

*Safety & Investigation Board
(Headquarters Pakistan Civil Aviation Authority)*



AIRCRAFT ACCIDENT INVESTIGATION REPORT

**CRASH OF CESSNA 402B REG # AP-BFG
IN ARABIAN SEA NEAR KARACHI
ON 24TH FEBRUARY 2003**

WARNING

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CRASH OF CESSNA-402B REG # AP-BFG IN ARABIAN SEA NEAR KARACHI ON 24 FEBRUARY 2003

Authority: Government of Pakistan, Ministry of Defence (Defence Division) letter # AT-8(1)/2003 dated 26th February 2003.

SYNOPSIS

Accident Notification

On notification of the Accident of Cessna-402B off the coast of Karachi, Latitude 24° 53'76"N, Longitude 066° 36'40"E, on 24 February 2003, Govt of Pakistan ordered an investigation.

Brief Resume

On 24 February 2003 a Cessna-402B aircraft, belonging to Edhi Air Ambulance Services (EAAS), was hired for a chartered flight from Karachi to Jazzak (310°/ 400 NM from Karachi) by Star Air Aviation. The hiring was on behalf of M/s MCC Resource Development Company (Pvt) Limited (MRDL), a Chinese Company operating in Pakistan.

The aircraft had eight passengers on board including the pilot. The Captain of the aircraft was Captain Syed Sajid Ali, Chief Pilot Edhi Air Ambulance Services. The aircraft took off from Karachi at 0811 Pakistan Standard Time (PST). The aircraft was being radar vectored. At 0820 PST the radar controller asked the aircraft (Cessna 402B, Reg # AP-BFG) to turn right on heading 290°. The acknowledgement of this heading was the last recorded transmission from the aircraft. At 0829 PST the aircraft was observed disappearing from the radarscope, 270°/35 NM from Karachi Radar. Search and Rescue services were launched to look for the aircraft around the last radar position. The first signs of wreckage were found by a Naval Helicopter at 1133 PST, about 5 NM North West of Churna Island. While the aircraft wreckage was recovered on 27 February 2003, five bodies were recovered about four hours after the accident and a sixth body was washed ashore on 09 March 2003. Two bodies are still missing.

1. FACTUAL INFORMATION:-

1.1 Aircraft Information:

- 1.1.1 Registration Marking: AP-BFG
- 1.1.2 Aircraft Type/ maker's Serial #: Cessna 402B / 1304
- 1.1.3 Engine Types and maker's Serial #: Continental TSIO-520E, Engine S # 812680-R on left wing. Continental TSIO-520E S # 275485-R on right wing

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- 1.1.4 Certificate of registration # and Validity: Serial #659
Issued on 27-06-1996, subject to renewal of C of A
annually.
- 1.1.5 Certificate of Airworthiness (C of A) #: Serial #
612, period 07-11-02 to 08-11-03
- 1.1.6 Date of construction of airframe: 1977
- 1.1.7 Name and address of owner: M/s Edhi Air
Ambulance, JIAP, Karachi Pakistan.
- 1.1.8 Maximum Gross Weight : 6300 LBS (2863.63 Kgs)
- 1.1.9 Loading Centre of Gravity (CG) limits in C of A and
CG position: 156.5" Aft of datum line.
- 1.1.10 Airframe History:
 - a. Time since manufacture: 6843:15 hrs
 - b. Time since last O/H: 51:35 hrs
- 1.1.11 Operating life and operating time of left and right
engines since manufacture and overhaul: 375:50 hrs
for left hand engine and 1256:30 hrs for right hand
engine since new.
- 1.1.12 Defects: No defect related to occurrence was
reported since last C of A during November 2002.
However, corrosion at many places & cracks were
found in the elevator area of the tail section during
the first C of A Inspection carried out in June 1996
in Pakistan.

1.2 Crew Information:

1.2.1 Pilot-in-Command

- 1.2.1.1 Name: Captain Syed Sajid Ali
- 1.2.1.2 Position in the Cockpit: Left Side
- 1.2.1.3 Date of Birth: 13th August 1944
- 1.2.1.4 Type of Licence held and #: CPL-1726(H) & (A)
- 1.2.1.5 Medical date with status: Class1 Medical
valid upto July 2003.

1.2.2 Rating:

- 1.2.2.1 Type(s) held: PA-34, Cessna 402, Grand
Commander 680 FL & BELL 206
- 1.2.2.2 Type Current: PA-34, Cessna 402 and BELL-
206
- 1.2.2.3 Flight Instructor Rating: Flight Instructor
- 1.2.2.4 Check Rating: Rated Check Pilot

1.2.3 Flying Experience:

- 1.2.3.1 Grand Total: 7045:00 Hours
- 1.2.3.2 Total In Command: 6000 Hours (Approx)
- 1.2.3.3 Total In Command on C-402: 1400:00 Hours

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1.2.3.4 Where Trained: Army Aviation School,
Dhamial Rawalpindi, Pakistan.

1.2.3.5 Date of Joining the Organization: Sept' 1990

1.2.4 **Pilot History:** The pilot was medically fit and had a flying experience of over 7000 hours. ~~In the past~~, he had made a gears-up landing at Hyderabad while flying a PA-34 (Piper Seneca) aircraft. Besides this, he had an incident at Karachi, in which his propeller touched the runway surface on landing (PA-34) earlier. The pilot was, however, suffering from no known physical ailment. His experience varied from helicopters to single engine / twin engines fixed wing aircraft. He was a qualified flying instructor.

1.3 **History of Flight:** The aircraft was to fly from Karachi to Jazzak on charter.

1.4 **Injury to Persons:** Fatal injuries to all seven passengers and Pilot in Command.

1.5 **Damage to Aircraft:** Destroyed completely.

1.6 **Other Damages:** No co-lateral damage. Aircraft plunged into the sea.

1.7 **Meteorological Condition:** Fair weather.

1.8 **Aids to Navigation:** A serviceable transponder was on board and transmitting on Mode 'C'.

1.9 **Communications:** Serviceable VHF Radio.

1.10 **Aerodrome and Ground Facilities:** Communication and Radar facilities were serviceable and available.

1.11 **Flight Recorders:** Not Installed (Less than 5700 Kg weights category aircraft).

1.12 **Wreckage & Impact Information:** The aircraft crashed over the sea after 18 minutes of flight at 270° / 35 NM from Karachi Radar. Substantial portion of the wreckage was recovered from a depth of 40 meters.

1.13 **Fire:** There were no signs of fire on the recovered aircraft wreckage.

1.14 **Survival Aspects:** Emergency Locator Transmitter (ELT) was installed in the aircraft, which did not operate.

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1.15 **Test and Research:** Engine and aircraft parts were sent to various laboratories for tests and analysis.

2. **EVIDENCE COLLECTION – PRELIMINARIES:** Aircraft Technical and Operational Documents were taken into custody following the crash. Radar recording and ATC communications were preserved.

2.1 **Mass of Aircraft:** The flight manifest indicated that the total weight of the passengers was 1273.8 Lbs. The pilot's weight from last medical report, was 155 Lbs. There were no records of trim sheets in Edhi Air Ambulance Service (EAAS). The aircraft was carrying full fuel, i.e 166 US Gallons (996 Lbs) and the aircraft dry weight on the last C of A was 4501.2 Lbs. The total weight of the aircraft on take off for this flight was 6953.6 Lbs.

2.2 **Radar Recording:** The radar picture showed a normal flight path until a sudden gain in height from 8500 feet to 8800 feet. Then the aircraft lost height rapidly. The speed increased continuously from 120 Kts to 179 Kts till the aircraft disappeared from the radarscope at 2600 feet. The rapid decrease in height and increase in air speed indicated a high rate of descend, with a dive angle of 21 to 22 degrees. Heading variations were discernable from the original track of 290° to 330° and then to 310°. The calculated rate of descend was about 10,050 feet per minute.

2.3 **Dead Bodies:** Five bodies were recovered about 4 hours after the crash. All bodies recovered were intact with no limbs separated except the PIC, whose left leg was severed at the thigh. The leg was recovered a day later and was found intact except the imputation at the upper thigh. Only the two occupants of the front seats (i.e. the pilot and co-pilot seats) had deep cuts on the forehead, nose-bridge and the jaws area, the others had bruises only. The hands of the PIC were folded in a manner depicting a posture to avoid an impending blow in the face. Autopsy was done on only two bodies (PIC and Capt Nadir). Afghan government did not allow the autopsy of Afghan nationals.

2.4 **Aircraft Wreckage Recovery:** The wreckage was recovered on 27 February 2003, three days after the crash. The salient features of the wreckage were:

2.4.1 Wreckage was recovered by naval divers and as such wreckage diagram was prepared by them. The wreckage was spread over an area of 250 meters by 290 meters.

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- 2.4.2 On both the propellers, one blade each was found bent in the direction of rotation and one blade was bent opposite to the direction of rotation. Third blade on both the propellers was slightly bent, indicating feathered position.
 - 2.4.3 The left wing, after breaking away from fuselage during impact with water, collided with the fuselage and caused sequential damage.
 - 2.4.4 The carpet of the cabin floor was intact and clear of any burn marks etc.
 - 2.4.5 Most of the seat cushions were recovered. Those were not torn, there were no burn marks and no penetrating sharp cuts on any of the cushions.
 - 2.4.6 Harnesses of the front seats were attached at the bolts but snapped (torn off by a great force) from a point, a few inches away from the attachment points.
 - 2.4.7 Steel cables running to the tail section indicated that very strong tensile force acting from the rear of the aircraft caused their separation.
 - 2.4.8 The tail cone, horizontal stabilizer, elevators and the rudder were not found.
 - 2.4.9 Examination of the wreckage did not reveal any evidence of bird strike, any penetrating metals or fire. Similar evidence was also not found on the dead bodies.
- 2.5 **Certificates of Airworthiness (Cs of A)** Certificate of Airworthiness inspection in 1996 indicated corrosion in the tail section, which was repaired. There were cracks, whose propagation was stopped by drilling two holes. Manufacturer's advice was not sought on those repairs. These repairs required the use of a Structural Repair Manual (SRM), which was not available in EAAS to guide their engineer as to how this structural repair was to be accomplished; however, general structure repair manual was used for the work. In the subsequent six Cs of A since 1996, there was neither a mention of these snags nor was any monitoring done on those repairs. EAAS is not registered with Cessna Company and it was not in possession of the revised Manual issued by the Company. EAAS was using a Maintenance Manual that was not updated. EAAS was unaware of the Supplemental Inspection Documents (SIDs), which have been developed

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by Cessna Corporation through Supplemental Structural Inspections Program for the Principle Structural Elements (PSE) of aging aircraft. "Principle Structural Elements is that structure whose failure, if it remained undetected, could lead to the loss of the aircraft". All supplemental inspections pertaining to stabilizer, rudder and wings were not accomplished.

- 2.6 **Radio Communication:** The aircraft had positive two-way communication with Karachi ATC and the radar. No distress call was received.
- 2.8 **ATC Transcript:** This indicated a positive two way communication, which shows that the aircraft was vectored clear of military training areas under positive radar coverage.

3. TECHNICAL ANALYSIS

The initial operational investigations pointed towards a sudden departure of the mishap aircraft (MA) from its flight path and disappearance in the Arabian Sea. In the absence of aircraft wreckage, the technical investigations were focused on aircraft history awaiting the aircraft wreckage recovery.

- 3.1 **Liaison with Cessna Historian and Manufacturer:** The manufacturer and historian of Cessna aircraft incidents/accidents was contacted for guidance and relevant information. Mr Ronan Hubert, Historian and General Manager, was provided with damage details and pictures containing break up patterns. Cessna Company responded by providing the latest technical and operational documents including important "Supplemental Inspection Documents" (SIDs). These documents were a great help in the investigation.
- 3.2 **Old Airframe:** Airframe of Cessna 402B was constructed in 1977 with a capacity for 07 passengers and one flight crew. FAA WASHINGTON DC USA issued its Export C of A # E 299264 on 10 June 1996. The application for issue of C of A in Pakistan was filed on 27 June 1996. It had completed 6843:15 hours since new and 53 hrs since last C of A on 08 November 2002 before crash.
- 3.3 **Engines:** The aircraft was fitted with Continental Engines (TS10 520E); S No 812680-R (Left Engine) and S No 275485-R (Right Engine). The flight report of last 10 flights did not record any defect. These engines had flown 375:50 hours and 1256:30 hours since last overhaul inspection.

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3.4 Overhauled Propellers: The engines were fitted with McCauley Propeller 3AF 32C 504C, S No 931435(LHS) and 940538 (RHS) with blades S No NA121, NA149, NA145 (LHS) and NL037, NK077 and NK079 (RHS). Those operated for 4280:00 hours since last overhaul.

3.5 Aircraft Wreckage Analysis:

3.5.1 A general view of the aircraft wreckage reconstruction showed that main wreckage consisted of three major parts i.e fuselage with right wing, the left wing and tail area in many pieces. The right wing was still attached to the fuselage. There was no evidence of any fire or damage due to external hit by any physical object or spherical disintegration. The carpet in the passenger cabin was undamaged. There were no fire marks, carbon deposits, or any kind of sharp cuts or holes or wrapping effects. It indicated the absence of any explosion or collapse of aircraft cabin floor prior to impact with water. The carpet, passenger cabin furnishing, seat cushions, entire structure of right side fuselage wall and seat installation railing on the floor were examined and there was no evidence of explosion or fire.



3.5.2 Luggage compartment was found absolutely in clean condition and no in-flight cargo compartment fire signs were observed. There were no signatures of any explosive device being operated; the compartment was intact and it collapsed due to impact. There were no signs of any dragging of luggage or hit marks.

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3.5.3 The damages to right wing leading edge; were caused due to impact with water. There were no cuts, smears, colour marks or dents. The wreckage parts also did not show any evidence of fire or explosion.

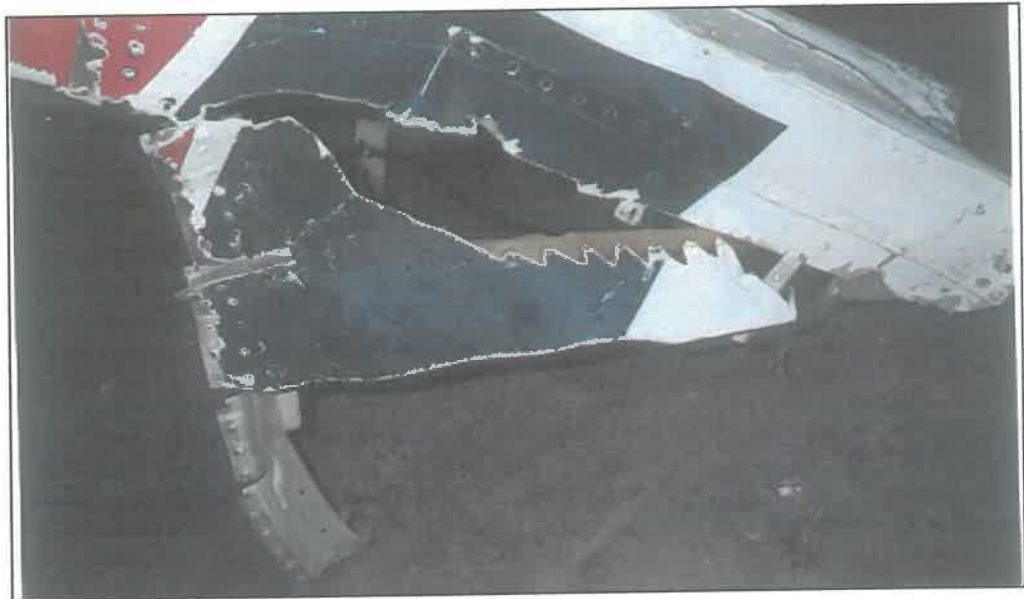


3.5.4 Another important area of evidence was the difference in damage to metal sheets in the rear as compared to forward area:

- a. Damages on wings, engines and fuselage were due to impact with water. The portions were quite large without any instantaneous shearing apart into a number of pieces.

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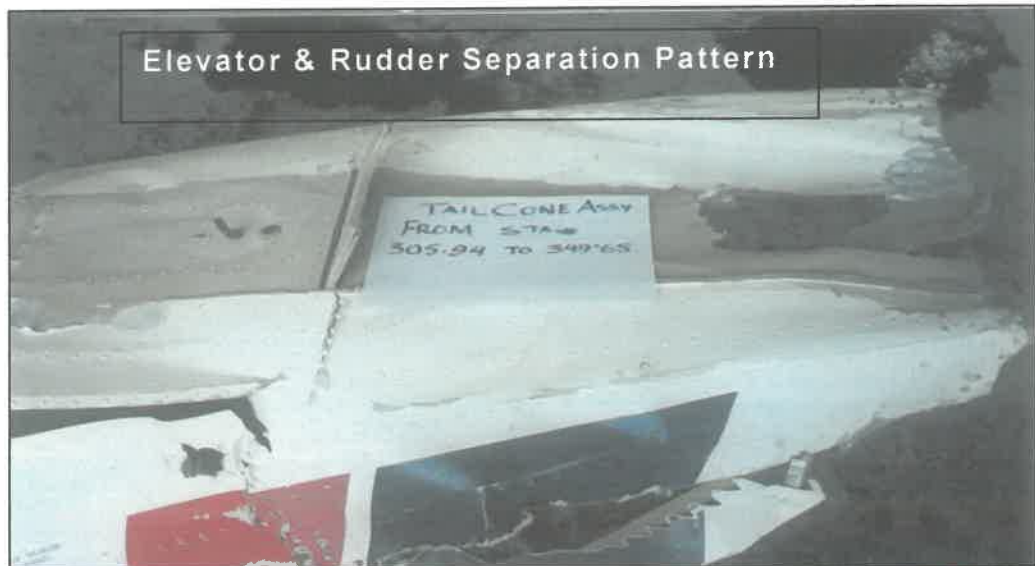
- b. Structure close to tail section was found in many panels, which appeared to have separated into haphazard and sheared off pieces. A very important fact was that there was little impact damage on the vertical fin.



Tail/Aft Fuselage Breakage Pattern

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3.6 **Critical Analysis of Aircraft Wreckage:** The aircraft wreckage was investigated for possible evidence of the following:

- a. Bird Hit.
- b. In-flight Fire.
- c. Internal/External Sabotage.
- d. Engine Fire or mechanical Failure of pistons resulting into loss of power to maintain flight.
- e. In-flight Structural Failure.
- f. Hit by ground fire.

3.7 **Bird Hit:** Aircraft frontal area, nose cone, windows and panels were examined for remains of birds. The fractured portions of windscreen and cockpit were examined for blood spots, flesh fibres and birds' feathers. A detailed and careful examination did not show any evidence of bird/birds hit. The leading edges of all aerodynamic surfaces were examined and no sign of bird hit was found.

3.8 **In-flight Fire**

3.8.1 **Preservation of Fire Evidence by Water:** As the aircraft had gone into the sea, there was no ground fire and sequential break-up similar to ground impact. Hence, the wreckage can be examined for evidence of in-flight fire more accurately. In case of fire prior to impact with water the entire evidence is preserved due to aircraft going into water.

3.8.2 All the panels, floor carpets, seats, instruments, electrical harnesses, looms, etc were inspected for signs of carbon deposits, burn marks, and heat effects, the results were negative. Similarly there was no evidence of fuel, oil, hydraulic or electrical fire. Detailed examination of aircraft did not reveal any carbon deposits, burning marks, molten material, and existence of fusion, adhesion or heat effects; thus negating the possibility of in-flight fire.

3.9 **Internal/ External Sabotage**

3.9.1 **Search for metal particles in cross sections of aircraft materials:** Aircraft parts were inspected and analysed for any internal explosive device. Aircraft hard and soft parts were searched for the presence of penetrated minute metal particles. These particles are found arrested/embodied in

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seats, carpets, glasses and even human remains. However, no such particles were found.

- 3.9.2 **High Temperature and Pressure Effects:** The evidence for the effects of high-pressure gases was examined. Broken and exposed cross sections, initially with magnifying glass and later in different labs. Similarly, melting effects of high temperatures generated during explosion were searched for but no such effects were seen anywhere. Even materials used in aircraft furnishing such as fabric covers, seat cushions, foams and carpets did not reveal any temperature effects.
- 3.9.3 **Focal Point and Imaginary Lines of Explosion:** Finally, the entire aircraft structure recovered from seabed was examined for deep cuts and metal penetrations to find any focal point of explosion with the help of imaginary lines or trajectories, which are made by shrapnels. Though there were innumerable cuts and penetrations all around the aircraft structural parts, these cuts were without any focal points and were irregularly distributed and were not in any suggestive explosion pattern. It established that no internal explosion had taken place in the aircraft. Examining various minor parts of different surfaces, found scattered in the main wreckage, further substantiated this fact.
- 3.9.4 The wreckage was examined for presence of any craters, volcano shaped protrusions, high-speed cuts and metal flow in spherical direction. No such evidence, indicative of operation of explosive devices, could be established. Assemblies of looms were intact, they should have separated otherwise. Instrument and instruments panel were generally intact; there was de-shaping but no disintegration.
- 3.9.5 **Aircraft Joining Parts Components Examination:** Aircraft rivets, spars and hinges, which join aluminium panels to form airframe aerodynamic surfaces, were examined for sabotage evidence but these parts were clear of any such indications. In this case owing to falling of the wreckage in the sea the evidence was preserved and not masked/destroyed due to ground fire and sequential break-up, which invariably happens on ground impact. Therefore, it was beyond doubts that no explosive device operated in the aircraft.

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- 3.10 **Investigation for Engine Failure Possibility:** Both Engines and Propeller Blades were examined and then despatched to Aviation Workshop. The propellers of these engines were overhauled and tested at the same workshop during the last overhaul.
- 3.11 **Propeller Blades and Hub Assembly Examination:** MaCauley Propeller serial numbers 940538 and 931435 were mounted on engines NO 275485 and 8122680 respectively. All the blades of propeller 940538 were found in feathered condition. Blade serial number one and two were found bent in the direction of rotation, whereas blade three was found bent in the direction opposite to the rotation. The links were found intact at piston rod position and there was no evidence of any mechanical failure or maladjustment or abnormality in the hub assembly. The results were similar on the blades of the other propeller with the exception that blade two was found slightly bent.



- 3.12 **Conclusion from Propeller Investigation:** The report on propeller examination concluded that blades were in feathered position without any abnormality and their condition was normal except crash damage. The bends indicated that blades were rotating at high speed at the time of impact and feathered position indicated that props were rotating with engine power. The evidence coincided with the flight conditions and supported the fact that engines were working.
- 3.13 **Piston Engine Investigation Results:** Both the engines were disassembled after visual examination of their

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electrical and fuel systems. Detailed examinations concluded that physical damages to the fuel lines, pneumatic and electrical components and other break-ups were due to general damage sustained due to post impact failure. It further says that the carbon deposits were normal depending upon engines' operating hours. The report finally concluded that engine mechanical parts i.e. camshaft, crankshaft, connecting rods, cylinder barrel and pistons were intact.

- 3.14 **Testing of Fuel Samples:** Fuel samples, taken from the bowzer on the day of occurrence, were analysed. The report determined that the fuel was without any solid contamination or sediments. Its colour was light green against blue as per specification.

3.15 Instrument Analysis

The aircraft instruments i.e VVI, Altimeter, Horizontal Situation Indicator, Turn and Slip Indicator, Artificial Horizon (gyros), Air Speed Indicator and Course Indicator were analysed under ultraviolet light conditions and other techniques. These examinations did not show any impact marks of the needles on the respective dials. Absence of impact marks indicated that forces of impact reaching the instrument panel were not very high. It is also supported by the wreckage damage pattern of the engines and wing leading edges. In this case engine cowlings and leading edges of both wings absorbed the main impact. Therefore, the instrument panel remained intact with the fuselage. The instruments were still attached to their respective panels and were removed without causing any further damage. The readings noted with the help of ultra violet light were as follows:-

Horizontal Situation Indicator	Found set at 284 degrees
Vertical Velocity Indicator	Needle was missing and no marks on the dial
Course Indicator	Found set at 284 degrees
Turn and Slip Indicator	No marks
Altimeter Pressure	Colman's window set at pressure of 29.87 units at 978 feet.
Air Speed Indicator	108 Knots

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These readings supported the events in terms of direction, speed and impact forces at the time of occurrence. The impact on Pitot tube and damage to the instruments resulted in erroneous readings on Altimeter, VV1 and AS1.

3.16 In-flight Structural Failure

- 3.16.1 To investigate any possibility of an in-flight structural failure, it was necessary to establish that aircraft wreckage was deficient of some major aerodynamic surfaces. Efforts were made to account for all major aerodynamic control surfaces. It was appearing from the beginning that aircraft tail section, except the vertical fin, was not with the wreckage. The search efforts could not locate the tail section, comprising the rudder, horizontal stabiliser and elevator assemblies.
- 3.16.2 The radar picture and the analysis of aircraft damages after its impact over sea were also indicative of an aircraft, which fell without tail section. The evidence was in the form of accelerated descend and impact damages at the wing leading edges. The non-availability of tail section in the vicinity of main wreckage was also indicative of the fact that aircraft descended without horizontal stability. The breakaway pattern of control cables was also an indication of this inference.
- 3.16.3 Extensive search operations were conducted to look for the missing parts of aircraft tail section. Probable area downstream of impact point was searched but the missing tail parts could not be located. Items as small as a metallic pen, purse and notebooks were located in the vicinity of main impact. Major surfaces, which had drifted downstream of main impact point, were found with little difficulty at a distance of 1.5 nautical miles.
- 3.16.4 **Significance of Size of Tail Section:** The missing tail section comprised two large aerodynamic surfaces i.e. horizontal stabiliser and rudder. The horizontal stabiliser is 20 feet in length, the width being four feet at the centre, decreasing to one and a half feet at the extremes. The rudder is seven feet long and width two feet. Had these surfaces been lying in the vicinity of remaining aircraft wreckage, these would have been detected. It is,

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therefore, concluded that the tail section separated in air well before the impact. The radar picture suggested that the event took place about 3.5 NM before the impact point. Owing to the shape of tail plane and rudder, separation at 8500' above surface, wind pattern and finally the sea current could have taken these parts anywhere. Therefore, it was impossible to give the likely location accurately to for underwater search, though efforts were made.

3.17 Supplemental Structural Inspection Program

3.17.1 The Supplemental Structural Inspection Program for the Cessna Model 401/402 airplane is based on Model 402/402C current airplanes usage and state-of-the-art analysis, testing and inspection methods. Analysis methods include durability, fatigue and damage tolerance assessments. The Supplemental Structural Inspection Program was developed through the combined efforts of Cessna Aircraft Company, Model 402 operators, and the FAA. This program is valid for Model 401/402 aeroplanes with less than 40,000 flight hours. A practical state-of-the-art inspection program is established for each Principle Structural Element (PSE), where:

'A PSE is that structure whose failure, if it remained undetected, could lead to the loss of the aircraft. Selection of a PSE is influenced by the susceptibility of a structural area, part or element to fatigue, corrosion, stress corrosion, or accidental damage'.

3.17.2 The inspection program consists of the current structural maintenance inspection, plus supplemental inspections, as required, for continued airworthiness of the aircraft as years of service are accumulated. The current inspection program is considered to be adequate in detecting corrosion and accidental damage. The emphasis of the Supplemental Structural Inspection Program is to detect fatigue damage whose probability increases with time.

3.17.3 **Objective:** The objective of the Supplemental Structural Inspection Program is the detection of **damage due to fatigue, overload or corrosion** through the practical use of non-destructive inspection (NDI), as well as visual inspections. This Supplemental Inspection Document (SID) addresses primary and secondary airframe components only.

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Powerplant, electrical items and primary and secondary systems are not included in this document. To establish the basis for these items, the following assumptions were made by the manufacturer:

- a. The aircraft has been maintained in accordance with Cessna recommendations or equivalent.
 - b. Where the SID is directed to a specific part or component, it is implied that the inspection will include observation and evaluation of the surrounding area of parts and equipment. Any discrepancies found during this inspection outside the scope of the SID should be reported to Cessna through the existing condition reporting system, so that changes can be made to the SID where necessary.
 - c. Service Experience: Three sources of information were used to determine service discrepancies by the manufacturer:
 - i. Service experience data was collected from current Model 402 owners. Surveys were conducted which asked the operators to describe any major structural repairs made to their aeroplanes.
 - ii. Cessna Service Bulletins and Service Information Letters, issued to repair common service discrepancies, were reviewed.
 - iii. FAA Service Difficulty Records covering a time period from the mid-1970's to December 1995 were reviewed.
- 3.17.4 **Stress Analysis.** Mathematical models were developed for the Model 402 through Model 402B airframes and airframe components. Models were developed for the wing and carry-through, flap, aileron, engine beam, fuselage, horizontal stabiliser, elevator, vertical stabiliser, rudder and nose and main landing gears. These models were reviewed to identify components that exhibit the potential for additional inspection requirements.

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3.17.5 **Fatigue and Damage Tolerance Analysis.** Fatigue and damage tolerance analyses were conducted for the critical areas of the PSEs.

3.17.6 **Testing.** New static tests were conducted to verify the mathematical models, which were developed. Test results from previously conducted static tests and fatigue cyclic tests were also reviewed to identify the critical areas of the PSEs.

3.17.7 **Classifications for Types of Operation.** The severity of the operation environment needs to be determined. If the aircraft currently operates in severe environments or has in the past, the 'Severe' flight profile should be used. Examples of severe operations would include flying over mountainous terrain or near coastal areas or conducting low-level ground surveys.

3.18 Maintenance Schedules-Discrepancies

3.18.1 Maintenance Schedules are approved by Airworthiness Directorate CAA Pakistan to ensure that all maintenance actions under continued airworthiness program are included in the maintenance activities of the operator. In other words it ensures compliance of inspections / repair programmes issued by manufacturer.

3.18.2 Detailed study of 'Service Manual' issued on 1st September 2000 by manufacturer revealed that a number of Special Inspections Documents related to Horizontal Stabiliser and Rudder attachments were issued for compliance on aircraft, which had completed 20 years or 15000 airframe hours, which ever was earlier. These needed inclusion in the Maintenance Schedule of Cessna aircraft but were not included in approved Maintenance Schedule. In addition, a number of SIDs was issued on landing gears, engine mounts and many airframe spars, which were also not included in the Maintenance Schedule Approved by CAA Pakistan. There are a total of 49 SIDs, which should have formed part of the Maintenance Schedules but were not included in Approved Maintenance Schedule.

3.18.3 The Cessna 402B, AP-BFG, of EAAS was registered in Pakistan when it had completed its 20 years of service life. The SIDs were already due and were supposed to be complied with. The aircraft operated

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almost 25% of its service life in Coastal area (i.e Karachi). Furthermore, it is not known where and under what conditions was it used prior to its arrival in Pakistan.

3.18.4 These SIDs were not included in the Maintenance Schedule approved by CAA Pakistan because neither any Pakistani Operator nor the Airworthiness Directorate was aware of the latest maintenance documents or Supplemental Documents from the manufacturer. Schon Air, which is the representative of Cessna Company in Pakistan, got its Maintenance Schedule approved for Cessna-402 by Airworthiness Directorate in year 2002 yet these SID were not included. EAAS had an arrangement with Schon Air to share the technical information issued by Cessna Company.

3.19 **Material Evidence of In-flight Tail Separation:** The structural parts, especially the airframe panels along with their riveted spars were carefully examined. It was revealed that the general failure or, break up pattern and damages in the front fuselage and wings, had different pattern from the aft fuselage and empennage area. The differentiating features were that the panels close to tail, beyond which the sections were not available in the wreckage, were found to be torn apart sharply without any bending, wrapping or converging into bent layers. These panels separated / broke away from mating panels and sheared off in very short period of time without coming in contact with other adjacent structural parts during failure. This is the fundamental indication of failure under aerodynamic loading. Bending and converging of layers can be seen on wing leading edges and nose compartment as explained earlier.

3.20 **Metallurgical Analysis at Laboratories:** Having lost hopes to recover tail section from sea and with reasons to believe that tail section had separated in the air, actions were taken to conduct metallurgical analysis of aircraft structure parts, for detecting material evidence of in flight structural failure of tail plane. Three specific areas were focused for such metallurgical analysis i.e.

3.20.1 Pieces of steel cables connecting aircraft control surfaces with cockpit controls were taken from elevators, elevator trim and rudder areas.

3.20.2 Fractured pieces of Aluminium sheets close to tail section including right hand side lower cabin and

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upper panels, fuselage panels and vertical fin panels.

3.20.3 Upper and lower bolts joining wings with fuselage.

3.20.4 Analysis of steel cables was carried out to detect any evidence of instantaneous or fatigue failure. Instantaneous failure could have occurred during flight or during sequential break up of aircraft structure after impact with sea. The physical examination of wires and strands indicated tensile failures. The elongation of strands and separation from their swirl is caused due to large pulling force. Three tests were conducted on samples of wires taken from each cable. These tests included metallographic examination, breaking load in KN numbers and chemical composition tests.

3.20.5 Aluminium sheets taken from aircraft cabin and side cabin panels close to tail section were subjected to Hardness tests, tensile strength tests, elongation tests and chemical composition tests. Hardness was measured in VPN numbers and results were between 133 and 139 VPN, which indicate that hardness was same for all the aluminium sheets taken from different portions of tail section. It may be noted that hardness numbers should have changed if fatigue had any ill effects on the physical properties of material under tests. Elongation tests at 25 mm gauge length also showed elongation range 9.8% to 13.8% for various aluminium pieces, again an evidence supporting absence of fatigue effects leading to failure. Finally chemical composition tests also did not reveal any changes in Carbon, Silicon and Manganese contents in the sheet material.

3.20.6 Analysis of main spar bolts was carried out through hardness tests in VPN numbers, conditional examination for hardening and tempering state and chemical composition tests to determine the % of Carbon, Silicon and Manganese. There was no deviation in the chemical composition and physical state.

3.21 **Conclusion of Metallurgical Examination:** The metallurgical analysis did not reveal any evidence for:

3.21.1 Existence of Fatigue damage in Steel cables.

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3.21.2 Any abnormal deviation in chemical composition of aluminium sheets used in aircraft cabin close to the tail.

3.21.3 Any deformation in wing attachment bolts.

3.22 OPERATIONAL ANALYSIS

3.22.1 **Flight Preparations:** In the domain of documents, flight preparations were scrutinized. Flight plan had been appropriately filed. The cruise speed for the journeys was planned at 150 Kts. The flight level from Karachi to the landing destination was given 085 (8500 feet) and the return was planned at flight level 095 (9500 feet). The Estimated En-route Time (EET) was 3 hours each way. The endurance of the aircraft, given in the flight plan was 4 hours for each journey. Meteorological report/brief had been taken. Upper air winds were neither requested for nor given by the Met Department. Actual winds at 5000 and 7000 feet on 24 February 2003 at 0500 hrs LT were 280/17 and 340/08 respectively.

3.22.2 **Radar Picture:** Radar recording indicated a smooth flight upto 8500 feet. A two way positive communication between radar and the mishap aircraft existed throughout. At 8500 feet the aircraft was seen (on radar) to gain height suddenly to 8800 feet before it started losing height rapidly. There was no distress call, nor an attempt at making one that was left unfinished, was heard. This aspect brought into sharp focus that the event faced by the pilot was sudden and pilot had no reaction time to counter the event that faced him abruptly and violently. The pilot's posture in autopsy was indicative that he was reacting instinctively to the situation. It is inferred that he found the aircraft uncontrollable and was expecting the unavoidable crash. The rapid descend after an initial abrupt ascend by 300 feet (8500 to 8800 feet) also suggested swift, unexpected, unusual and uncontrollable altitude changes. If one or even both engines fail, such a violent and abrupt change in aircraft attitude is not possible. Failure of a control surface would also not lead to such a sudden nose down maneuver except if the tail of the aircraft separates in the air. More weight to this factor was also lent by the fact that tail section was not found

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anywhere in the vicinity of the main point of impact of the aircraft. A serviceable transponder was installed in the aircraft, which was transmitting on Mode 'C'. Since the transponder was installed in an area of the fuselage, which is ahead of the tail section, the radar was receiving the transponder signals till the aircraft disappeared from the radarscope at 2600 feet.

3.22.3 **Weight and Balance Performa (Trim Sheet):** The technical analysis shows an in-flight structure failure in the form of tail separation. Thus the investigation was focussed on the Weight and Balance status of this flight. The weight and balance performa (trim sheet) for the flight was not prepared. Furthermore, there was no trim sheet (weight and balance performa) record available in EAAS for any past flight either. Efforts were thus made to calculate the actual weight of the aircraft for the mishap flight. Available documents, witness statements and applicable manuals were consulted to arrive at the actual weight configuration at the time of its departure from Karachi.

3.22.4 The total weight of the aircraft was 6953.6 Lbs, as discussed in para 2.2, when it departed Karachi. 653.6 Lbs or 10.38% thus exceeded the manufacturer's maximum allowable weight of 6300 Lbs for take off. How many times in the past was the weight limitation violated could not be ascertained for want of records.

3.22.5 **Air Speed:** The Flight Plan showed a planned Ground Speed (GS) of 150 knots (Kts) for the journey. The ground speed shown on the radar picture was 120 Kts. The actual recorded wind velocity at 7000 feet was 08 knots from direction 340°. Therefore, a head wind component of 2.7 Kts while flying a heading of 270°. The same wind would have had a head wind component of 5.1 Kts when the aircraft was flying heading 290°. It indicates that an aircraft, which should have had a True Air Speed (TAS) of 150 Kts was barely able to reach a TAS of 125. This also substantiates the fact that the aircraft was over loaded.

3.23 Wreckage Examination

3.23.1 **Estimation of Impact Attitude from Wreckage Reconstruction:** An examination of general

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impact impression and damage of major airframe surfaces revealed that aircraft impacted at a shallow angle and in a left roll. The damage to right wing leading edge, breaking of left wing and hitting the empennage; upward collapse of aircraft belly and damage to engine cowling are indications of such impact.

3.23.2 Tail Separation in Air: Earlier discussion also pointed out that the aircraft tail separated in the air. The radar picture registers an initial gain of 300 feet and then the aircraft lost height rapidly. During flight the tail provides longitudinal stability to the aircraft. In Cessna-402 the location of CG is ahead of CP. The Centre of Pressure (CP) is sum total of aerodynamic loads. Therefore, during the tail separation process, the tail plane would go up as if elevator is going up, resulting in aircraft pitch-up. After complete separation of tail, CG would take the aircraft nose down as balancing CP vector is reduced. The increase in height by 300 feet before the rapid descend, is suggestive of such an action taking place at the tail plane just before it finally broke and detached itself from the aircraft structure. Following break away of the tail plane, the CG took effect and the aircraft nose pitched down.

3.24 Miscellaneous: Some other factors, which were considered by the investigation team, are appended below:

3.24.1 Sudden CG Shift. A possibility of a sudden CG (centre of gravity) shift exists if large cargo loads of an aircraft shift suddenly in flight. This aircraft had no major cargo load. A CG shift could also be affected if the tail is separated from the aircraft structure in the air. The second factor has already been analysed.

3.24.2 Pilot Incapacitation. Pilot incapacitation was considered from two aspects. Firstly, the pilot suffering from a sudden severe heart attack or some other physical disability and secondly, something striking the pilot e.g. bird or any foreign object. The first one was negated because a qualified pilot, current on the type but travelling as a passenger occupied the right seat (Co-pilot seat). Had the Captain been incapacitated, he would have taken over controls and given a call. This did not happen. The possibility of both pilots simultaneously suffering from physical incapacitation was

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considered remote. The second possibility was negated because there were no signs of a bird strike, which could incapacitate both the pilots together. Had a foreign object hit them, their bodies would have shown signs of such a possibility.

4. Findings

- 4.1 A Cessna 402B aircraft belonging to EAAS and flown by Captain Sajid Ali Chief Pilot EAAS, was hired for a chartered flight from Karachi to Jazzak by Star Air Aviation.
- 4.2 A Chinese Company MCC Resource Development Company (Pvt) chartered a flight from Star Air Aviation. The aircraft was arranged from EAAS.
- 4.3 The aircraft was serviceable when it took off from Karachi at 0811 PST (Pakistan Standard Time) on 24 February 2003.
- 4.4 The aircraft had eight persons on board including the pilot.
- 4.5 The aircraft took off with a total weight of 6953.6 Lbs. The manufacturer's maximum allowable weight for take off is 6300 Lbs, which was exceeded by 653.6 Lbs or 10.38%.
- 4.6 No records of Weight and Balance (Trim Sheets) were available with EAAS for the mishap flight or for any flight flown prior to the day of the crash.
- 4.7 In the absence of any records of the Weight and Balance Performa (Trim Sheets), repetitive violations of the manufacturer's allowable loads could not be ascertained and, therefore, could not be ruled out. Repetitive overload can result in structural failure.
- 4.8 The aircraft was manufactured in 1977 and was thus about 26 years old.
- 4.9 The aircraft was under positive radar control and was being radar vectored.
- 4.10 The aircraft was in communication with the Radar upto 0820 PST, when it acknowledged a change of heading from 270° to 290°.
- 4.11 The aircraft was flying at 8500 feet when its height suddenly increased to 8800 feet from where it started losing height rapidly, at 20 - 21° dive angle till it

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disappeared from the radarscope at 2600 feet and 179 Kts at 0829 PST.

- 4.12 The planned cruise speed was 150 Kts, whereas the actual true air speed was about 125 Kts. The chart in the Pilot's Operating Handbook gives true air speed of 152 Kts at that cruise altitude.
- 4.13 Five bodies were recovered about four hours after the accident. The sixth was washed ashore and recovered on 9 March 2003. Two bodies are still missing.
- 4.14 Postmortem was carried out on the bodies of the PIC and Capt Nadir only. No shrapnels / metal pieces or burn marks were detected on their bodies. Afghan government disallowed autopsy of her nationals.
- 4.15 The major aircraft wreckage was recovered three days after the crash i.e on 27 February 2003.
- 4.16 The airframe and engines were found at and around main impact point in the sea but tail comprising rudder, horizontal stabilizer and tail cone are still missing.
- 4.17 Detailed examination of main fuselage, wings and engine did not show any evidence of in-flight fire, sabotage or damage due to any object hitting the aircraft from outside.
- 4.18 There was no evidence of bird-hit on cockpit, wing leading edges or on frontal area.
- 4.19 The damages to the aircraft hull, structural and ancillary equipment, were due to impact with water.
- 4.20 The panel and cables close to tail bulkhead showed evidence of in-flight structural failure.
- 4.21 Metallographic examination of structural panels at laboratories did not reveal any signatures of sabotage i.e use of explosive device to cause structural disintegration in the air.
- 4.22 The instrument panel and the cabin floor also substantiated the fact that there was no internal explosion or an external hit.
- 4.23 Corrosion and cracks were detected in the elevators (tail section) during first C of A inspection in 1997. The rectifications carried out on these observations were without consulting the SRM/Cessna.

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- 4.24 Updated "Service Manual" issued by Cessna Corporation through Change No 20 dated 01 September 2000 was neither available nor followed in schedule maintenance.
- 4.25 Cessna Corporation issued a number of "Supplemental Inspection Documents" (SIDs) on elevator and rudder assemblies. Series 53 and 55 of SIDs were not complied with on the mishap aircraft.
- 4.26 The approved Maintenance Schedule did not include these important SIDs.
- 4.27 The mishap aircraft was inducted in 1997 with 19 years of Service in EAAS and a series of SIDs were due on completion of 20 years but due to outdated maintenance service manuals these SIDs were not in the knowledge of maintenance personnel.
- 4.28 **Cause**
 - 4.28.1 The primary cause of the accident is structural failure due to overloading and non-compliance of Supplemental Inspection Documents (SIDs) issued by manufacturer through Change 20 of Service Manual dated 1st September 2000.
- 4.29 **Finalization:** The investigation is finalized as:
 - 4.29.1 Failure to remain within specified weight limits by the pilot and inadequate maintenance.
 - 4.29.2 Human Factor – Avoidable.

5 RECOMMENDATIONS:

- 5.1
 - a) Edhi Air Ambulance Services to ensure the availability of latest Maintenance Manuals, Service Bulletins and Airworthiness Directives pertinent to the types of aircraft/helicopters flown by them.
 - b) The same measures are to be ensured for compliance by Airworthiness Directorate in all General Aviation Companies operating in Pakistan.
- 5.2
 - a) Edhi Air Ambulance Services to ensure compliance with the weight limitations in aircraft/helicopter operations.

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- b) The implementation of the same is to be ensured in all General Aviation Companies operating in Pakistan by Flight Standards Directorate.
- 5.3 The approved "Maintenance Schedule" be updated by Airworthiness Directorate to include any supplemental inspections as per the latest Manufacturer's instructions.
- 5.4 Flight Standards Directorate to ensure preparation of Trim Sheet and devise a procedure of spot checks on weight and balance.
- 5.5 The manufacturer is to devise a procedure to ensure dissemination of up to date maintenance / operations manuals to the operators and civil aviation regulatory bodies.

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