AAIS Case Reference: 01/2010

AIR ACCIDENT INVESTIGATION SECTOR

FINAL

SERIOUS INCIDENT INVESTIGATION REPORT

LANDING WITHOUT GEAR EXTENSION

Diamond DA-42
A6-FTZ
Horizon International Flight Academy
Al Ain International Airport
United Arab Emirates
23rd February 2010

General Civil Aviation Authority
of
United Arab Emirates

OBJECTIVE

This investigation is performed in accordance with the UAE Federal Act No 20 (1991), promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 48, CAR Part III Chapter 3 and in conformity with Annex 13 to the Convention on International Civil Aviation.

The object of his safety investigation is to prevent aircraft accidents and incidents by identifying and reducing safety-related risk. The GCAA AAIS investigations determine and communicate the safety factors related to the transport safety matter being investigated.

Reports are publicly available from :
http://www.gcaa.gov.ae/en/epublication/pages/investigationreport.aspx

It is not a function of the GCAA AAIS to apportion blame or determine liability.

Notes:

1. All times in the report are Local Time (Local time "LT" in UAE was UTC+ 4h)
2. The word "Aircraft" in this report implies the aircraft involved in the serious incident
3. The word "Team" in this report implies the Investigation Team

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ABBREVIATIONS

A	Aeroplane
AAIS	UAE GCAA Air Accident Investigation Sector
AFM	Aircraft Flight Manual
AMM	Aircraft Maintenance Manual
AMO	Approved Maintenance Organization
AMS	Approved Maintenance Schedule
amsl	above mean sea level
ATC	Air Traffic Control
ATPL	Air Transport Pilot License
CAAP	Civil Aviation Advisory Publication
CAR	UAE Civil Aviation Regulation
CAR-OPS	UAE Civil Aviation Regulation – Flight Operation
CAT	Category
CAVOK	Cloud and Visibility OK
CFI	Certificated Flight Instructor
CG	Centre of Gravity
C of A	Certificate of Airworthiness
COM	Communication
CRJ	Canadair Regional Jet (The Bombardier)
CRM	Cockpit Resource Management
CVR	Cockpit Voice Recorder
Cm	centimetre
CMR	Certificate of Maintenance Review
CPL	Commercial Pilot License
EICAS	Engine Indicating and Crew Alerting System

ELP	English Language Proficiency
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FE	Flight Examiner
GCAA	UAE General Civil Aviation Authority
hrs	hours
ICAO	International Civil Aviation Organization
IIC	Investigator In Charge
ILS	Instrument Landing System
JAA	Joint Aviation Authorities
kg	kilogram
KIAS	Knots Indicated Air Speed
Km	kilometers
LDA	Landing Distance Available
Ldg	Landing
LH	Left Hand
LT	Local Time
m	metres
mb	millibars
MCC	Multi Crew Co-operation
MHz	Mega Hertz
MSI	Major Structural Inspection
MSN	Manufacturer Serial Number
No.	Number
OK	all correct
PAPI	Precision Approach Path Indicator

PPL	Private Pilot License
QNH	barometric pressure adjusted to sea level
RH	Right Hand
S/E	Single Engine
SN	Serial Number
SOP	Standard Operating Procedures
TO	Take Off
TSO	Time Since Overhaul
TSN	Time Since New
T1	Training Area 1
UAE	United Arab Emirates
UTC	Co-ordinated Universal Time
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Range (Navigation System)

SYNOPSIS

The GCAA was informed of the serious incident, on the 23rd February 2010, formed and dispatched an Investigation Team (Team), which commenced the investigation. The following day the State of the Manufacturer (Austria) was notified and assigned an Accredited Representative to the investigation. The UAE GCAA lead the investigation and issued the final report.

On February 23rd, 2010, a Diamond DA 42 aircraft, registration A6-FTZ, owned and operated by an UAE based training organization, departed from Al Ain International Airport for a skill test flight with 2 crew members on board. During landing on Runway 01 of the same airport at approximately 13:52, the aircraft contacted the runway without landing gear extension, initially with its tail skid, propellers, foot-steps and subsequently with the lower part of both engines' cowlings. The aircraft came to a full stop on the runway, near intersection B. All of the propellers and exhaust tubes were damaged, along with damage observed on the lower part of the engine cowlings, foot-steps, and antennas consistent with wheels up landing. No crew injuries were experienced during the occurrence.

The Team determines the probable cause of the serious incident was error of omission in the checklist due to various distraction combined with the high workload of the handling pilot (examinee), accentuated by most probably initially an ATC interaction and later a low fuel warning light, resulted in the crew not completing and verifying the landing checklist prior to land.

The GCAA AAIS sent a copy of the draft Final Serious Incident Investigation Report to the State of the Manufacturer (Austria), the Manufacturer, the Operator and the GCAA inviting their significant and substantiated comments on the report. Comments were received.

The safety issues raised in this report include:

1. Training methodology including CRM and Threat and Error Management training, the procedures at the operator organization, and SOP used by the operator.
2. Unavailable weight and balance calculation for the flight.
3. Landing gear warning system.
4. Tail skid design.

Safety Recommendations concerning the above stated issues are addressed to the GCAA, Operator and Manufacturer.

1 FACTUAL INFORMATION

1.1 History of the Flight

On February 23rd, 2010, at approximately 12:30, a Diamond (DA) 42 Aircraft, registration A6-FTZ, owned and operated by a locally based training organization, departed from Al Ain International Airport with two flight crewmembers on board which consisted of a flight examiner and an examinee pilot, who was the handling pilot. The flight was a multi engine instructor instrument rating skill test.

Upon landing at Al Ain International Airport for a full stop, as the last exercise of the required skill test manoeuvres, the Aircraft contacted the Runway 01 with its tail skid, propellers and then the lower part of both engines' cowlings (see Appendix 1).

On the day of the serious incident, the flight examiner had performed a MCC session on a CRJ-200 simulator from 07:20 to 11:30, an aircraft type he was qualified as an instructor. The examinee pilot initiated his duty at 06:30 on that day and had performed an approximately 3-hours navigation flight on the Cessna-172 as a flight instructor, and thereafter he had about 2-hours interval prior to his DA-42 skill test.

The preflight briefing was conducted at the training organization's hangar between 11:55 and 12:20, thereafter the pilot, under examination, was tasked by the flight examiner to perform the pre-flight inspection. At approximately between 12:20 – 12:30, both pilots entered the aircraft for the flight.

Takeoff was performed from Runway 19, and the ATC provided clearance for the manoeuvres altitude to be 4,000 ft and below, at the training area 1 (Flight Training Organization's fixed wing training area, see Appendix 2).

The examinee pilot conducted all the required manoeuvres including one engine out emergency procedure, as has been tasked to perform by the flight examiner at the training area 1.

Thereafter the Aircraft returned to Al Ain International Airport, and while returning from the training area 1, the Aircraft flew overhead the VOR and cleared to perform an ILS approach to Runway 01, and circle to land on Runway 19.

However, while performing the ILS approach on Runway 01, the crew was informed by Al Ain Tower that the Runway in use was changed to 01, due to wind direction change.

The flight examiner requested two Touch-and-Go manoeuvres on Runway 01, which were satisfactorily performed by the examinee. On the first Touch-and-Go, the examiner flew the Aircraft to demonstrate the Touch-and-Go, whilst when the Aircraft was rolling on the runway, the controls were handed over to the examinee who continued the takeoff.

Finally a full stop with asymmetric (simulated left engine failure) approach and flapless landing was requested to be performed on Runway 01, by the examiner.

On the downwind leg, abeam the runway 19 threshold, the examiner pulled back the left engine power lever to simulate a left engine failure. Evidence from the ATC recording, which was confirmed by the examiner's statement, indicated that the landing gear warning horn was in operation when the left power lever was below a certain position (about 25% of the power lever travel according to AFM) during the downwind leg. However, the left power lever was again pushed slightly forward of the 25% position in order to cancel the warning horn and continue the simulation of left engine failure. On the downwind leg, after the Aircraft was abeam the threshold of runway 01 but before turning towards base leg, the crew was instructed by the ATC Tower to extend the downwind due to traffic. Then, after a short period of time, the flight was cleared by the

ATC for base leg turn, the Aircraft turned establishing on the base leg and the crew was subsequently given clearance to land on Runway 01. As per the examiner's statement, the landing gear selector switch was selected down by the examinee in order to lower the landing gear. As per the examinee's statement, he thought that he had lowered the landing gear selector lever on the base leg.

The Examiner also stated that the landing gear warning horn appeared again when the left power lever was inadvertently pulled back from that certain position until the landing gear lever has been lowered. When the Aircraft was on long final, after the ATC provided landing clearance, the examinee performed the landing checklist items. Both pilots reported that the three green lights, which indicate the landing gear down and locked position, illuminated after lowering the landing gear selector lever. Additionally, the examiner stated that he remembered the green lights were illuminating before touchdown.

On the approach for Runway 01, a "Left Low Fuel Warning" message appeared on the EICAS indicating low fuel quantity on the left fuel tank. Neither pilots were alarmed when the EICAS message appeared as the fuel tanks were full at take off and the flight duration was only 1.37 hours.

During the Aircraft flare at approximately 13:52, the fuselage contacted the runway surface. The tail skid of the Aircraft touched down first, followed shortly by both propellers contacting the ground, at that time, both pilots realized that the Aircraft landed without proper landing gear extension.

According to the examiner's statement, as soon as the Aircraft came to a full stop, the electrical master switches were turned off, the canopy was opened normally by one of the pilots, and both of them evacuated the cockpit with no consequences.

The estimated latitude and longitude of the Aircraft first touch point on the Runway 01 was 24°15'02.27"N, 55°36'27.29" E, and the Aircraft came to a full stop at latitude and longitude 24°15'16.31"N, 55°36'29.98"E.

According to the maintenance engineer of the training organisation, who supervised the Aircraft removal, while the Aircraft was being lifted up by the crane and slings, the landing gear extended by gravity. Before the Aircraft was able to stand on the runway with locked down gears condition, the ELECT MASTER had been switched to ON. After the Aircraft was on the runway with locked down landing gear, the ELEC MASTER was switched to OFF again and thereafter the Aircraft was pushed away from the runway (see Appendix A1).

1.2 Injuries to Persons

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	2	-	-	-	2
Total	**2**	**-**	**-**	**-**	**2**

1.3 Damage to Aircraft

From the Team observations, after towing the Aircraft into the hangar and the associated photographs taken on the runway, the damage to the Aircraft was as the following:

- Damaged left engine propeller blades (see Figure A1-1) :
    - All blades fractured, from the original 78 cm length, the remaining length of the blades were respectively : 60, 51 and 53 cm
    - All three propellers' rubber boots were still attached
    - The metal covers of all blades' tips bent
- Friction grit at the lower external surface of the left engine composite cowling (see Figure A1-2)
- Worn out damage on the exhaust tube of the left hand engine (see Figure A1-2)
- Worn out damage on the left hand foot step (see Figure A1-3). The remaining part was 29 cm of the original 36 cm. Fatigue marks and twisting were found on the footstep attachment on the aircraft skin (see Figure A1-4)
- Light scar mark on the left hand main landing gear door (see Figure A1-5)
- Damaged right engine propeller blades (see Figure A1-6), with the following details:
    - All blades were broken. From the original 78 cm length, the remaining length of the blades were respectively: 45, 47 & 50 cm
    - All three propellers' rubber boots were still attached
- Friction grit at the lower external surface of the right engine composite cowling (see Figure A1-7)
- Worn out damage on the right engine's exhaust tube. The exhaust had a flat cut of 15 cm long (see Figure A1-8a), 9 cm width (see Figure A1-8b), and the remaining tube length was 7 cm outside the engine casing (see Figure A1-8c).
- Worn out damage on the right hand foot step, with a remaining part of 27 cm from the original 36 cm (see Figure A1-9), and sign of fatigue was found on the attachment with the aircraft skin.
- No visible scar mark was found on the right hand main landing gear door.
- Lower central COM 2 Antenna had a light scar about 2 cm long (see Figure A1-10).
- Friction grit of an area approximately 34 x 4 cm on the lower part of the fin (see Figure A1-11).
- Friction grit on the tail skid (see Figure A1-12).

The following are the parts/items that have been replaced during the Aircraft's repair:

PART NUMBER	ITEM	QTY
52-7810-H000102	EXHAUST PIPE	2
05-9900-S000201	GEARBOX INSTALLATION SET	2
05-7121-K001301	RUBBER MOUNT RH ENGINE	2
NM-0000-0004401	BOLT, ENGINE MOUNT	4
NM-0000-0004501	RUBBER MOUNT LH ENGINE	2
05-7121-K001102	RUBBER WASHER	4
05-7121-K001002	STOP PLATE	2
05-7121-K001401	ASSY FORWARD SHOCK MOUNT	2
D60-5300-61-00X02	FOOT STEP ASSY LH WHITE	1
D60-5300-62-00X02	FOOT STEP ASSY RH WHITE	1
SHL_19	SILICON HOSE SHL 19 GR.19MM	3
071-00221-0010	KA61 ANTENNA WITH BNC	2
MTV-6ACF_CF187-129_1	PROPELLER	2
A00307	PACKING CARTOON	4
D60-7116-06-00	COWLING ASSY	1
D60-7116-02-00	COWLING ASSY	1
071-00221-0010	KA61 ANTENNA WITH BNC	2
D60-5183-00-61	TAIL KID	1

1.4 Other Damage

- Smears/scars on the runway surface were found where the Aircraft contacted the runway from the first point of contact until it came to complete stop (see Figure A1-13 up to A1-19, A1-23, and A1-24)
- One runway centerline light was scared on the surface having residual debris from the aircraft tail skid (see Figure A1-14).

1.5 Personnel Information

1.5.1 The Examiner Pilot

Captain : Male, 36 years old

License : UAE ATPL

Validity	: 24 April 2011
Flight Examiner	: The UAE based Training Organization was authorized, with a GCAA Certificate of Designation, to utilize the commander as a flight examiner
Validity	: until 13 October 2011
All classroom training and checking	: Current at the time of the serious incident
Proficiency Check	: Current at the time of the serious incident
Medical certificate :	Class1, valid up to 31st March 2010
Ratings	: 1. S/E LAND Instructor – Instrument 2. Authorised Flight Examiner on behalf of GCAA for Cessna 172 and Diamond 42 aeroplanes to conduct : - Pilot Proficiency Check - Skill test for issuing of PPL (A) - Skill test for issuing of CPL (A) - Skill test for issuing of Flight Instructor Rating (A) - Skill test for issuing of Instrument Rating (A)
English Language Proficiency	: ICAO English Level 4 - Recurrent testing required in 3 years
Flying Experience	
Total hours on all aircraft types	: 6,782 hrs
Total Command Hours	: 5,038 hrs
Total Instructor Hours	: 2,537 hrs
Total Hours on type	: 255 hrs
Total Hours on other types	: 6,444 hrs
Total Hours last 30 days	: 12.2 hrs
Total Hours last 24 hours	: 2.0 hrs
Previous rest and duty period	
Off duty	: 15:38 LT (after total 7:58 working hours) on 22nd Feb 2010
On duty	: 07:23 LT on 23rd Feb 2010
Rest	: 15:45 hrs

1.5.2 The Examinee Pilot

Captain	: Male, 42 years old
License	: CPL
Validity	: 24 Jan 2017
All classroom training and checking	: Current at the time of the serious incident
Proficiency Check	: Current at the time of the serious incident
Medical certificate	: Class 1, valid up to 31st July 2010
Ratings	: 1. S/E Land Instrument
	2. Flight Instructor S/E Land
Flying Experience	
Total hours on all aircraft types	: 3,280 hrs
Total Command Hours	: 3,012 hrs
Total Instructor Hours	: 2,775 hrs
Total Hours on type	: 16.7 hrs
Total Hours on other types	: 3,263 hrs (multi engines : 32.5 hrs)
Total Hours last 30 days	: 49.1 hrs
Total Hours last 24 hours	: 5.2 hrs
Previous rest and duty period	
Off duty	: 16:59 LT (after total 11:03 working hours) on 22nd Feb 2010
On duty	: 06:32 LT on 23rd Feb 2010
Rest	: 13:33 hrs

1.6 Aircraft Information

The Diamond DA42 (also known as the *Twin Star*) is a carbonfibre construction light twin aircraft powered by jet fuel burning turbo diesel engines, introduced for the first time at the May 2002 Berlin Airshow. The first flight of the DA42 was flown on 9th December 2002 and obtained the JAA type certification in late of 2003, and FAA type certification in mid 2004. The powerplant consists of two 100kW (135 hp) Thielert Centurion 1.7 avtur burning turbo diesel four cylinder piston. Each engine drives three blade MTV-6A-129 hydraulic constant speed propellers.

The Aircraft was built in November 2009, and flown by the Operator for the first time on December 22nd 2009, when the Aircraft's TSN was 25.5 hours.

1.6.1 Aircraft General Information

Aircraft Type:	DA 42
Aircraft Manufacturer:	Diamond Aircraft Industries GmbH.
Aircraft MSN:	42.427
Max TO/Ldg Mass:	1,785 kg
Date of first C of A under UAE Registry :	22/12/2009
Date of the last C of A:	22/12/2009
Last C of A expiry date:	21/12/2010
C of A category:	Transport (Passenger)
Aircraft Station License:	Issued on 10/12/2009 and valid until 09/12/2010
Insurance Validity Period:	effective from 01/01/2010 to 31/12/2010
TSN:	181.3 hrs
Last CMR date:	17/12/2009, at 25.5 hrs
Next Due CMR	16/04/2010

Engines

Engine Type:	TAE 125-02-99
Engine Manufacturer:	Thielert Aircraft Engines GmbH.
Engines' MSN:	No. 1 02-02-02459 No. 2 02-02-02461
Engines' TSN (hrs):	No. 1 181.3 No. 2 181.3
Engines' TSO (hrs):	Only 100 hr Inspection performed at TSN 97.9 hr

Propellers	
Propeller Model:	MTV-6-A-C-F
Blade Model:	CF 187-129
Propeller Manufacturer:	mt-propeller Entwicklung GmbH
Propeller Hub SN:	No. 1 080383 No. 2 080384
Blade SN:	No. 1 ZC-34493, ZC-34494, ZC-34495 No. 2 ZC-34508, ZC-34509, ZC-34510

1.6.2 Aircraft Maintenance

Maintenance Schedule Reference :	Operator AMS DA42
Last inspection:	100 hrs inspection completed on 14/01/2010
Last CMR:	Issued on 17/12/2009, next CMR was due on 16/04/2010

History of Defects

Based on the Aircraft technical logs, two defects were noted during the period of operation with the Operator (from December 22nd 2009 until the occurrence date) and total of 155.8 flight hours. Those defects occurred before the 100 hrs inspection and were as following:

- Hydraulic leakage from LH main landing gear damper
- Collapsed RH main landing gear damper.

Inspection Program

The Operator was also certified under CAR-145 AMO/159/05 maintenance organization which was valid from 19th June 2005 until 18th June 2010.

The Operator's Approved Maintenance Schedule was detailed in the Operator's AMS DA42 document, Issue 1 that was approved by the GCAA on 14th August 2008.

The scheduled inspection of the Aircraft was defined as the following:

a. Daily/Preflight Inspection (Check 'A')

To be carried out before the first flight of the day in accordance with the schedule in the DA42 AFM Section 4. A5.

b. 100, 200, 1000, 2000 Hour Inspection

To be carried out each 100, 200, 1000, 2000 flying hours, respectively.

c. First MSI (Major Structural Inspection)/12 Years

To be carried out at 6000 flying hours or 12 years whichever comes first.

d. Subsequent MSI/12 Years

To be carried out at the next 4000 flying hours or 12 years whichever comes first.

e. C of A Test Flight

To be carried out at each annual renewal of the Certificate of Airworthiness.

Until the day of occurrence, the Aircraft was only inspected for the first 100 Hour Inspection. On that inspection, the following rectifications were performed:

- Replacement of the cracked RH and LH engine turbo heat shield [1]
- Replacement of the collapsed RH main landing gear damper
- Fitting new port wheel and tire assembly due to a flat spot on the tire

Subsequently, a Certificate of Release to Service was issued on 13th January 2010 in accordance with CAR Part V, the. On 14th January 2010, a maintenance test/check flight was performed with no deficiencies/findings.

1.6.3 Mass and Balance

There was no specific aircraft loading and takeoff mass and balance calculation (load sheet) form being used by the Operator for every flight. In the Technical Logbook form, only spaces for fuel on takeoff and on arrival were reserved.

The last Aircraft weighing revealed 1,306.4 kgs empty weight as recorded by the weighing report issued on 16th December 2009.

From the last Aircraft Technical Logbook page No A 5008, which was completed after the occurrence, the fuel on takeoff was 76.4 US Gallons (in "full" condition) while the fuel on arrival was 50 US Gallons.

With 2 crewmembers on board, and with the assumption of 85 kg per person [2]; the take off mass was about 1,719 kg, while the centre of gravity was at 2.477 m from the datum plane as described in the AFM. The take off mass and centre of gravity were within the permissible limitation.

[1] The Investigation assumed that the cracks were found during that 100 Hour Inspection since it was not mentioned noted in the Aircraft Technical Logbook before the 100 Hours Inspection.

During the occurrence, the aircraft landing weight was about 1,637 kg and centre of gravity was at 2.441 m from the datum, which were within the permissible limitation (refer to AFM chapter 6.4.4, and as plotted in figure 1). The mass and balance of the Aircraft had no influence on the occurrence.

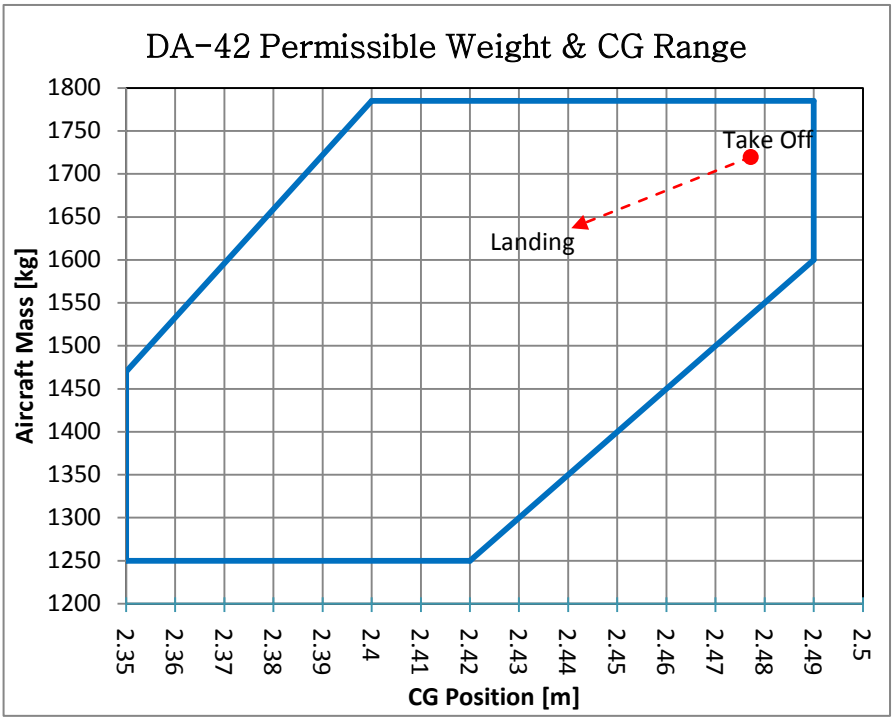

Figure 1- Aircraft Weight and Balance on the Day of the Serious Incident

1.6.4 Fuel

Fuel is stored in two main wing tanks and an auxiliary tank installed in each engine nacelle. Normally, the right tank feeds the right engine and the left tank feeds the left engine.

Both sides of the fuel system are interconnected by cross feed lines. Fuel supply for each engine is controlled by one fuel selector valve. When "CROSSFEED" is selected, the system will feed the engine from the opposite side tank in order to extend range and keep fuel weight balanced during single engine operation.

The Aircraft was refueled with JET-A1 to full tanks capacity. According to the AFM, the main tanks total capacity was 50 US Gallons (25 US Gallons each) and the auxiliary tanks capacity was 26.4 US Gallons resulting in about 243 kg calculated fuel total weight.

[2] Refer to CAR-OPS 1.615(a)(2).

The "Left Low Fuel Warning" message that appeared on short final, was perceived by the both pilots as being a "false warning" based on their assumption that the fuel tanks were full on the takeoff and the flight duration was only 1.37 hours which would not consume that much amount of fuel.

1.6.5 Landing Gear and Warning Indicators

The landing gear is a fully retractable, hydraulically operated, tricycle landing gear. The main components of the landing gear are shown in Figure 2. Struts for the landing gear are air-oil assemblies. The hydraulic power for the landing gear operation is provided by an electrically powered hydraulic pump, which is activated by a pressure switch when the required pressure is too low. Electrically actuated hydraulic valves, which are operated by the gear selector switch, provide the required hydraulic pressure for the movement of the landing gear.

The gear selector switch is located on the instrument panel. The switch must be pulled out before it is moved to "UP" or "DOWN" position.

Each main leg is a tubular steel strut. A trailing arm attaches to the bottom of the strut and an axle for the wheel assembly attaches to the trailing arm. A damper behind the tubular strut also attaches to the trailing arm and absorbs the landing loads.

When the landing gear is retracted, the main wheels retract inboard into the center wing and the nose wheel retracts forward into the nose section. The landing gear hydraulic system holds the main gear legs in the retracted position.

Springs assist the hydraulic system in gear extension and locking the gear in the down position. When the main gear legs extend, the legs geometrically lock and a latch holds the legs on the locked position during rebound loads. After the gears are down and the downlock hooks engage, springs maintain force on each hook to keep it locked until it is released by hydraulic pressure.

The three green lights, located directly next to the landing gear operating switch, illuminate to indicate that each gear is in the correct position and locked. If the gear is in neither at the full up nor the full down and locked position, a red warning light on the instrument panel illuminates whereas the three green lights will not appear.

Should one engine power lever be placed in a position below 25% while the landing gear is in the retraction position, a warning horn will chime to alert the pilot that the gear is not consistent with the landing configuration. Additionally, a CHECK GEAR message will appear on the PFD cautioning the crew that the landing gear is not down and locked. The same warning appears if the flaps move to LDG position (fully extended) while the gear is in the retraction position.

To test the gear warning system, the TEST button, which is located next to the gear selector switch, has to be pushed to annunciate aural gear alert.

To prevent inadvertent gear retraction on ground, an electric weight-on-wheel switch (squat switch), installed on the LH main landing gear leg, prevents the hydraulic valve from switching if the master switch is ON and the gear extension switch is placed in the "UP" position.

The landing gear is designed to be manually operated in the event of failure. Since the gear is usually held in retraction position by hydraulic pressure, gravity will allow the gear to extend if the system fails for any reason. To extend and lock the gears in the event of failure, it is only necessary to relieve the hydraulic pressure by means of the emergency gear extension lever which is located under the instrument panel to the left of the center console. Pulling this lever relieves the hydraulic pressure and allows the gear to fall free.

Before pulling the emergency gear extension lever, the gear selector switch has to be placed in the "DOWN" position.

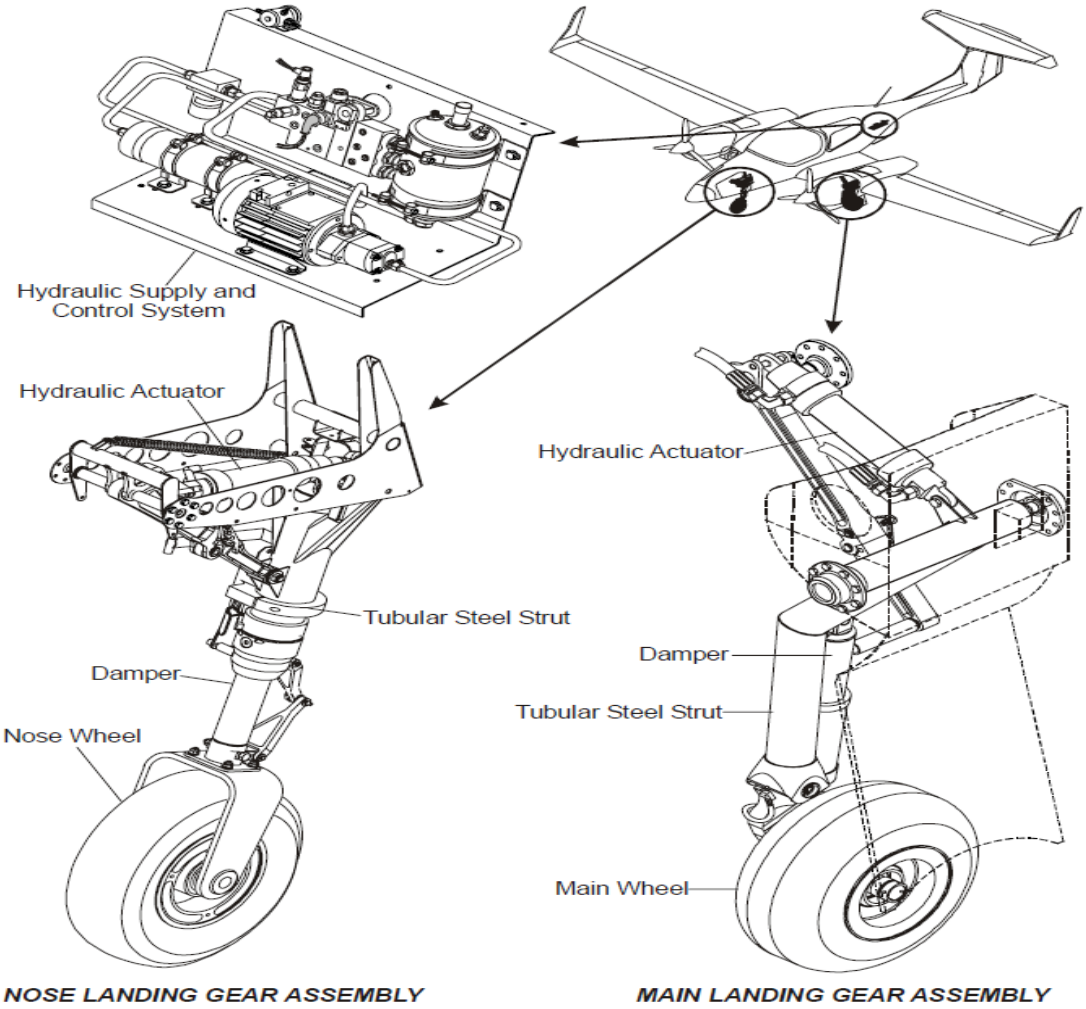

Figure 2

Main Components of the Landing Gear

1.7 Meteorological Information

The weather report at Al Ain Airport at 10.00 UTC which was the approximate time of the serious incident was as follows:

Wind	: 290 degrees / 5 knots
Cloud and Visibility	: CAVOK
Temperature	: 30 degrees centigrade
Dew point	: 02
QNH	: 1014.8 mb
Forecast	: No significant change

1.8 Aids to Navigation

Not applicable to this investigation.

1.9 Communications

The Aircraft was operating under call sign 'xxx702D'. All communications between the Aircraft and Al Ain Tower were performed on 119.85 Mhz and were satisfactory. The recordings were clear in English and made available to the Investigation.

1.10 Aerodrome Information

Al Ain International Airport is located approximately 13 km (about 8 nautical miles) northwest of Al Ain and has one runway 01-19.

Runway 01 has a CAT 1 Instrument Landing System, a Landing Distance Available (LDA) of 4,000 m, 45 m wide and has a threshold elevation of 869 ft amsl. The runway surface is made of asphalt concrete.

Runway 01 is equipped with an ICAO precision approach CAT 1 lighting system, threshold lights, visual approach light (PAPI, both sides with an angle 3^0), centerline lighting, runway edge lights, and stopway lights.

After the serious incident, the runway was closed and information was disseminated. The runway became operational after the removal of the Aircraft.

1.11 Flight Recorders

The Aircraft was not equipped with FDR (Flight Data Recorder) or CVR (Cockpit Voice Recorder). Since the Aircraft weight is below 5700 kg, and according to CAR Part IV – CAR OPS 1.470, it was not required to be equipped with FDR nor with CVR.

1.12 Wreckage and Impact Information

The traces of the contact between the Aircraft and the runway, also the debris of the Aircraft are included in Appendix 1, Figures A1-13 up to A1-24.

1.13 Medical and Pathological Information

Not Applicable to this investigation.

1.14 Fire

No fire involved in this occurrence.

1.15 Survival Aspects

There was no structure failure of the seats and the seat belts attachment.

The Airport Emergency Plan was activated immediately and the Al Ain Airport Airfield Rescue and Fire Fighting units responded. The Aircraft fuel tanks remained intact, no fuel spillage was recorded. However, no emergency action was required by the fire and emergency service unit, but the service unit was continuously present to monitor and on standby as a precaution.

The Aircraft was recovered by lifting with slings and a crane, the landing gear was able to be extended and locked, see Figure A1-23 and A1-24.

The Aircraft was then pushed from the occurrence location on the runway, and vacated the runway heading to the Operator's hangar, see Figure A1-25.

1.16 Tests and Research

For the Investigation purposes, several landing gear retraction and extension tests were performed by the Team on February 23rd and 24th, 2010.

Normal Landing Gear Retraction and Extension Test

When the Team arrived at Al Ain airport, the Aircraft was already moved into the Operator's hangar. The Team had the opportunity to test extending and retracting the landing gear. The testing was performed with the Aircraft on jacks and both wings and rear fuselage on trestle condition. The landing gears could be retracted and extended freely.

The Team performed normal landing gear extension and retraction test in accordance with the maintenance practices of the AMM Section 32-30-00. Details of the performed tests were as following:

- ***Landing Gear Retraction Test***
    - ELECT MASTER switched to ON
    - Both engine power levers set to full forward
    - Landing gear selector lever set to UP, then the occurred events were as following:
        - Hydraulic pump operated
        - Three green (SAFE) lights switched off
        - Red light (UNSAFE) illuminated
        - Landing gear retracted
    - When landing gear was fully retracted, then the occurred events were as following:
        - Red light (UNSAFE) switched off
        - Hydraulic pump stopped after a while

- ***Landing Gear Warning Test***
    - Left engine power lever moved to idle, landing gear warning horn appeared
    - Left engine power lever moved to full forward, landing gear warning horn disappeared

- ***Landing Gear Extension Test***
    - Landing gear selector lever set to DOWN, then the occurred events were as following:
        - Hydraulic pump operated
        - Red light (UNSAFE) illuminated

- Landing gear extended

- When landing gear was fully extended, then the occurred events were as following:
  - Red light (UNSAFE) switched off
  - Three green (SAFE) lights illuminated
  - Hydraulic pump stopped after a while
- Both engine power levers retarded to IDLE

The test was performed numerous times with the same results, which indicated that all relevant Aircraft systems were functioning properly.

1.17 Organizational and Management Information

According to the Training Certificate Organization No. U.A.E 03/2008, the Operator is a GCAA approved training organization for conducting ground and flying training courses. The approved training courses are for Helicopter training, Fixed Wing training, Flight Dispatcher and English Language Proficiency (ELP) course.

The Operator's fleet consists of:

- Helicopters : 10 Bell 206, and 3 Robinson R44
- Fixed Wing : 13 Cessna 172SP, 1 Cessna 182, 3 Diamond DA42 and
- 3 simulators for helicopter and fixed wing training

As indicated in its Operation Manual, Part A, the Director of Operations and Head of Training positions were occupied by the same person. According to this Operation Manual, the responsibility of the Director of Operations, also known as the Delegated Accountable Manager, is to manage the sectional departments involved in the training and act according to national and international legislation and the Operator's policy. The responsibilities of the Head of Training are to ensure satisfactory integration (planning), implementation and completion of flying training and synthetic flight training, and to supervise the progress of individual students. The Head of Training also coordinates the theoretical knowledge instruction in close cooperation with the Chief Ground Instructor.

Each of the other heads of departments and postholders was occupied by individual different than the above postholders.

Nevertheless the entity had always requested the GCAA for approving a different person for the post of the Head of Training. A new Head of Training was appointed to the position with a GCAA approval letter dated 22nd February 2010 (the day before the serious incident) for a period of six months.

1.18 Additional Information

1.18.1 Previous Diamond aircraft accidents

The Team performed a search in order to indentify if there were any other similar occurrences. The Austrian Department of Aviation Accident Investigation Branch of the Federal Office of Transport provided information regarding a previous Diamond DA-42 aircraft serious incident, registration LZ- ADS, which occurred on 05 July,2007 at Plovdiv airport Bulgaria.

On that date, at 10:54 Diamond D-42 was flying from Sofia to Poliva for the training purpose with one instructor and a training pilot. During Touch-and-Go at Plovdiv airport, the crew reported after landing "landed without landing gear".
The investigation concluded that the landing gear retraction system worked properly and considered that the serious incident occurred because of the "crew error in aircraft operation consisting in non-extended landing gear because of non-complete landing gear check list".

Recommendation for improvement in the areas of operator's maintenance, quality system, training, and management was made. Also, the aircraft manufacture was recommended for assessing any possibility to improve of the non-extended landing gear horn warning sound.

1.18.2 GCAA Examiner Selection

For the Flight Examiners, the GCAA has published a document (CAAP 27) dated 1st January 2006 which states:

> ***INTRODUCTION*** *(Section 1)*
>
> *The GCAA will designate and authorise as Examiners suitably qualified persons of integrity to conduct, on its behalf, in examining, inspecting and testing persons for the purpose of issuing licenses, ratings and assessment, in accordance with the provision of CAR OPS 1. The standard of competence of pilots depends to a great extent on the competence of the examiners.*
>
> ***PURPOSE*** *(Section 2)*
>
> *The purpose of this CAAP is to provide additional requirements to the existing CAR OPS 1 concerning examiners on aeroplane. These requirements are therefore complementary to CAR OPS 1 that takes effect on 1st January 2005.*
>
> *It addresses requirements related to roles, privileges, training, limitations, authorisation, reauthorisation, conduct of test/check and tolerances applicable to flight examiners. If these requirements are found suitable, regulations will be promulgated when the CAR FCL is introduced.*
>
> ***AUTHORISATION/RE-AUTHORISATION*** *(Section 9)*
>
> ***Authorisation*** *(Section 9.1)*

All examiners prior to authorisation must be suitably trained, qualified and experienced for their role on the relevant type/class of aeroplane. No specific rules on qualification can be made because the particular circumstance of each organisation will differ. It is important, however, that in every instance, the examiner should, by background and experience, have the professional respect of the aviation community.

***Re-authorisation** (Section 9.2)*

Examiners may be re-authorised in accordance with this CAAP. To be re-authorised, the examiner shall have conducted at least two skill tests or proficiency checks in every yearly period within the three year authorisation period. One of the skill tests or proficiency checks given by the examiner within the validity period of the authorisation shall have been observed by an Inspector of the GCAA or by a Senior Examiner specifically authorised for this purpose.

The GCAA's Licensing Inspectors functions are supported by a Licensing and Aeromedical Procedures Manual. Revision 2 of the Manual dated June 2010 states the following:

Training Requirements for Examiners
The Examiner's training and qualification program must be approved and forms part of the Operations Manual Part D in the case of an operator. All applicants for training must hold, or have held, a UAE licence prior to the application. Operators may nominate pilots to become Examiners, provided they meet the following requirements as outlined in this section.

Training Course
Applicants will be required to successfully complete a formal Examiner's course conducted by an approved organization (as specified earlier in this section) unless the applicant holds or has held examining and training authorisation or privileges on aircraft or simulators with a foreign authority. The examiner's course must be compatible with the operator's type of aircraft and / or simulator and should cover the following:

1. *Pilot examining duties, functions and responsibilities.*
2. *UAE legislation and operator policy and procedures.*
3. *Methods, procedure and instructional technique.*
4. *Evaluation of pilot (or F/E) performance, including:*
   a. *detection of faults*
   b. *detection of improper or insufficient training*
   c. *adverse personal characteristics*
5. *Appropriate corrective action to be taken for unsatisfactory performance.*
6. *Approved methods, procedures and limitations for performing the required normal, abnormal and emergency procedures in the aircraft. In particular;*
   a. *Sufficient in-flight training and practice in conducting flight checks from either pilot seat.*
   b. *The appropriate safety measures to be taken from either pilot seat for emergency situations that are likely to develop in training.*
   c. *The potential results of improper or untimely safety measures during training.*
7. *Human factors evaluation for multi crew operations.*

8. *Licensing and company documentation.*
9. *Simulator operation (if applicable).*

Additionally they will be required to comply with the requirements set forth in Lic Form xxx.

The xxx used in order to de-identify the number which includes ground observation training, flight observation training, under supervision recommendations and review.

In addition there is a section detailing the Examiner Monitoring requirement of the GCAA, which requires the:

Examiner shall be monitored at least once annually by an Inspector from the GCAA. The monitoring shall consist of, but not limited to, the following, including completion of the FO/CHK form by the Inspector.

Procedures

1. *Review required licences and medical for validity. Licence and medical dates must be current and valid. The licence must contain appropriate ratings for the operations conducted. If instrument rated, review and retain a copy of the pilot's last instrument competency check.*
2. *Review and retain copies of the Examiner's last proficiency check in each type aircraft he is authorized to conduct flights in.*
3. *Review the pilot's file of flights he has conducted during the last year. Cross check the proficiency check dates with his logbook and the company's method of keeping track of flying activities*
4. *Monitor the Examiner conducting an oral examination of the candidate.*
5. *Monitor the Examiner conducting a Proficiency Flight Check with the candidate.*
6. *The post flight debriefing should recap the entire proficiency check including the oral and flight check, clearly evaluating and providing an accurate critique of all manoeuvres and procedures performed.*
7. *Complete the GCAA form FO/CHK and debrief the Examiner as to the shortcomings of the proficiency check. If the outcome of the monitoring is unsatisfactory, inform the Examiner that his authority shall not be issued/renewed based on the performance of this monitoring, and that he shall suspend his actions as an Examiner until such time as he satisfactorily completes another Examiner monitoring with the GCAA.*
8. *Provide the Examiner with a copy of the letter to the company indicating that the Examiner did not perform in accordance with the standards and requirements of the GCAA, and therefore shall not represent the GCAA in further official examining duties until such time as a satisfactory recheck can be accomplished.*
9. *If a satisfactory recheck on the Examiner cannot or is not completed within the one month grace period after the Examiner monitoring is due, the GCAA shall send a registered letter to the Examiner informing him that his check authority has been denied/cancelled and requesting him to return the Examiner's Certificate (If issued), stamp and letter of authority to the GCAA as soon as possible. A letter shall be posted to the Post Holder Accountable Manager and /or Post Holder Head of Training describing the details of the procedure and informing their company that the pilot has no authorization to conduct future proficiency checks, nor shall any proficiency checks conducted by him be recognised by the GCAA.*

1.19 Useful or Effective Investigation Techniques

Not applicable to this investigation.

2 ANALYSIS

The Aircraft remained relatively intact which offered benefit to the Investigation, both pilots on board survived, and data including photographs were available from several sources.

For the Investigation purposes, the following has been performed by the Team:

- Investigation on the occurrence area including Aircraft debris and the Aircraft traces on the runway,
- Investigation of the Aircraft damage,
- Testing the landing gear retraction and extension cycles,
- Conducting interviews with the involved pilots and related personnel,
- Review the Aircraft operational documents and records,
- Review both pilot documents and records,
- Review the recorded radio communication between Al Ain ATC and the pilots,
- Review the Operator's operational documents, and
- Review the GCAA's process for examiners' approval before and after the occurrence.

There were some contradictions between the available evidence and pilots statements.

2.1 Aircraft System

As stated in 1.1, based on the examiner's interview, the landing gear lever had been lowered to the 'DOWN' position prior to landing by the examinee. The examinee stated that he thought he had lowered the landing gear lever. Both pilots explained that they remember seeing the illuminated three green landing lights after lowering the lever. Before the touchdown, the examiner claimed that he remembered that three green lights were illuminated.

As mentioned in 1.6.5, the three green lights illuminate to indicate that each gear is consistent with the landing gear lever position, down and locked. If the gear is in neither at the full up nor the full down and locked position, a red warning light on the instrument panel illuminates, while the three green lights will not appear.

In Paragraph 1.6, it is stated that the Aircraft obtained JAA and FAA certification, which means in accordance with JAR/FAR23.1309 requirement, landing gear system and the associated components are considered separately and in relation to other systems, the occurrence of any failure condition that would prevent continued safe flight and landing of the Aircraft must be extremely improbable (10^{-9} of probability of failure), and the occurrence of any other failure condition that would significantly reduce the capability of the Aircraft

or the ability of the crew to cope with adverse operating conditions must be improbable (highest failure probability of this condition is 10^{-5}).

Probability of locking simultaneous failure of all gears before touchdown

Each gear strut, as a component of the landing gear, has an independent autonomous locking system, which can be considered of having a probability of 10^{-5} of failure or as an improbable event. Locking failure of a gear strut has no effect and will not cause locking failure to the other gear struts, therefore it might be quantified that the probability of simultaneous failure of all gear struts is less than 10^{-9}. Based on this, simultaneous locking failure of all gear struts, with three green lights lit as confirmed by both pilots, before the touchdown, might be considered as an extremely improbable event.

Probability of collapse of the already locked down gears at touchdown

As stated in 1.6.5, springs assist the hydraulic system in gear extension and locking the gear in the down position. When the main gear legs are extended, the legs geometrically lock and a latch holds the legs in the locked position during rebound loads.

A collapse of one locked down gear due to spring or latch failure at touchdown, again as an independent component of the landing gear system, might also be considered as an improbable event. Therefore a collapse of all locked down gear struts simultaneously at touchdown might be considered as an extremely improbable event.

Retraction of the landing gear after normal touchdown

When the pilot inadvertently place the landing gear selector switch to UP position after touchdown with normal down locked gears, the landing gears are protected to not respond and would stay in its extended and locked position by the electric weight-on-wheel switch (squat switch) that is installed on the LH main landing gear leg, which would prevents the hydraulic valve from switching when the master switch is ON. This switch opens the electrical power to the solenoid valves of the hydraulic supply and control system is isolated. This over-rides the position of the landing gear selector switch.

Failure of weight-on-wheel switch, which might be considered as an improbable event, could lead to gear retraction on ground when the landing gear selector switch is selected to UP position. However, this scenario might not be valid because the position of the landing gear selector switch was found at DOWN position as shown in Figure A1-26, except if the landing gear selector switch was inadvertently placed in UP position during the landing roll after the touchdown, then when the pilot realized that it was an inadvertently action, the selector switch was re-placed to DOWN position as pilot automatic reaction. Nevertheless, this case again might not be valid in relation to Paragraph 2.3 which analyzing evidently the unavailability of scar lines on the runway from both main tires.

Failure of Hydraulic systems

As explained in 1.6.5, in the event of failure, and it is also valid for hydraulic system failure, that manual landing gear extension can be performed by placing the landing gear selector switch to the DOWN position and then pull out the emergency extension lever to relieve the hydraulic pressure, the landing gears should be extended and locked. However, the emergency gear extension lever was found NOT at a Pull Out position after the occurrence, which means no hydraulic system failure was experienced during the occurrence.

In case there was a hydraulic failure after the Aircraft touched down, there would have been additional marks on the runway before the stopping point, such as hydraulic fluid, or other evidence of the malfunction. In any case, the system was tested several times in the hangar after the occurrence with satisfactory results and without any malfunction.

Failure of Electric System

A failure of the on-board electrical system causes the landing gear automatically to extend, as stated in 1.6.5. The hydraulic pump is not driven anymore and both solenoid valves open. The hydraulic locking mechanism of the landing gear system is inoperable. In the case of this on-board electrical failure, the same procedure as hydraulic failure has to be followed by performing manual landing gear extension. When the gear is fully extended it will geometrically lock in the down position. However, the landing gear may slowly extend.

There is a possibility during landing when on-board electrical failure occurs, that the landing gear was still extending but not in locked condition yet at touchdown. Nevertheless, this scenario could be considered not valid because the available evidence proves that there was no on-board electrical system failure before and during the occurrence (refer to 1.15 and 1.18). In addition, the several test performed in the hangar after the occurrence didn't reveal any malfunctions of the system.

2.2 Analysis from the Damaged Aircraft and Scars on the Runway

Based on the photographs shown in Figure A1-13 up to A1-19, the sequence of Aircraft impact mark, along its roll until it stopped on the runway was as the following:

- The first impact point on the runway was from the Aircraft's tail skid, and the Aircraft floated for a while above the centre line which can be seen from the distance of the broken scars line after the first impact point as shown in Figure A1-13.
- Then, the LH propeller started touching the ground (see Figure A1-17) leaving slashes and damaged the blades' tips,
- Thereafter, the LH footstep and almost in the same time the RH footstep touched the ground. Then, while LH Propeller was still rotating and becoming shorter, after 15 consequent slashes, the LH exhaust tube started touching the ground (Figure A1-17).
- Then RH propeller started touching the ground, while almost in the same time, the LH propeller stopped to rotate after leaving 19 slashes from the rotating blades tip (see Figure A1-15 and A1-17).
- The RH propeller continued rotating and becoming shorter, after 4 slashes, the RH exhaust tube started touching the ground (see Figure A1-16 and A1-17).
- The RH propeller stopped rotating after leaving 16 slashes engraved by the rotating blades tip.
- Then, the Aircraft, which was still moving while decelerating, started changing heading to right side of the runway (Figure A1-17).
- Before the Aircraft totally stopped, as shown in Figure A1-19, longitudinal scars on the runway were drawn by rubbing with the bottom surfaces of the Aircraft as following :
    - LH engine cowling and exhaust tube
    - LH footstep

- Transponder antenna
- Tail skid
- DME antenna
- RH footstep
- RH engine cowling and exhaust tube

As illustrated by the photograph shown in Figure A1-11, the airplane's area that touched the runway was also in front of the tail skid, the plastic addition of the Aircraft which is there to protect it. Calculations indicate that the position of the tail skid will only protect the aircraft when the landing gear is extended. But in this event the landing gear wasn't extended and the aircraft was damaged behind the skid. In case the skid was extended further towards the fin, have a better protection might be availed.

Based on the photographs given in Figure A1-20 and A1-24, it can be seen that:

- Condition of the aircraft at full stop on the runway where the gears were in extended but not locked position as shown in Figure A1-20 and A1-21. Scars were found on the bottom surface of the front cockpit as shown in Figure A1-20;
- No obvious worn-out marks or scars were found on the sidewall of the RH main tire as shown in Figure A1-22;
- Marks on the runway came from the LH and RH main tires as shown in Figure A1-23 and A1-24. These curve scars lines from both main tires were formed when the Aircraft was lifting up. Because of the gravity forces of both main landing gears while the Aircraft was lifting up, both main tires suppressed the runway surface and leaved these tire marks behind.

Based on the above mentioned evidence, there was no any evidence available of scars or marks on the runway came from the LH and RH main tires which should be formed if the gears were down but not locked during the Aircraft movement, since from the Aircraft's touchdown until its stop on the runway. However, there was evidence of curve scars lines came from both main tires on the runway which were formed when the Aircraft was lifting up. It should be the same as when lifting up the Aircraft, that both main tires also should suppress the runway and leave scars on the runway surface during the Aircraft movement from the touchdown until stop, if the gears were in down but not locked condition, but unfortunately it was not the case. In this case, it was most likely that the landing gear selector switch has been placed to DOWN position at the time, or after the aircraft totally stopped on the runway, and obviously before the ELECT MASTER was switched to OFF.

Scars on the bottom surface of the front cockpit, and no obvious worn-out marks or scars on the sidewall of the RH main tire are other evidence clarifying that the gears were not in extended condition during landing.

2.3 Flight Examination Performance

Pilot Qualification

The examiner was properly authorizsed in his respective role to perform the multi engine instrument rating check ride/skill test flight. Also, the examinee was relatively experienced with about 32.5 hours in multi engines, and he was being checked for multi engine instrument pilot instructor rating qualification.

At the time of the occurrence, the examiner had completed just over 6.5 hours of duty while the examinee was over 7.33 hours, which was within their allowable duty time and they were suitably rested, more than 12 hours prior to commencing their duty cycle.

Weight and Balance

As stated in Paragraph 1.6.3, the mass and balance of the Aircraft during the occurrence was within the weight and balance envelope limitation, and it had no influence on the occurrence. However, there was no specific aircraft loading and takeoff mass and balance calculation (load sheet) form used by the Operator for each flight. Since the Aircraft had 4 seats configuration, it is considered that mass and balance calculation or load sheet should be available before takeoff of each flight.

As an example, figure 3 below shows the Aircraft mass and balance when all four (4) seats are occupied, fuel is 42 US Gallons (fuel only in the main tanks) before takeoff, and fuel remains 22 US Gallons at landing. The takeoff weight calculation gives 1,780 kg which is below the MTOW, while the CG is 2.515 m from the datum which is beyond the centre of gravity limitation. From this example it is considered that the weight and balance could be possibly overlooked before takeoff when there is no load sheet available.

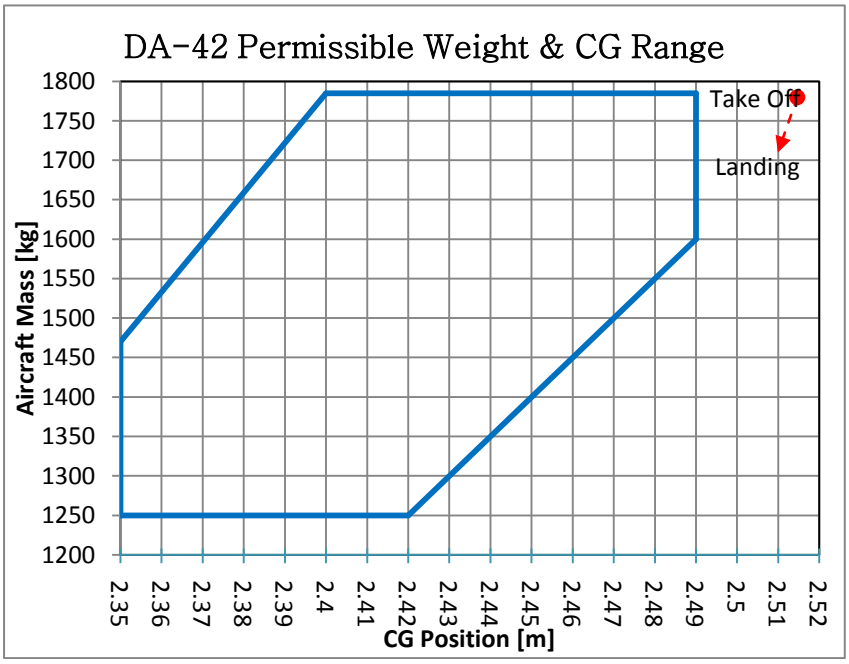

Figure 3 An example of Aircraft Weight and Balance of four occupied seats and 42 US Gal of takeoff fuel configuration

The Skill Test Flight

As mentioned in Paragraph 1.1, the flight was a multi engine instrument rating check ride/skill test flight.

At the time of the event the regulatory oversight, including authorisation and monitoring of the examiners' performance was performed by the Flight Operations Unit of the UAE GCAA. Shortly after the event, this function was transferred to the Licensing Section. A review of the relevant processes indicated that after the serious incident examiners were thoroughly supervised and an effective oversight of the abilities was performed by the relevant Licensing Section.

Regarding the event the examiner stated that pre flight briefing was conducted before the test flight. The test flight was performed uneventful and started from the taxiing, take off, and climb to the training area (see appendix 2) performing the required manoeuvres. Subsequently they returned back towards Al Ain airport, for performing normal Touch-and-Go's, then continued the second Touch-and-Go simulating short field full flap landing. Finally full stop landing with simulated one engine failure was performed, and the Aircraft landed without an extended and locked landing gear.

On the first Touch-and-Go, the examiner flew the aircraft to demonstrate the Touch-and-Go. While the Aircraft was rolling on the runway, the controls were handed over to the examinee and continued the takeoff.

This controls transfer had no contribution to the occurrence, but for a skill test flight, this action is considered not usual. Actually if the examiner feels it is required to demonstrate first, the examiner should demonstrate the normal Touch-and-Go completely, and thereafter request the examinee to perform the same exercise. Or, during the pre flight briefing, the examiner should explain first about the certain exercise(s) to be performed. If there was a SOP of controls transfer, most likely that this procedure has not been followed, or there was no controls transfer procedure available, especially for skill test flight. Also, it could be considered that there was room for improvement for the Touch-and-Go procedure.

The full stop landing with simulated one engine failure was asked by the examiner to be performed by the examinee. When the Aircraft was at downwind abeam threshold runway 19, the left power lever was reduced by the examiner, followed by conducting the normal engine failure check and simulated feathered the left engine by the examinee. Left power lever of the simulated left engine failure was approximately to 25% to omit the activation of the landing gear warning horn. There was no proper procedure of thrust zero setting on the simulated engine failure available, which is required to simulate a proper engine failure event. In addition if the engine lever is set to zero there is going to generate drag which is not as close as possible to the fathered propeller. The left power lever was obviously set so to omit the activation of the landing gear warning horn.

At base leg, the examiner claimed that landing gear selector switch was lowered to position DOWN by the examinee, while the examinee explained that he thought he had lowered the landing gear selector switch to DOWN. Based on this explanation, it could be considered that the examinee was not sure about his action. Most likely no gear callout had been performed otherwise the examinee had lowered the landing gear selector switch obviously and most probably would remembered his action. Based on this, it could be considered that there was a lack of the gear callout procedure.

According to the SOP, and as both pilots explained that landing gear should had been lowered on the base leg for one engine failure landing, while on the downwind for normal landing.

On the long final Runway 01 after landing clearance was given, the examinee recalls that he performed the items of the landing checklist, simultaneously pointing the related items. The examinee explained that the pilot performs the tasks first and then reads thereafter the paper checklist, which is compatible with one pilot

operation aircraft. It should be taken into account that possibly the checklist was interrupted, either by an ATC communication or by another task. The primary effect of interruption/distraction is to break the flow pattern of ongoing activities and this was early indentified.[3]

In case of a possible Radio Interruption, the pilot had two options, to continue the performance of the checklist during the radio transmission, or interrupt the performance of the checklist in order to communicate with the ATC. In case the pilot continued his task, attempting to attend the radio and the checklist would have created an increase of workload. This temporarily increased workload, may increase the likelihood of error in one or both tasks. In case they interrupted their checklist performance in order to listen to the radio, such an interruption may either be unmarked, or marked with an explicit hold. But none of the pilots remembered holding the checklist, to answer the radio, or providing a cue to themselves such as announcing the interaction, thus both are aware of the issue. We also have to underline that interruption to listen to or respond to the radio is often followed by conversation between the pilots of the information gathered from the radio, thus extending the period of interruption.

It could be considered that the standard procedure of the checklist and CRM was known to the pilots but was not available for the Instructors of this Operator.

Still on final Runway 01, when Left Low Fuel caption on EICAS appeared, the examinee informed the examiner that the Aircraft was fully refueled before the takeoff, and both pilots stated they were not concerned by this caution, based on fact that the Aircraft has just been flying for approximately 1 hour and 22 minutes.

The fuel used was about 26 US Gallon or about one third (1/3) of the capacity fuel tanks, which means fuel was still available about two third (2/3) of the maximum capacity tanks.

The examinee claimed that he remembered hearing the single chime of the EICAS Left Low Fuel caution alert, but didn't remembered hearing the continuous intermittent chime tone of the landing gear warning. In contrary the examinee explained that he was pretty confident that there was no landing gear aural warning during approach and landing. This time, the examinee was not sure about hearing the aural landing gear warning. But the landing gear aural warning was either not noticed or not heard due to performing other task. Although a louder aural warning might not contribute to a safer landing, a flashing light might have safety enhancement by alerting and assisting the pilot of recognizing the unusual situation.

As mentioned in Paragraph 1.1, landing gear warning horn sometimes appeared when the left power lever was below about 25% position, and this was also valid for the right power lever. It means that there was no failure when operating the landing gear warning horn.

Especially on final, one of the power levers most probably the right power lever as the remaining power of the simulated left engine failure, or both power levers (when required) should be obviously once or more times below 25% to obtain and control the approach airspeed for zero flaps landing, which had a result of appearance of the landing gear warning horn, and it should disappear again when it was placed above that position.

From the recorded radio communication between the Aircraft and Al Ain ATC, the aural landing gear warning was noticeably heard when the pilot confirming Al Ain Tower '***Clear to land xxx Seven Zero Two Delta***'. After

[3] "Checklist Interruption and Resumption : A Linguistic Study by Linde, Coguen, NASA Contractor Report 177460, June 1987

about 46 seconds later when the Aircraft was already on the runway, the landing gear warning horn was again heard ones on the last word of the last sentence when the pilot informing the Tower *'.....on the runway.....we are on the runway'*.

This last exercise was a simulated left engine failure flapless landing, and with the assumption that no gear callout was performed, and when the landing checklist was being performed on final, it is probable that the landing checklist was not performed according to standard procedure. Although there was no strong reported cross wind speed and direction, the wind speed was approximately 5 knots from 290° for Runway 01, the attention of both pilots was concentrated on control of the aircraft, in particular controlling the airspeed. The single chime of the EICAS Left Low Fuel on final indicates that the aircraft at one time was in a high left side slip condition such that the fuel sensor detected low fuel condition on the left tank. This left low fuel detection was the result of fuel in the left main tank moving outboard of the tank (note: the low fuel sensors are installed on the inboard end of each inboard fuel chamber).

On downwind, it is probable the Aircraft flew with a right sideslip to maintain heading due to the asymmetrical thrust and cross wind from the right. Starting from base leg, and especially on final, the Aircraft had to change the attitude for landing by controlling the remaining power (left power lever was not used simulating the left engine failure), and corrective actions on the flight controls and trims to maintain proper heading and controlling the approach speed. This pilot's workload, combined with the addition of the left low fuel caution warning required additional pilot attention.

The Team concludes that the landing gear down and locked three green indicators were in NOT illuminated condition.

In addition, there was no illumination of the red (UNSAFE) light. The continuous intermittent aural landing gear warning horn was not coming to their attention as the crews were distracted.

The Phase before the Event[4]

The Team made an effort to indentify why both pilots omitted to ensure that the landing gear was down and locked and areas of improvement in order to avoid reoccurrence of the event.

It is known that [5] crew error was found to be a causal factor, inadvertent omission of normal procedural step played a pivotal role[6], the crew forgot to perform a flight-critical task and did not catch error with the

[4] Loukopoulos, Dismukes, & Barshi , *The Multitasking Myth: Handling Complexity in Real-World Operations* (Ashgate)

Dismukes, Berman, & Loukopoulos , *The Limits of Expertise: Rethinking Pilot Error and the Causes of Airline Accidents* (Ashgate)

R. K. Dismukes, & J. L. Nowinski, (2007) Prospective Memory, concurrent task management, and pilot error, *In A. Kramer, D. Wiegmann, & A. Kirlik (Eds.) Attention: From Theory to Practice. New York: Oxford University Press*

[5] Berman, B. A. & Dismukes, R. K. (2006) Pressing the Approach: A NASA Study of 19 Recent Accidents Yields a New Perspective on Pilot Error. Aviation Safety World, December 2006, 28-33.

[6] National Transportation Safety Board (1988). *Aircraft accident report: Northwest Airlines, McDonnellDouglas DC-9-82, N312RC, Detroit MetropolitanWayne Country Airport, Romulus, Michigan, August 16, 1987*. (NTSB/AAR-88/05). Washington, D.C: National Transportation Safety Board.

associated checklist, as indicated in five (5) of the twenty seven (27) major U.S. airline accidents between 1987 and 2001.

Much of the error management in a multi-crew environment relies on cross checking of vital data and actions by the other crewmember. This facility is not available to the single pilot and therefore other techniques have to be employed.

In an ideal world the system will have eliminated latent errors. However, in the real world latent errors ready to trap the unwary pilot do exist in many guises. Therefore one needs to be constantly alert for these traps and be conversant with the aircraft and the operation to the greatest extent possible. Adherence to SOPs is again one of the main defenses and all pilots should be alerted to situations which are new, untried, distract from normal operations, outside SOPs, or they find themselves unable to follow the SOPs. The pilot should be comfortable with the operation. If not then it is probably necessary to take action to restore the comfort factor.

Workload planning will allow the pilot to make decisions in good time and to self cross check any critical actions before implementation.

This serious incident clearly indicates that the safety nets which put in place by the Regulators, Manufacturers and the Operator, didn't preclude the pilot from landing without extending the landing gear. Therefore we need to understand why the pilots forgotten such a safety critical task and then indentify areas of improvement both at individual/team performance level as well as at Organizational Level.

Pilots are taught at linear environment, they have to perform a task after the other, but in the real world almost nothing progresses at a linear sequence.

Pilots routinely manage multiple, competing, concurrent task demands successfully but research highlighted the problem of omissions insofar omitted checklist items are concerned. Checklist's errors per flight are 3.2±2.9 (range 0-14). From the 194 observed errors, 50 errors involved checklists, mainly a checklist item was deferred and later forgotten or checklist interrupted by external agent or an event and item never completed. Pilots are venerable to omissions when among others they are interrupted, when they must perform tasks outside normal sequence and when interleave multiple tasks.

Repetition on the line basically translates into automaticity. A task (or sequence of tasks) becomes automatic when it can be carried out without conscious effort. The brain functions essentially automatically, relying on the presence of subconsciously learned triggers that prompt memory (again subconsciously) to recall and carry out the next activity in the sequence.

National Transportation Safety Board (1989). *Aircraft accident report: Delta Air Lines, Boeing 727-232, N473DA, Dallas-Fort Worth International Airport, Texas, August 31, 1988*. (NTSB/AAR-89/04). Washington, D.C: National Transportation Safety Board.

National Transportation Safety Board (1995). *Aircraft accident report. Runway overrun following rejected takeoff. Continental Airlines flight 795, McDonnell- Douglas MD-82, N18835, LaGuardia Airport, Flushing, New York, March 2, 1994*. (NTSB/AAR- 95/01). Washington, D.C: National Transportation Safety Board.

National Transportation Safety Board (1997). *Aircraft Accident Report: Wheels-Up Landing, Continental Airlines Flight 193, Douglas DC-9, N10556, Houston, Texas, February 19, 1996*. (NTSB/AAR- 97/01). Washington, D.C: National Transportation Safety Board.

National Transportation Safety Board (2001). *Aircraft accident report: Runway overrun during landing, American Airlines flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999*. (NTSB/AAR-01/02). Washington, DC: National Transportation Safety Board.

After having performed the same tasks in the same way and with the same timing a couple of thousand times, like an experience pilot has, the brain also develops certain expectations.

Again this errors of omission occurred due to inability of the human brain to process information whilst addressing multiple tasks, concurrently. As multitasking increase our vulnerability to errors, which it surly depends to the individual's capability to multitask. In addition it depends to the degree tasks are practiced, to the degree to individual task requirement, effort as well as attention and to the cues available to prompt recall of intended actions.

Therefore what may be done in order to minimize the possibility of omissions? Needless to underline that adherence to procedures is the key element. Nevertheless every pilot intends to perform an excellent flight, especially in our case which was a skill test, where there was an additional element of performing.

Having in mind the above one may propose recommendations to address the issues raised and prepare the pilots for the inevitable possibility of errors of omissions. Multitasking, asking the pilots especially in the single pilot operation environment, which has its limitations to handle tasks concurrently is an area that the pilot has to be prepared. Company procedures are to prepare the pilots and efforts to solve as many potential problems on the ground, instead of leaving pilots to perform what they might think as a good solution to the specific problem. Threat and error management theoretical and practical exercises are to make single pilot operation or examiner/instructors duties aware as human limitations of the brain processing information. But this approach must address the specific issues of the specific group of people that it is addressing. As it was revealed in the past pilot training programs historically focused almost exclusively on the technical aspects of flying and on an individual pilot's performance; they did not effectively address to crew management issues that are also fundamental to safe flight. These observations have led to a consensus in industry and governmental training programs should place emphasis on the factors that influence crew coordination[7]. In addition [8]CRM and human factors training programs concerns directly the introduction of changes to the existed culture-attitude of the pilots and a necessary presupposition for the effective application of CRM/human factors training programs is a research-study by the management to indentify:

a) A proactive determination of their existed culture-attitude and the impact on it by the introduction of changes through the training program;

b) Selection of the most efficient measures, procedures, methods and mechanisms for the existing cultures.

Furthermore company procedures have to clearly predetermine what pilots should do in case there is an interruption, due to various reasons, in the normal flow of checklist reading, as this will assist them and minimize the possibility of omission.

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[7] Wiener, E. L., Kanki, B.G.,& Helmreich, R. L. (Eds.) (1993). *Cockpit resource management.* CA: Academic Press.

Helmreich, R. L., & Merritt, A. C. (1998). *Culture at work in aviation and medicine: National, organizational, and professional influence*s. Alders hot: Ashgate.

Salas, E., Bowers, C.A., & Edens, E.(2001) (Eds.) *Improving teamwork in organizations: Applications of resource management trainin*g.Hillsdale, NJ: LEA, I nc.

[8] Lainos J., Nikolaidis E., *(2003) Presuppositions for the effective introduction of changes to the aviation safety culture, through Crew Resource Management training program. The case study of a Southeastern European Airline.* 12th International Symposium on Aviation Psychology Write University Dayton Ohio, USA.

3 CONCLUSIONS

3.1 Findings

(a) The Aircraft was airworthy and properly certified.

(b) The Aircraft had a valid certificate of Insurance.

(c) The flight crew held valid licenses.

(d) During the pre-flight briefing, the examiner should have performed a more in depth review of transfer of control, one engine out simulation.

(e) There was no load sheet form or any other means available to calculate the weight and balance before flight.

(f) The taxi, takeoff, climb to training area, required manoeuvres of the test flight, two Touch-and-Go were performed uneventfully.

(g) The last exercise was the simulating one engine failure full stop landing.

(h) During the whole flight, no indications of any anomalies on the aircraft engines or systems were found.

(i) No clear aircraft transfer control procedure was available.

(j) There was no clear procedure available of thrust zero setting on the simulated engine failure.

(k) There was no clear landing gear down and locked callout procedure.

(l) The Operator did not provide CRM or Threat and Error Management training to the examiner.

(m) The checklist was interrupted during the downwind leg.

(n) The Operator did not address the check list interruption in depth.

(o) Both pilots were under the impression that the landing gear was down for landing.

(p) On the last exercise, the Aircraft landed without extended and locked landing gear.

(q) Simultaneous locking failure of all gear struts, with three green lights lit might be considered as an extremely improbable event.

(r) Collapse of all locked down gear struts simultaneously at touchdown might be considered as an extremely improbable event.

(s) There was no hydraulic system failure involved.

(t) There was no electrical system failure involved.

(u) Photographs of the aircraft damages and scars on the runway clarifying that the gears were not in extended condition during landing.

(v) The aural landing gear warning was noticeably heard twice on the background from the radio communication between Aircraft's pilot and Al Ain Tower, when the Aircraft was on final and on the runway.

(w) From the result of the several landing gear retraction and extension tests, showed that the landing gear system functioned as its normal operation, and no abnormal operation was found.

(x) The landing gear selector switch has most likely been placed to DOWN position at the time, or after, the aircraft totally stopped on the runway.

(y) None of the pilots were injured.

3.2 Probable Cause

The Air Accident Investigation Sector determines the probable cause of the serious incident was error of omission in the checklist due to various distraction combined with the high workload of the handling pilot (examinee), accentuated by most probably initially an ATC interaction and later a low fuel warning light, resulted in the crew not completing and verifying the landing checklist prior to land.

4 SAFETY RECOMMENDATIONS

4.1 Recommendations to GCAA

SR 08/2012

To review the training methodology, to conduct Touch-and-Go and single engine failure circuit procedures.

SR 09/2012

To review the qualification of all Operator's Flight Instructors.

SR 10/2012

To review and approve the weight and balance calculation method of the DA-42 aircraft.

SR 11/2012

To assess the necessity of single pilot CRM with Threat and Error Management training for all flight examiners and instructors.

SR 12/2012

To publish clear guidelines of how many post holder/management positions may be held by one individual in an Operators' organization structure.

4.2 Recommendations to the Operator

SR 13/2012

To develop load sheet form or any other means of calculating weight & balance, and to be include in the flight preparation procedures, that weight and CG shall be determined before each flight.

SR 14/2012

To review the necessity to enhance SOPs in the following areas specifically:

(a) Pre flight and safety briefing

(b) Transfer control procedure

(c) Touch-and-Go procedure

(d) Zero thrust setting procedure

(e) Single engine failure circuit procedures for dual engines

(f) Abnormal/emergency operations

(g) Running checklist procedure & CRM (including completing the landing checklist before reporting *clear to land* to ATC).

(h) Gear call out procedure

(i) Standard crew call out.

4.3 Recommendations to the Manufacturer

SR 15/2012

Aircraft manufacture to assess the possibility of implementing a landing gear visual warning such as flashing light inside the landing gear lever, as an additional warning on retractable gear aircraft in order to enhance the pilot alertness.

Answer of the Manufacturer:

"In April 2008 Diamond Aircraft Industries approved a visual 'Check Gear Caution' that illuminates on the G1000 display in addition to the acoustic warning horn, which is production standard since then. A retrofit of this feature is rather difficult as extensive time consuming work in a sensitive area, requiring highly skilled avionics-technicians familiar with the integrated avionic system of the DA 42, bears the risk that this does more harm than good".

SR 16/2012

Aircraft manufacture to assess in future design changes the necessity to redesign the tail skid.

Answer of the Manufacturer:

"Extending the tail skid would not influence the damage that occurs to other components such as propellers, engines, engine cowlings and firewalls which are the major damages after a gear up landing. The saving of repair costs would be very low compared to the overall repair costs. Furthermore the overall damage that occurs to a DA 42 after a gear up landing is very little".

Appendices

Appendix 1 Aircraft Damages and Runway Scars

Figure A1-1 : Damaged Left Hand Engine Propeller Blades

Figure A1-2 : Damaged Left Hand Exhaust Tube and Bottom Engine Cowling

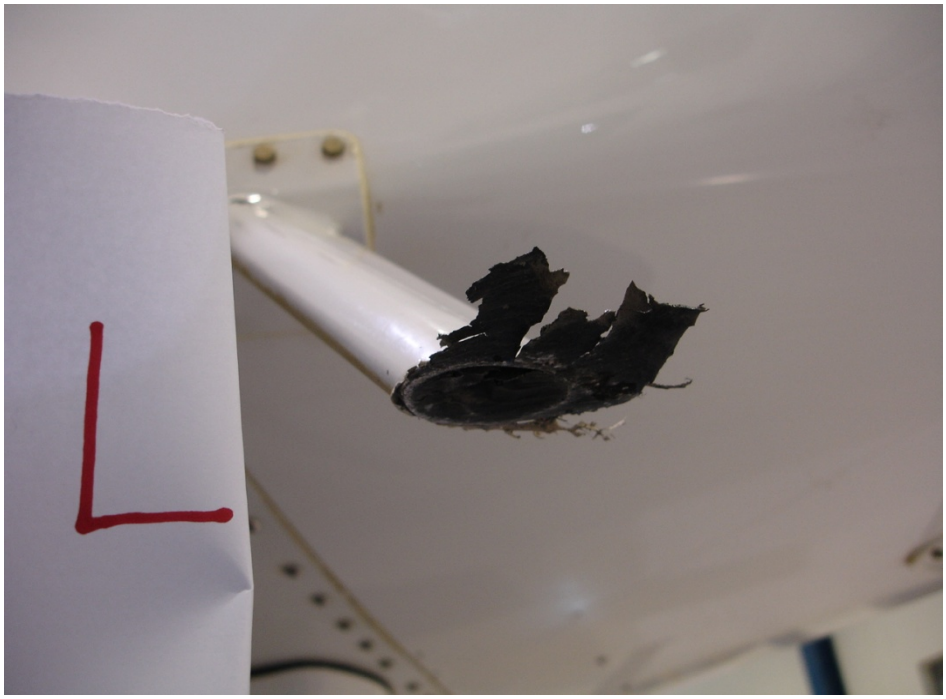

Figure A1-3 : Worn-out Damaged Left Hand Foot Step

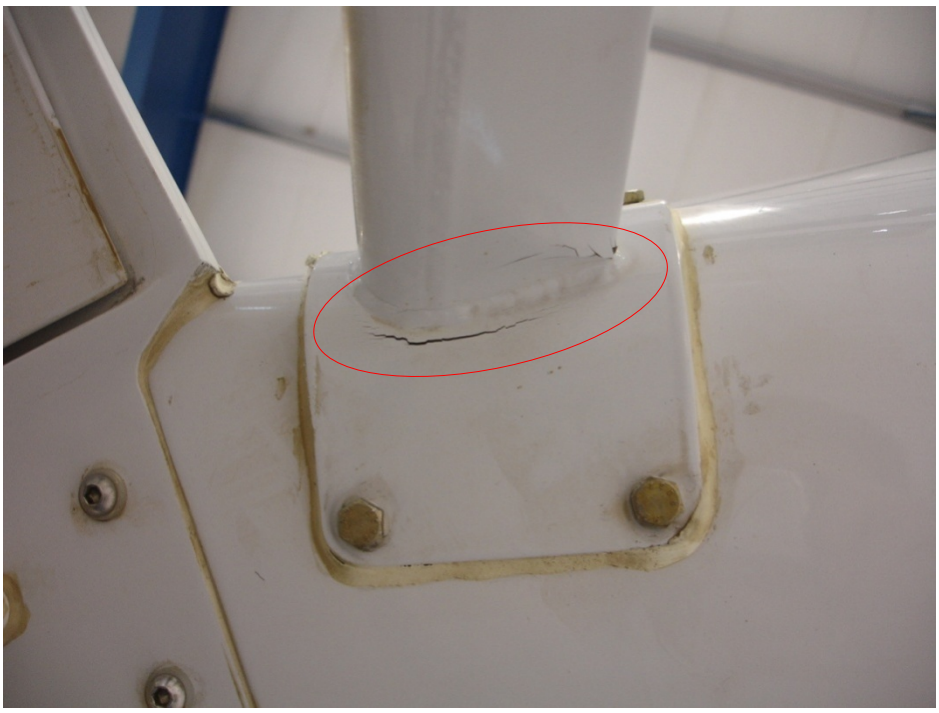

Figure A1-4 : Fatigue Damage on the Root of Left Hand Foot Step

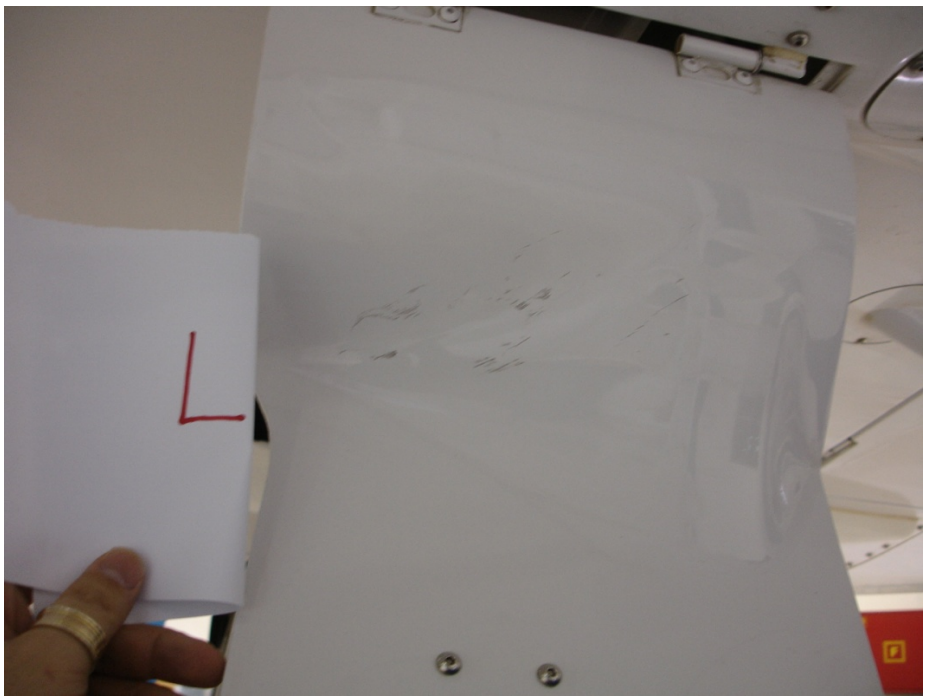

Figure A1-5 : Light Scar Mark on the Left Hand Main Landing Gear Door

Figure A1-6 : Damaged Right Hand Propeller Blades

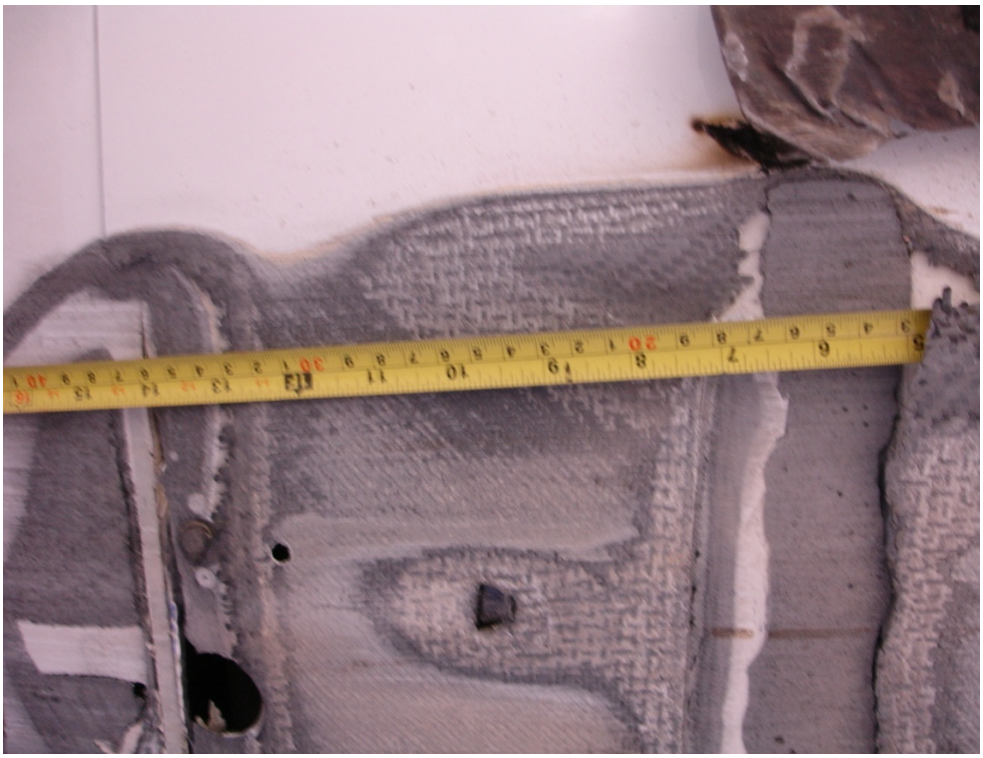

Figure A1-7 : Damaged Right Hand Exhaust Tube and Bottom Engine Cowling

Figure A1-8a : Damaged Right Hand Exhaust Tube with a flat cut of 15 cm length

Figure A1-8b : Damaged Right Hand Exhaust Tube with a flat cut of 9 cm width

Figure A1-8c : Damaged Right Hand Exhaust Tube with remaining length of 7 cm outside the engine casing

Figure A1-9 : Worn-out Damage Right Hand Foot Step

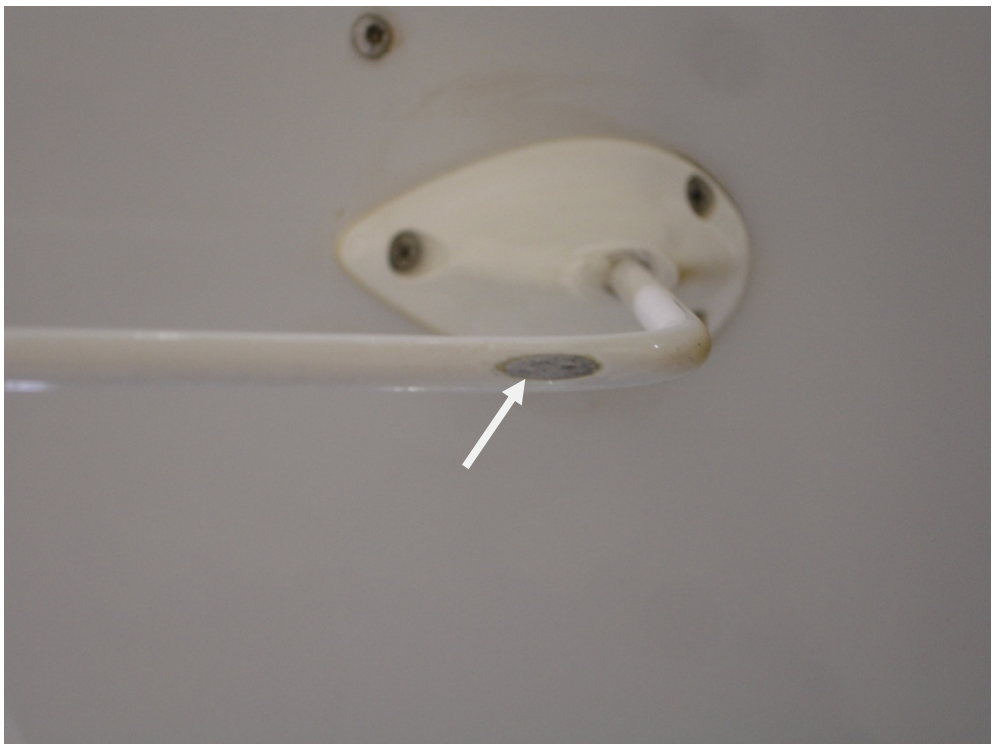

Figure A1-10 : Light Scar of Lower Central COM 2 Antenna

Figure A1-11 : Destruction/Grit of Lower Part of The Fin

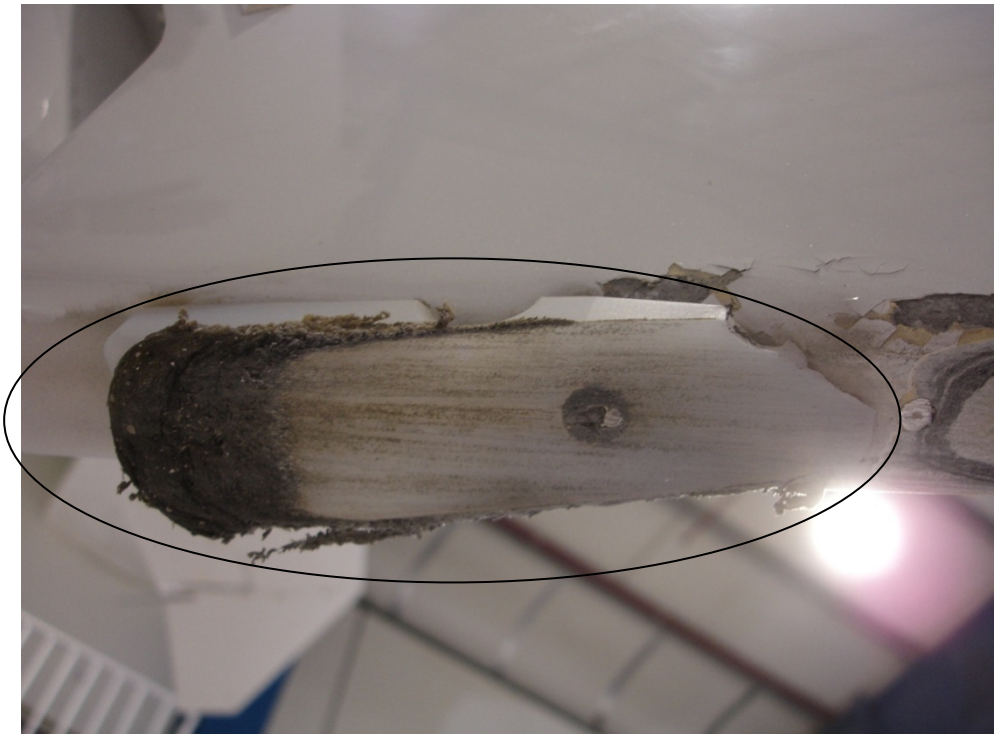

Figure A1-12 : Tail Skid Destruction

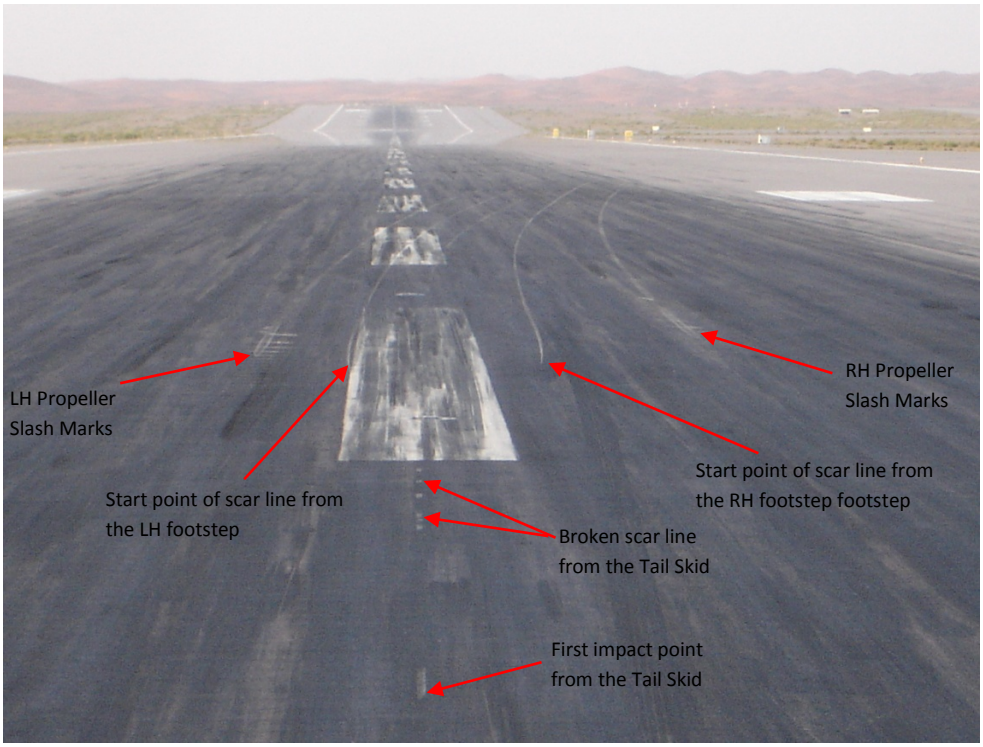

Figure A1-13

First Impact Points and scars lines on the runway

(photograph was taken after the aircraft has been vacated and debris has been cleaned from the runway)

Figure A1-14

Fracture and Scar Line on the Runway Centre Line Light

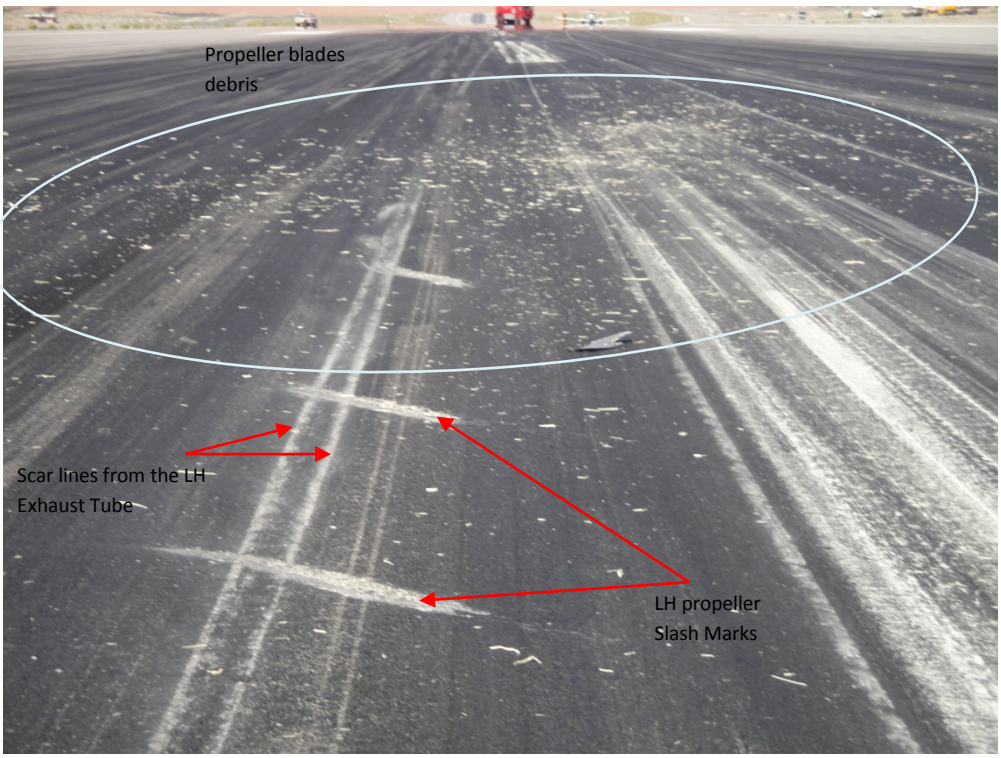

Figure A1-15

Scars lines on the Runway from the Left Side Parts of the Aircraft
and Debris of the propeller blades

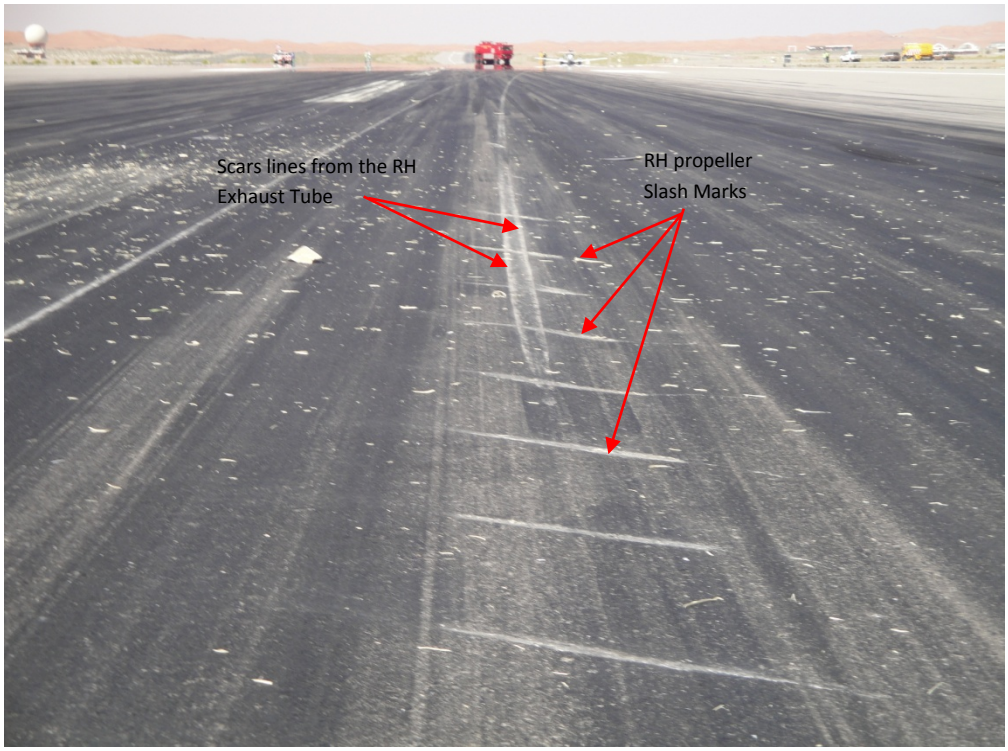

Figure A1-16

Scars on the Runway from the Right Side Parts of the Aircraft

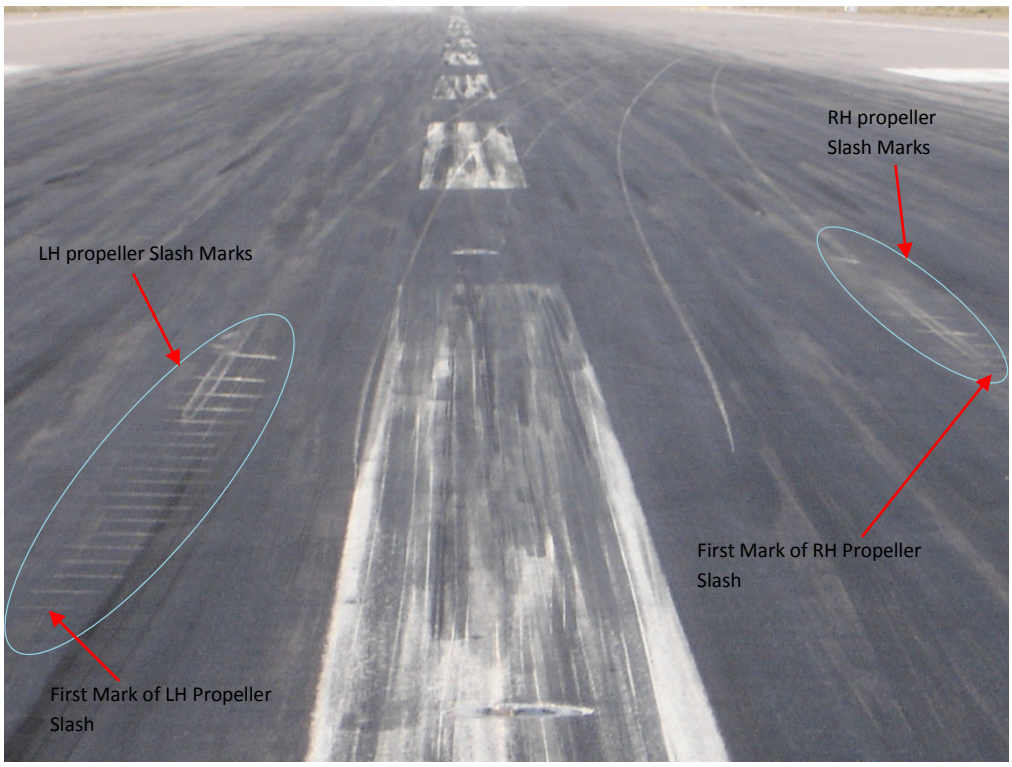

Figure A1-17

Slashes from the Rotating Propellers

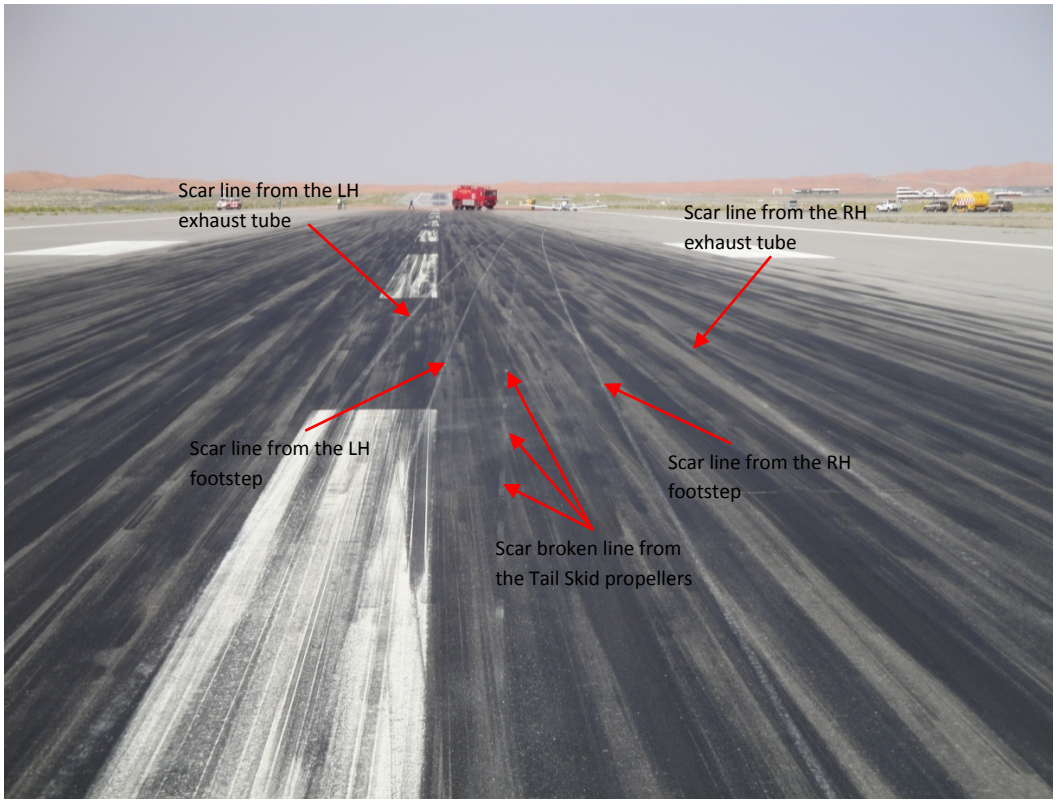

Figure A1-18

Scars lines on the Runway

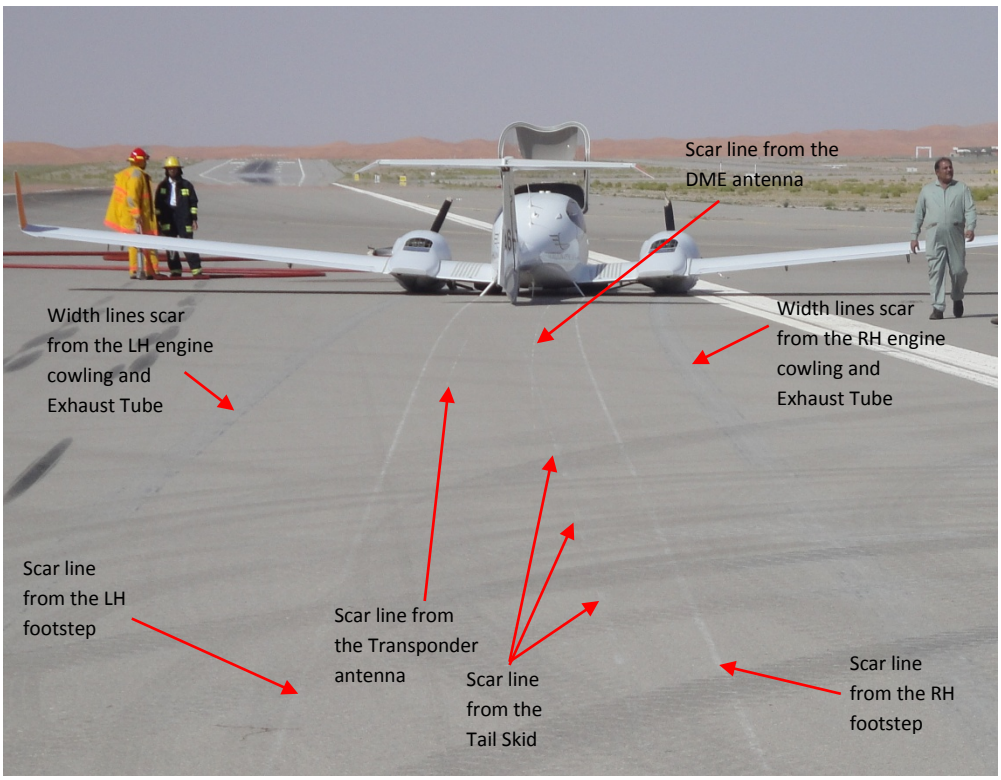

Figure A1-19

Scars lines on the Runway before the Aircraft stopped

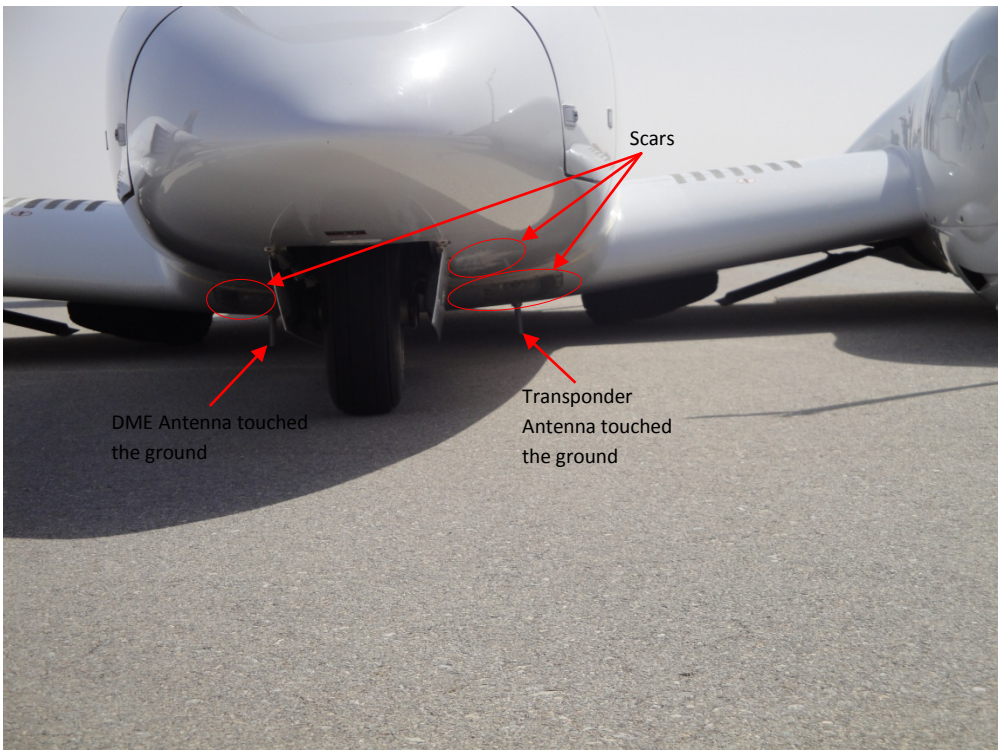

Figure A1-20

Nose and Main Landing Gear condition when the aircraft at full stop on the runway

Figure A1-21

Right main Landing gear condition when the aircraft at full stop on the runway

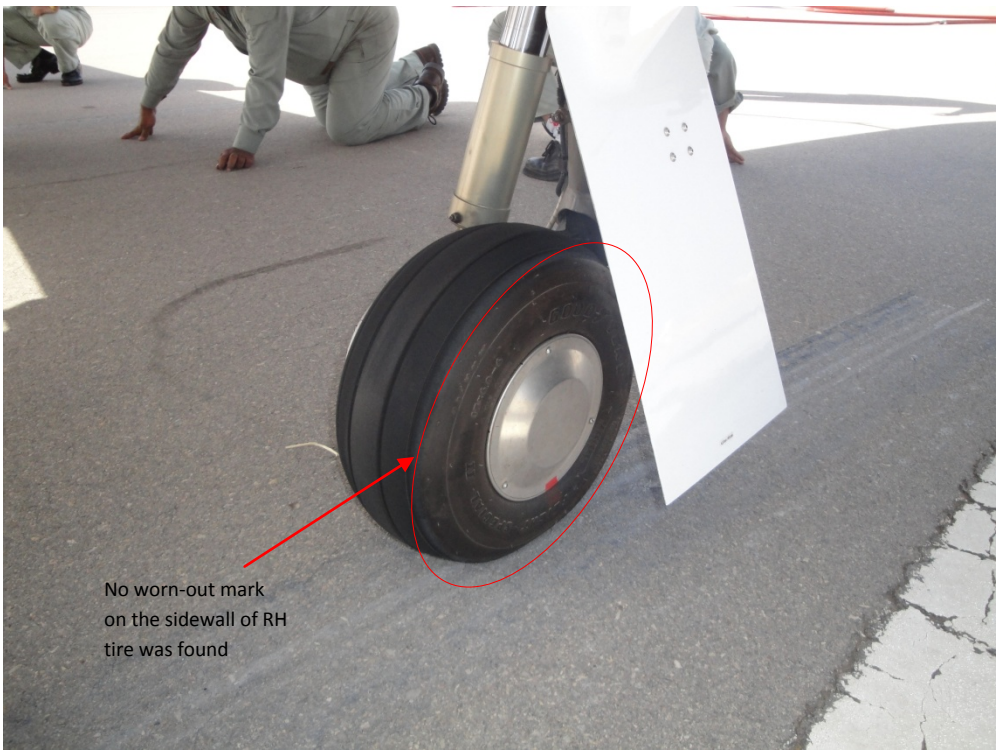

Figure A1-22

Right main landing gear condition after lifting up the aircraft

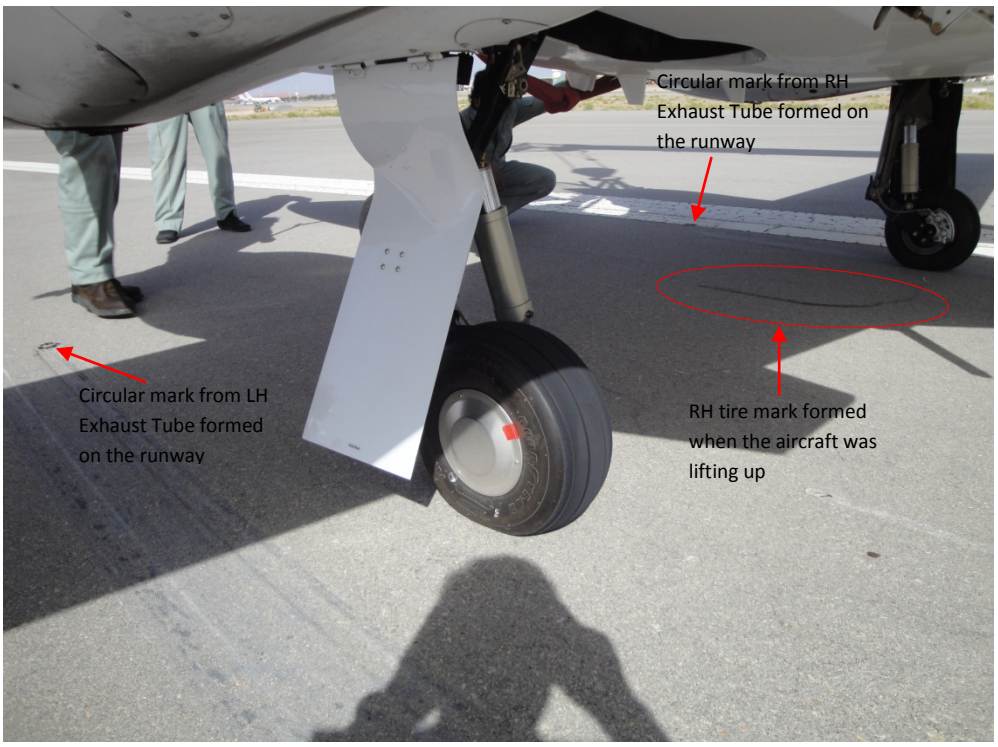

Figure A1-23

Landing gear was able to extend when lifting up the aircraft

Figure A1-24

The Aircraft in stand up condition after lifting up the Aircraft

Figure A1-25

The Aircraft was pushing away from the runway

Figure A1-26 Cockpit after the Occurrence

Appendix 2 Fixed wing Training Area 1 (TA1) Description:

TA	WPT	Coordinates
Area 1	A1	N24° 21' 51.9" E055° 56' 44.38"
	A2	N24° 30' 29.51" E056° 05' 20"
	A3	N24° 34' 57.12" E055° 59' 50.91"
	A4	N24° 35' 13.4" E055° 50' 05.9"
	A7	N24° 23' 11.6" E055° 50' 26.7"

Training Area 1-

Training Area 1 (TA1) is located 14 NM to the north east of OMAL. Demarcated by A1, A2, A3, A4 and A7. T1 is also across the border over Oman. Most of the area to the east is also mountainous. Therefore in low visibility conditions it is advisable to remain above 2500ft for safety purposes.