenance who checked the flight’s engine start, push-beck, did not monitor anything unusual even at beginning of taxi.

II. There seemed to be a fine weather at the point of departure and the recorded surface wind was 020(degree) at 22kns. Therefore flight no 191 was signaled to taxi to runway no 32 right (32R) for departure. According to the Takeoff Data Card of the company the stabilizer trim setting was 5(degree) aircraft noseup, the takeoff flap setting was 10(degree) while the takeoff gross weight was 379,000 lbs. The low pressure compressor (N1) r.p.m setup was 99.4%, serious engine breakdown speed (V) was 139 kns, recorded airspeed (KIAS), rotation speed (VR) was 145 KIAS, and at the same time takeoff safety speed was 153 KIAS.

III. The flight no. 191 had been signaled to taxi into position on runway 32R and hold. The flight was indicated to take off at 1502:38 and the captain informed at 1502:46 ‘American one ninety-one under way’. The flight crew’s voice on the call was recognized as the captain’s because company personnel knew their voices well, as well as the ensuing V1 and VR speed callouts on the cockpit voice recorder (CVR).
IV. Until the rotation the takeoff roll was normal, when suddenly the sections of the left, or No. 1, engine pylon formation came off the aircraft. White smoke or vapor was seen by witnesses appearing from the vicinity of the No.1 engine pylon. The whole of engine and pylon of No. 1 got split apart from the aircraft, went over the wing top and dropped down the runway.

V. After rising up to 6,000 ft down runway 32R, flight no 191 had reached an altitude of about 300ft escalating in a wings-level altitude above ground (a.g.l) with its wings still stable. The aircraft started to descend in just a short while after that and started to rotate and sway to the left, with its nose pitched downward. While it descended, it continuously rolled towards left side until the wings were past the upright position.

VI. The crash of flight no. 191 took place in a wide field and trailer park around 4,600 ft northwest of the departure side of the runway 32K. in the duration of the crash the aircraft was completely damaged and an explosion was created along with ground fire.

VII. The time noted of the aircraft crash was 1504, during daylight hours and the coordinates of the crash location were 42(degree) 00'35"N, 87(degree) 55'45"W.

Damage to Aircraft
The aircraft was completely demolished as the impact was humongous.

Other Damage
A number of automobiles, an antique hangar and a mobile house were damaged along with it.

Personnel Information
There were all skilled flight and cabin personnel.

Aircraft Information
American Airlines Inc. owned and operated, flight no 191, a McDonnell-Douglas DC-10-10 was power-driven by 3 General Electric CF6-6D engines. The left engine was measured to be 11,512 lbs, the pylon, 1865 lbs, totaling up to engine-pylon assembly weight of 13,477 lbs. The aircraft’s center of gravity (c.g) moved from aft 2% to about 22% mean aerodynamic chord (MAC) due to the loss of the engine-pylon formation. The final c.g was within the advance (16.4% MAC) and aft (30.8% MAC). Meanwhile the lateral c.g shift was 11.9 inches towards right side.

Meteorological Information
The weather was seemingly fair at the moment of the catastrophe. According to the surface monitoring at O’Hare International these were the notations:

1451, surface aviation: Unclouded, clarity 15 mi, climate none, thermal reading 63(degree F), dewpoint 29(degree F), winds 020(degree) at 22 kts altimeter 30.00 inHg.

1511, local: Unclouded, clarity 15 mi, climate none, thermal reading 63(degree), dewpoint 29(degree F), winds 020(degree) at 19 kts gusting to 28 kts, altimeter 30.00 inHg., conclusion aircraft calamity.

Aids to Navigation
Not applicable.

Communications
No faults were found in communications.

Aerodrome Information
The location of Chicago-O’Hare International Airport is 16 mi northwest of downtown Chicago and has a total of 7 runways. The 10,003 ft lengthy and 150 ft large with a concrete ground is the runway 32R. The distance from the ground of the runway is recorded to be 649ft mean sea level (m.s.l) at its southeast end and at the northwest end it is 652 ft m.s.l.

DC-10 Service points 54-48 and 54-59 were announced by the McDonnell-Douglas on May 31, 1975 and February 1, 1978. These 2 service points were issued to service-related unacceptable circumstances. The replacement of the pylon forward bulkhead’s upper and lower spherical bearings were mentioned in service point 54-49 as well as the methods for achieving repairs. Compliance was suggested at the operator’s ease.

The replacement of the pylon aft bulkhead’s spherical bearing had been mentioned in service point 54-48 and the compliance with changes was open to be decided based on operator’s practice. The achievement of modification methods included the following note. ‘It is recommended that this procedure be accomplished during the engine removal.’ The recommendation was repeated in the service points and mentioned that, ‘The following instructions assume that engines 1 and 3 are removed.’ Although, according to American Airline’s vice president for maintenance and engineering, affirmed at the Safety Board’s public hearing, that
manufacturer’s review for repair timing is not particularly persistent with air carrier procedures. Taking for instance the need for engine’s change is not being estimated ‘with any great accuracy’ by American Airlines. It would have been unworkable to accomplish the methods of service point 54-48 as ’it has to be scheduled,’ and even the aircraft would have to be planned to undertake the changes needed.

The pylons were to be eradicated in conformance with the operations contained in Chapter 54.00.00 of the DC-10 Maintenance Manual as conducted in the service point 54-48. Firstly the exclusion of the engine and then the removal of the pylon is directed in Chapter 54.00-00. The weight of the pylon is 1,865 lbs. and the c.g. point is about 3ft forward of the of the forward connector points; on the other hand the total weight of the pylon and the engine together is 12,477 lbs. and the c.g. point is around 9 ft forward of the forward connector points. The sequence presented for the exclusion of the attach fittings as per the manual was: The forward upper attach assembly, the forward lower attach assembly, the thrust link, and the aft bolt and bushing.

After the December calamity the forklift was rectified for drift down and ‘nothing was found’. The unit was reexamined after a number of months. The defect was amended, downward drift was found and no more complexities were experienced.

The maintenance methods of all United States carriers directing DC-10 series aircrafts were reviewed in the time of post-accident investigation. There were about 175 pylon and engine assemblies detached and reinstalled by the United States carriers as per the evidence. The lowering and lifting of the pylon and engine as an individual unit was included in 88 of these operations. 12 of the 88 were submerged and uplifted with the help of an overhead crane. The rest 76 were raised with the use of forklift. Cracks were found where the forklift was used and there were 9 such situations wherein impact destruction was sustained.

After the incident additional analysis was done, so the NTSB suggested the accompanying to the FAA:
- To convey directives for the answers related to the pylon assembly and reinstallation procedures. To make sure that no more damage is done evacuation of the sealant is most vital. Alongside, various processes must be taken to identify the damage or cracks on little bolts and more.
- To bring directives for thorough checking of all DC aircrafts pylon assembly inspection procedures.
- A note can be sent regarding all flights to quit honing the method of detaching the pylon along with the engine to the maintenance department and tell them to follow the methods used by FAA.
- Re-examining of the air speed would be important information in case of an engine loss.
- Issuing Airworthiness Directives (AD) to inspect all DC-10 aircraft for engine pylon damage
- Proposed revision to 14 CFR 121.707 to more clearly define major and minor repair categories
- Instructions for revisions of operational procedures and instrumentation to increase stall margin during secondary emergencies

Federal Aviation Regulations were pertinent to the DC-10

1.7 Accidents have changed civil aviation regulations globally

The following Federal Aviation Regulations were pertinent to the DC-10 design and certification:
- 14 CFR 25.207 Stall Warning There should be apparent and distinguishing stall warning with enough margins to avoid inadvertent stalling with the flaps and landing gear in any usual point to the pilot in straight and turning flight.
- 14 CFR 25.701 – Flap Interconnection There must be proper synchronization of the movement of flaps on opposite sides of the plane of symmetry with a mechanical interconnection, except for when airplane is accommodated with flight safety features with the flaps retracted on one side and extended on the other.
- 14 CFR 25.1435 Hydraulic Systems The indication of the pressure and the amount of fluid in each continuously functioning system must be shown by implementing a means at a flight crewmember station.
- 14 CFR 25.1529 Maintenance Manual Certain points must be considered by the applicant in creating important information:
  - Tolerances and modifications crucial for airplanes’ appropriate functioning.
  - Practices of leveling, raising and towing
  - Practices of adjusting control surfaces.

The following Air Carrier Operations regulations were pertinent:
- 14 CFR 121.379 Authority to Perform and Approve Maintenance, Preventive Maintenance, and Alterations Any aircraft, airframe, aircraft engine, propeller, or appliance for return to facility after repair, preventive repair, or
adjustments that are completed under paragraph certificate holder of the segment may be accepted by any certificate holder. However, the work must be done following the technical data assigned by the administrator if it is a case of serious repair or adjustment.

14 CFR 121.707 Alteration and Repair Reports A report of every serious renovation or adjustment of airframe, aircraft engine, propeller or appliance of an aircraft functioned by it must be prepared by the certificate holder upon its finalization.

The following reporting requirement is also relevant:
14 CFR 21.3 Reporting of Failures, Malfunctions, and Defects Type Certificate (plus a supplemental Type Certificate) holder, Parts Manufacturer Approval (PMA), TSO authorization or the licensee of a Type Certificate must declare any breakdown, fault or error in any product, element, method or article created by it which actuates any of the circumstances indexed below.

? Fires triggered by a setup or devices malfunction, breakdown or error.
2.1 Task#- 2) Explain how the system should have worked in normal situations

Hydraulic system structure of the aircraft

The two engine hydraulic pumps generate power to three pressurize systems that are corresponding. Two auxiliary pumps are included in system 3. In case of any accidents the auxiliary pumps are used as an alternate. However, these are mechanized through air driven generator. In case the engine stops operating, 2 reversible motor pumps, an operating system, are able to lend power to the unpressurised system. The 2 irreversible pumps are used to generate power to the different areas of flight controls.

Pumps (Engine-driven)
The 3 engines are pressurized by the engine driven pumps. It consists of right and left pumps. The hydraulic system is used to generate power to the brake system as well as the low steering wheel and the flight controls. The flight board panels are included with separate switches which are used to control these pumps. All systems have ire shut off valve accessible in them to have power over the fluid supply. Even if there is insufficiency of power of electricity, the pump has the capacity to stay functional and it starts by itself once it has been shut off. [Reference#3A-hydraulic system structure’

Auxiliary Pumps

There are 2 electrical auxiliary pumps in the number 3 hydraulic system which works when the engine is not functioning. Pilot’s overhead panels have switches which have control over the auxiliary pumps. The number one auxiliary hydraulic pump acts as an crisis source for the flight controls and supply them with pressure. During the failure of all engines the ADG is used to supply power to the auxiliary pump.

Reversible motor pumps

By using reversible pumps pressure can be conveyed from a functioning hydraulic system to the one that has been unpressurized. This is referred to as the mechanical shift of energy. The shift of pressure is 2 way. There are control buttons in the flight engineer board which can turn on the pumps. In case the hydraulic fluid of the operating system falls under a particular value, the pump and the motor blend stops functioning.

Irreversible Motor Pumps

There are 2 irreversible motor pumps used to exchange hydraulic pressure. This pressure is divided between the systems. The pumps generate power to the upper and lower radar, horizontal stabilizer. The non reversibility is stopped with the switch being moved from ‘RUDDER STBY PWR’ to ‘OFF’ point.

2.2 Operation of the Hydraulic System

The main flight controls which consists of the inboard and the outboard ailerons, 2 segments of radars and elevators each, while the secondary flight control which contains the slates for the leading edge, inboard & outboard flaps, double horizontal stabilizer and spoiler, is all found in the hydraulic system. The two forms of control surfaces are both operated with 2 hydraulic systems.

The right inboard and left outboard aileron and elevator both are controlled by the hydraulic system number 1 as well as the system of upper radar, pilot’s brake setups and the horizontal trim. Furthermore, the left inboard and right outboard aileron and elevator is controlled by the hydraulic system number 2 along with the system of the lower radar and the right side outboard elevator. As for the hydraulic system number 3, it has control over the right outboard and right inboard aileron plus the left and right inboard elevators, the actuators of radar, the first officer’s brake setups and trims of stabilizer.

These hydraulic systems are used to supply power to the controls and for instance if there is a system
malfunctions then one of them must be working to provide power. The backup forces to start by it are the two reversible motor pumps which do not need flight crew to switch it on.

Electricity is used to drive the auxiliary pumps no matter what the location is required on the ground. The backup electricity supply for one of the auxiliary pumps in case of an emergency is ADG.

3.1 Task#3- Explain the reason which led to this failure

Reason Which Lead To Component Failure

There was no proper maintenance system in which the procedures for instalment of the Eng 1 and pylon assembly were defective. Therefore, the Eng 1 pylon assembly was disjoined. 8 weeks prior to the incident after serious investigation, the team ascertained that the engineers were working on a simple procedure for disintegrating the engine and pylon assembly. The engineer need to part the engine first and the pylon assembly with help of a fork lifter according to the maintenance methods. However, they went along with parting both together to redeem time, labour and cost.

A shift change triggered the problem in it. The second shift attained information that the engine was not put steadily in the fork lifter plus the detachment task was yet to be completed therefore they had to begin from stage one once more. A crack had formed in the flange in the period of this stage. This actually occurred due to the connection of the flange and the clevis after the extraction of the bolt. Therefore, it ended up with a 10 inch crack in the flange attachment. Thereupon this indicates that the maintenance methods were not followed.

3.2 The Effect of the Failed Component on the System

Due to the detachment of the left wing from Eng 1 the electrical connections were cut off from the left wing. Failure of the recording of the incident was declared by the CVR following the phrase Datum by the pilot. It was around this time that the engine also got detached. Not much time after that displayed-stick shaker and slats disagreement system warnings were shown plus the lights in the cockpit stopped working as well. It all was caused by the disconnection of the electrical circuit. It had even supplied power to the voice recorder and stick shaker. As the engine had been cut off there was no electrical power and so the stick shaker wasn’t operating for the pilot. Even the retraction of the leading edge slats led by the hydraulic system had been detached due to the engine coming off 3 ft of the leading edge and this directed to loss in lift.

As there was no electrical power generation from Eng 1 to power the warning system in the cockpit the pilots had not been cautioned. (Reference#3B)

3.3 Effect of the Failed System on the Performance of the Aircraft

The hydraulic system failure created the retraction of the leading edge slats. These slats were very important in developing lift.

Hydraulic systems at hand in the wings help to extend them during takeoff. Although as the left wing slats were retracted due to hydraulic failure and right wing developing generating lift, there was asymmetrical slats agreement. Furthermore, as the warning systems were not working due to lack of electrical supply from Eng 1 the captain was not aware of the incident. Finally the plane began to roll towards left side because of the asymmetrical stall and pilots were unable recuperate it and so it crashed in the trailer park.

4.1 – Task#4 Comparison between my and NSTB RECOMMENDATIONS

The NSTB and FAA recommendations has been briefly highlighted in above tasks.

‘ Introducing severe manufacturer quality control programs and service difficulty and service information collection

‘ Issuing alert maintenance bulletins to discontinue improper maintenance techniques.

‘ Periodic training provided to mechanics and technician emphasizing on sticking on the AMM with all installation of parts with the given specific procedure.

‘ All the future and existing aircrafts must be fitted with a micro sensors to ensure pylon and engine attachments are completely secured.

4.2 Reducing the Incident/Accident Rate

Repairing of aircrafts must be done regularly and parts should be analyzed and replaced as soon as possible because there are components which are prone to crack under stresses.

Engineers must carry out the method of pylon assembly detachment which is supposed to be altered and corrected.

There should now be stick shaker for both the pilot’s controls. As this would help the pilots to not lower the
speed to V2 after the detachment of an engine. There should be no concession in the quality of the components also supervisors must make sure that to complete tasks in time no alternatives were taken.

Proper inspection should be done of the aircrafts at all time such that even the minor details should be checked.

The plain manufacturers should carry out all potential tests including loss of engine, hydraulic system, electric system and more. This is to be done because when NTSB team tested 13 pilots for the take off of the 191 simulators, none of them were able to save the aircraft.

4.3 Improving the System Operation

For Hydraulic System: For maintenance:

Planned maintenance should be done for the systems linked with hydraulics. Airworthiness mandate must make sure that all the methods are being rechecked.

There should be regular checks done to ensure that optimum quantity of hydraulic fuel is available at hand. There should be complete maintenance practices defined for any component of the aircraft.

By any way possible hydraulic leaks must be forestalled as they can be extremely hazardous. All the components which are open to the elements of stress must go through stress test.

In case of an event of failure activation of alarm would be very important.

5. Conclusion

It was a great learning experience for us since it broadened our span of knowledge to another level. In our assignment we came to know about the aircraft crash investigation. In summation it was one of the best experiences of life to work on this assignment as it my first assignment of b.Eng. I learned a lot from this as it's the latest innovation of era in aviation industry.

It is generally understood that accidents occur anytime and anyplace, although these can be stopped. To confirm the safety of hundreds of passengers in the flight well qualified and skilled engineers and pilots must be hired. No gap for mistakes in all parts of the aviation from maintenance till pilots should be given. It's necessary for everyone to follow policies and regulations and along with that the methods must be altered time to time. The most vital point is that every personnel should work as a single unit. Most significantly manufacturers must take all tests of every possible condition. Also proper pilot training should be given for these circumstances. According to the above suggestions, if all rules and regulations are followed the threat of a crash can be stopped therefore proving that flight no 191 could have been rescued.

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