FINAL REPORT

Incident of Millennium Airlines

Cessna Aircraft, model 152, bearing registration 4R-DJD

at Colombo Airport, Ratmalana - Sri Lanka

on 14th June 2014

Table of Contents

1. Abbreviation

AASL (SL) Ltd	- Airport & Aviation services (Sri Lanka) Ltd)
AIP	- Aeronautical Information Publication (AIP)
ANS	- Air Navigation Services
ASN	- Aviation Safety Notices
ATC	- Air Traffic Control
ATPL	- Airline Transport Pilot Licence
ATS	- Air Traffic Services
CAASL	- Civil Aviation Authority of Sri Lanka
CAVOK	- Visibility, cloud and present weather better than prescribed values or conditions
CEB	- Ceylon Electricity Board
CPL	- Commercial Pilot Licence
E	- East or eastern longitude
Ft	- Feet
FTO	- Flying Training Organization
GND	- Ground
GPS	- Global Positioning System
hrs	- hours
kts	- knots
m	- meter
NM	- Nautical miles
N	- North or northern latitude
PPL	- Private Pilot Licence
QNH	- Altimeter sub-scale setting to obtain elevation when on the ground
SPL	- Student Pilot Licence
SSR	- Secondary Surveillance Radar
UTC	- Universal Time Constant
VCCC	- Colombo Airport, Ratmalana, Sri Lanka

2. Introduction

2.1. The incident was notified to Mr. Parakrama Dissanayake, Senior Director of the Civil Aviation Authority of Sri Lanka by Mr. H.S. Hettiarachchi, Head of Airport Management, AASL (SL) Ltd, at 1020hrs local time on 14th June 2014 through a telephone call. Thereby, Mr. Parakrama Dissanayake authorized Mr. Susantha De Silva, Director Flight Safety to proceed to the Colombo Airport, Ratmalana in order to commence the investigation immediately. The preliminary investigation was conducted to secure vital data and obtaining of statements and interviewing of relevant company personal including the Student Pilot were held on the same day. Subsequently the Operator submitted an Aircraft Accident/ Incident Report to this Office.

2.2. Based on the circumstance of this incident, the Director General of Civil Aviation appointed a team to conduct safety investigation, which comprised of;

Mr. Susantha De Silva	- Team Leader
Captain T.N Deen	- Operations Team Member
Mr. Chaminda Wimalaratne	- Airworthiness Team Member and
Mr. S.P.B. Wattewewa	- Operations Team Member

2.3. The objective of this investigation and the final report is to prevent recurrence of similar incidents and not to apportion blame or liability. Therefore unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the States having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide regarding what action is required to be taken.

3. Synopsis

3.1.	Operator	:	Millennium Airlines Pvt Ltd The Land mark, Level 6, 385, Galle Road, Colombo 03.
3.2.	Registered Owner	:	Redbird Aviation Pvt Ltd No. 14, Castle Lane, Colombo 04.
3.3.	Aircraft Make and Model	:	Cessna 152
3.4.	Aircraft serial number	:	15284370

3.5.	Aircraft Nationality	:	4R (Sri Lanka)
3.6.	Aircraft Registration	:	DJD
3.7.	Type of flight	:	Flight Training
3.8.	Place of incident	:	Aircraft landed without wheel on Runway 22, Colombo Airport, Ratmalana on 14th June 2014. Subsequently, the wheel was found by Milleniya Police on the same day at Paragasthota, Milleniya, Sri Lanka.
3.9.	Date and Time	:	14th June 2014 at 0415 UTC (0945 hrs local time)
3.10.	Nature of the incident	:	Aircraft landed without the left wheel
3.11.	Persons on Board	:	Crew – 01
3.12.	Injuries	:	No injuries
3.13.	Damage to aircraft	:	Left wheel has been detached, fallen and damaged beyond the use. The strut broken at the end and needs replacement. (please refer Appendix 01)

Figure 1: 4R-DJD without left wheel

4. Factual information

4.1. History of the flight

4.1.1. On 14th June 2014, approximately at 0905 hrs (Local time), Millennium Airlines aircraft Cessna 152, bearing registration 4R-DJD was on a solo circuit training flight, operated from Colombo Airport, Ratmalana.

4.1.2. The Student Pilot proceeded south of the airfield (Training area) to practice on general training for the first time solo.

4.1.3. On completion he returned to Colombo Airport, Ratmalana and attempted a landing in which the Student Pilot felt an abnormality and a peculiar noise similar that to a metal shearing on tarmac. Then he has looked to his left and saw no port wheel attached. Once realizing that he has lost the port wheel the Student Pilot decided to go around and did a circuit. Finally he landed with the starboard wheel and then nose wheel and touched the left strut at low speed.

4.1.4. The landing performed during the daytime and indicated a wind of 280^0/10Kts at the time of touch down. The visibility at the time reported as 10km or more and the aircraft landed at 0415 UTC (0945 hrs local time) on same day.

4.2. Personnel Information

4.2.1. Student Pilot

Licence	:	Student Pilot Licence No. SPL/A/2343 issued by the Director General of Civil Aviation of Sri Lanka on 11th December 2013
Age	:	18 years
Flying experience	:	Total of 36.8 hrs and 7.5 hrs of solo

4.3. Aircraft Information

Type and Model	:	Cessna 152
Manufacture's Serial Number	:	15284370
Certificate of Registration	:	No. 266, Registered in Sri Lanka Civil Aircraft Register
Certificate of Airworthiness	:	Valid till 23rd April 2015

4.4. Meteorological Information: The prevailed weather conditions at the time of the incident were as follows;

It was a clear weather day with sunny morning with no ceiling and reported visibility was over 10km (CAVOK). The reported surface wind is as follows;

At UTC 04:01:41 reported surface wind 270/15kts
At UTC 04:08:54 reported surface wind 270/20kts

4.5. Aids to Navigation: There has not been any reported unserviceability.

4.6. Communication: Communication between flight crew and ATC has been found satisfactory and effective.

4.7. Aerodrome Information:

Name of the Aerodrome	: Colombo Airport, Ratmalana
Location Indicator	: VCCC
Reference point (latitude/longitude)	: 06 49 23N and 079 53 06E
Elevation	: 6.7m (22ft)
Runway identification	: 22
Runway markings	: Standard
Runway length	: Length 1773m
Obstructions	: Nil
Runway conditions	: Asphalt

4.8. Wreckage and impact information:

4.8.1. Runway:

Aircraft, 4R-DJD landed without the port wheel on Runway 22, Colombo Airport, Ratmalana. The Runway was not damaged, but left with a scraped mark. See picture below.

Figure 2: Runway 22, Ratmalana Airport, Colombo, Sri Lanka

4.8.2. Location where the wheel was found:

About 10NM south/south east of the Departure Airport, Ratmalana, the damaged wheel was found in Paragasthota area under Milleniya Police division, (approximate GPS coordination are 6^0 40′ 26.26" N and 80^0 00′22.28" E) on Southern expressway. At this location, there is a high tension power line over the southern expressway. The height of the power lines is approximately 115ft above the ground level and area elevation is approximately 100ft from mean sea level. According to the Milleniya Police, the first impact point of the wheel on the expressway is approximately 80m – 100m from the point where wires are crossing the highway (Shortest Distance). (Please refer Site Sketch at Appendix 02)

Figure 3: Site picture at Paragasthota, Milleniya on Southern Expressway

4.9. **Test and Research**:

4.9.1. Material Stress Test

Detached port wheel and the detached piece of the strut was given to Department of Materials Science and Engineering, University of Moratuwa for further analysis to determine following factors;

1. The material stresses imposed on the each semi-circle portions of the axel (Compressions and stretching)
2. Application points and directions of forces acted on the axel
3. Whether the breakage is due to an impact forces or material fatigue (fare wear and tear)

Figure 4: Damaged Strut

4.9.2. Flight Test Simulating the Flight Path & heights

A flight test was conducted under similar weather and other conditions which prevailed on the date of the incident, using the same type of aeroplane aero plane fitted with the same type of Mode 'C' and Mode 'A' transponder being flown on the same flight path. The purpose of this flight test was to determine as to at which height, Mode 'A' signal could be lost by Colombo Radar apparatus when being operated in the area concerned. The video map on the incident flight, obtained from Air Traffic Control Services, Colombo indicated a maximum duration of loss of blips (2 minutes 24 seconds) coincided in the area concerned. Flight test simulated the same heights at which the blips are lost. The Report of the Flight Test is at Appendix 04.

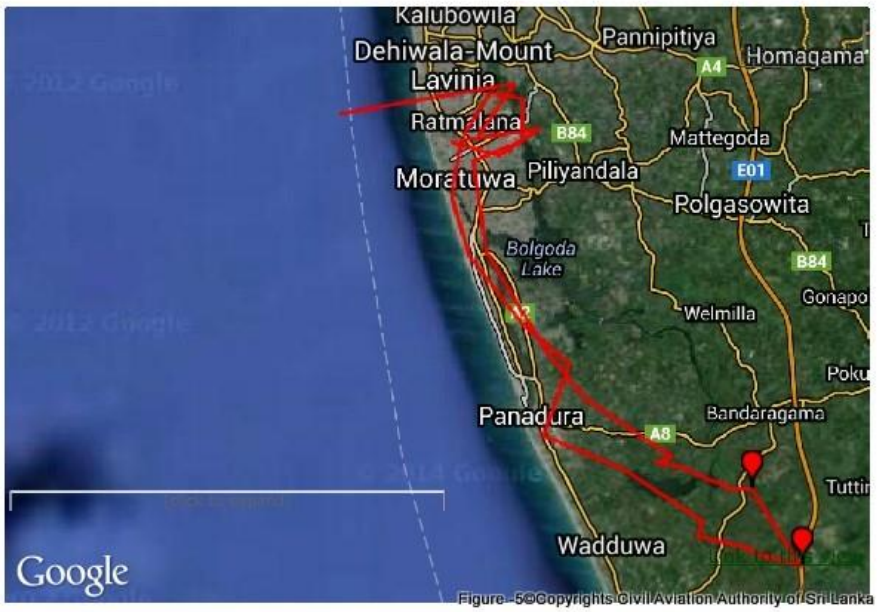

Figure 5: The flight path of the flight concerned

5. Possibilities

5.1. The following possibilities were derived by the Team after evaluating all facts;

a. Aeroplane hitting an object whilst flying at very low altitude

b. Wheel may have been damaged previously and fell off over the highway

c. Both above could have contributed to the incident

6. Analysis

6.1. Detachment of the wheel

6.1.1. Investigation and examination on the detached wheel and the strut revealed cracks and corrosion in the affected area. As per the conclusions of the Report obtained from the University of Moratuwa, severe corrosion in the strut end as well as in the fixing bolt have contributed to a crack initiation. The Report further confirms that the root cause of the detachment of the wheel is due to a fatigue crack initiated from the bolt hole of the strut. The Failure Analysis Report on Wheel Detachment obtained from the University of Moratuwa is at Appendix 7.

6.1.2. Further, the Report establishes that the final detachment was due to a brittle fracture due to a force acted slightly at an angle against the direction of the flight. Analysing the sequence of events through other evidence, such force has acted on the aeroplane when it was flying over the southern expressway.

6.1.3. However, determination of the type of the force, viz a tension force, torsion force or compression force, which may have acted to detach the wheel finally, was not possible through the said report.

6.2. Striking an object

6.2.1. **Evidences in ATC transcript recording:** In evaluating the ATC Transcripts, it was evident that the Student Pilot has suspected that he had 'Clipped a wire'. He stated this term during the conversation with the Tower Controller twice. However, the Student Pilot denied any low flying during the interview and stated that he might have used that term due to 'being scared' at that time. Further analysis on flight path derived from the Student Pilot interview and interpreting the blips on the video map showed that the Student Pilot had operated in the area corresponding to the area where the wheel was found. Further, the high-tension power lines were present in the same area.

6.2.2. **Eye witness statements:** Two eye witnesses were interviewed by the team and according to the statements they had seen the aeroplane flying low. Further, one witness had seen the Power Cables swinging unusually. The other witness stated that he had seen the aeroplane brushing the tree tops in the vicinity. However, it was difficult to confirm that they had seen the aeroplane hitting the wires and there was no evidence found of any damaged trees in the vicinity. The witness who saw the wires swinging had a restricted field of view and the visible time span of the aeroplane

appeared to be very low and thereby the possibility of seeing the aeroplane hitting the power line was remote for him. The position of the other witness is such that the power lines are not visible although a greater field of view than the first witness was available. Careful analysis of the eye witnesses suggests that there had been an unusual noise, swinging wires and an aeroplane flying with waggling wings at lower height than what they have seen before.

6.2.3. Records from Ceylon Electricity Board (CEB): There had been no power outages between 0900hrs to 1000hrs on 14th June 2014 from the power lines in the area where the wheel was found. Also through extensive inspections by the Investigation Team with the assistance of CEB personnel did not reveal any evidence of damages to wires or pylons due to the suspected impact.

6.3. Low flying

6.3.1. It is evident, through the test conducted by the Investigation Team, that the radar does not pick up the position of the aeroplane when the aeroplane is operated below 600ft in the area where the wheel was found. As a result, the blip does not appear on the radar scope.

6.3.2. During the incident flight, the longest time gap (2 minutes 24 seconds) between two detected points was evident in the same area where the wheel was found. Accordingly there is a likelihood of a height reduction from the height it was operating. This possibly the lowest and longest height drop in the incident flight. (The Areal Track is at Appendix 05).

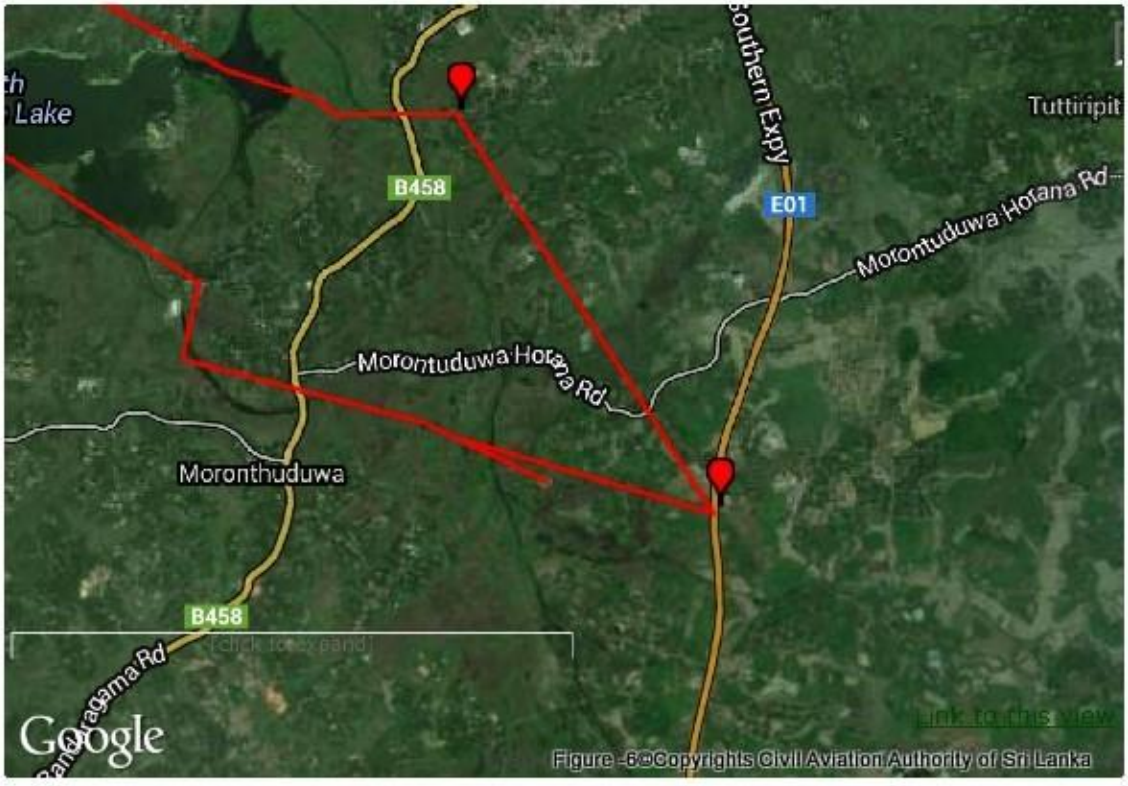

Figure 6: Indication of Radar on the area of operation

6.3.3. **ATC clearance:** The Student Pilot had been cleared by ATC to operate between 1500ft to 3000ft. However, the Student Pilot stated that he operated at 1000ft. The ATC transcript revealed that neither the Pilot had read back nor the Air Traffic Controller ensured the clearance is read back.

6.3.4. The aeroplane was airworthy and no reported defects in the aeroplane. Further, the instruments had been calibrated and since used only for 8 hours. Therefore chances of erroneous information through the Pitot Static Instruments is remote.

6.4. Landing gear

6.4.1. The previous maintenance records of the aeroplane before the subject flight did not have any record on damages to the wheel or strut.

6.4.2. Student Pilot stated, during the interview, that he had done a 'Three Point Landing' during the circuit flying before proceeding to the training area.

6.4.3. Failure analysis on wheel detachment done by the University of Moratuwa stated that there was an area of corrosion observed on the fracture surface of strut end and fixing bolt which indicates that the crack was open sometime before the final fracture (before the detachment of the wheel from the strut).

6.4.4. As per the Cessna Manufacturer's Service Manual there is no periodic maintenance inspections required in the strut end and fixing bolt.

6.5. Pilot Training

6.5.1. The Student Pilot was trained for his PPL initially at the Open Skies Flying School and subsequently at the Millennium Flight Academy under the supervision of the same Flight Instructor, who had moved to the latter. There is no adverse records against the Student Pilot during the period of his training. The Flight Instructor confirmed that skill level of the Student Pilot is better than an average student that he has come across during his long years of service as a Flight Instructor.

6.5.2. This particular sortie was Student Pilot's first training area solo flight and the Flight Instructor had cleared him for the flight. He was instructed by the Flight Instructor to return to the base in the event of weather conditions becoming unfavourable for the training sortie.

6.5.3. Any Flight Instructor is required to maintain a listening watch on intercom during any stage solo flight of a student. During the interview, the Flight Instructor confirmed that he was available throughout and gave the instructions via the intercom. However, it was observed that there had been a delay of 2 minutes in responding to the Student Pilot's request for assistance during the final stage of landing.

6.5.4. Also there was evidence of another Flight Instructor advising the Student Pilot when the Student Pilot requested for assistance from his Flight Instructor during the time at which his own Instructor was not available for advice.

6.5.5. It was evident during the Student Pilot interview and the Flight Instructor interview, that there was no procedure to write down the ATC clearance and the practice of the School had been to train pilots to memorize it.

6.5.6. Although the training area is demonstrated to the student during the familiarization flight the guidance material doesn't contain a demarcated training area map to guide the student pilots in understanding the training area.

6.5.7. The Flight Instructor confirmed that the students were instructed to operate the transponder in Mode 'C' during his interview. It is indicated in the after start up check list to keep the transponder in the standby position. There is no indication as to the switching on of the Mode 'C' in the check list after that. During the sortie, Mode 'C' had not been activated.

6.5.8. The school does not train pilots for spin avoidance although the exercise is available in the curriculum approved for the training school. During the Student Pilot Interview it was deliberated by the Student Pilot that even after his repeated request to train him on the exercise, the school didn't execute the training which was justified by the Flight Instructor as it is due to the aeroplane being prohibited for intentional entry to Spin.

6.5.9. Annex 1, Chapter 2, Paragraph 2.3.3.2 (f) requires the students to be trained on flight at critically high air speed; recognition of a recovery from spiral dives (spin) as a minimum requirement. This requirement is incorporated in the local regulatory system through ASN 55, Paragraph 3.3.2 (f) and included in the Section 3 of the PPL skill test form issued by CAASL, as a check item under 'spin entry and recovery - demo only (not required if certified by FTO)'.

6.5.10. The Flying School is certified for the conduct of training and checking on the issuance of PPL by the CAASL.

7. Conclusion

7.1. Findings

7.1.1. Civil Aviation Authority of Sri Lanka

7.1.1.1. It is found that the CAASL has not issued guidance material for the flight instructors in the following areas;

7.1.1.1.1. Training areas for flight training conducted from Ratmalana

7.1.1.1.2. Development of Ground and Flight Training Programmes for PPL, CPL and ATPL for both aeroplanes and helicopters

7.1.1.1.3. Guidance for Flight Instructors on conduct of training

7.1.1.2. It is found that CAASL had authorised the use of an aeroplane that cannot fulfil the minimum training requirement as stipulated in the ASN 55, Paragraph 3.3.2 (f).

7.1.2. Training School

7.1.2.1. It was found that there had been severe corrosion in the strut end as well as in the fixing bolt which led to a crack initiation in the bolt hole of the strut.

7.1.2.2. Just prior to the detachment of the wheel, there had been a force acting on the wheel unit slightly outward from the direction of the flight.

7.1.2.3. Student pilot in his communication had mentioned that he had clipped a wire twice.

7.1.2.4. It is very likely that the aeroplane had stricken the power lines during its operation over Milleniya area.

7.1.2.5. Aeroplane has been operated at 1000ft, according to the statement of the Student Pilot, not complying to the ATC clearance, which is 500ft lower than the cleared height of 1500ft.

7.1.2.6. It is very likely that the aeroplane has come down even below 600ft with or without the knowledge of the Student Pilot.

7.1.2.7. In evaluating the ATC transcript, it is found that there is a time gap of 2 minutes from the time of calling for assistance and to the time at which the response by the Instructor.

7.1.2.8. It is found that the students' first training area solo is treated as a normal solo flight.

7.1.2.9. The Student Pilot was not trained to record the ATC clearances

7.1.2.10. The Student Pilot had not acknowledged the ATC clearance given in this particular flight.

7.1.2.11. The Pilot check list issued to the students does not contain check item to confirm whether the Transponder is in Mode 'C' after the take-off or before leaving the circuit.

7.1.2.12. It is found that there is a likelihood of operating the aeroplane out of the approved training area by the Student Pilot violating the given instructions.

7.1.2.13. Spin avoidance training was not conducted by the Training School as per approved training programme.

7.1.3. Air Traffic Services Providers

7.1.3.1. Ratmalana/Colombo Airport control zone being a historical training area, is excluded from the joint control zones for the purpose of SSR operations (Vertical limit – GND to 4000ft). Therefore, even with the aeroplane which are equipped with Mode 'C', it is not mandated to activate Mode 'C'.

7.1.3.2. It is found that the Air Traffic Controller had not ensured the Student Pilot to read back the ATC clearance.

7.2. Probable causes

7.2.1. Detachment of wheel is due to severe corrosion in the strut end as well as in the fixing bolt that contributed to a crack initiation from the bolt hole of the strut and has propagated to its maximum level. Just prior to detachment a force which acted on the wheel, slightly at an angle outwards against the direction of the flight which caused a brittle fracture. The force is likely to have occurred over the expressway due to an impact with the power line.

8. Safety Recommendation

8.1. Civil Aviation Authority of Sri Lanka

8.1.1. It is recommended that the training schools be guided by the CAASL in the following areas;

8.1.1.1. Acceptable training areas demarcation.
8.1.1.2. Development of student guidance materials.
8.1.1.3. Procedure for authorization of students for solo flights other than first Solo.
8.1.1.4. Developing Flight and Ground Training Programmes for the issuance of PPL, CPL and ATPL for aeroplanes and helicopters.
8.1.1.5. Guidance for Flight Instructors on conduct of training.

8.1.2. It is recommended that in the event an authority is given for the use of an aeroplane with restricted capabilities to conduct mandatory items required for the training programme, a condition shall be included to demonstrate the mandatory items at least in near simulation.

8.1.3. It is recommended that CAASL shall prohibit the use of aeroplane that cannot deliver the minimum requirements in future.

8.1.4. It is recommended that CAASL shall revise the approval procedure for authorising aeroplane for training purposes.

8.2. Training School

8.2.1. It is recommended that the training school to implement the followings;

8.2.1.1. Recording of students' behaviour during the training process in relation to flying skills, Airmanship and Attitude.

8.2.1.2. Recording of briefing given to students before all solo flights.

8.2.1.3. Mandatory use of Mode 'C' operation in training area exercises.

8.2.1.4. Training on spin avoidance during their flying training prior to first solo flight.

8.2.2. It is recommended that the corrosion detected at the wheel be referred to the Manufacturer for further guidance on possibilities of inspecting such development of cracks during regular inspections.

8.3. Air Traffic Services Providers

8.3.1. It is recommended to amend the AIP to include all training flights to operate with Mode 'C' transponder and mandate operations of Mode 'C' transponder in training flights.

8.3.2. Ensuring read back of ATC clearance by student pilots

Members of Investigation Team

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Mr Susantha De Silva, Team Leader

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Captain T.N Deen, Operations Team Member

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Mr. Chaminda Wimalaratne, Airworthiness Team Member

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Mr. S.P.B. Wattewewa, Operations Team Member

Appendix 01- Photo expressions of the aero plane, 4R-DJD

Figure 7: View of 4R-DJD, Cessna 152 aircraft without left wheel

Figure 8: Left wheel of 4R-DJD, Cessna 152 aircraft

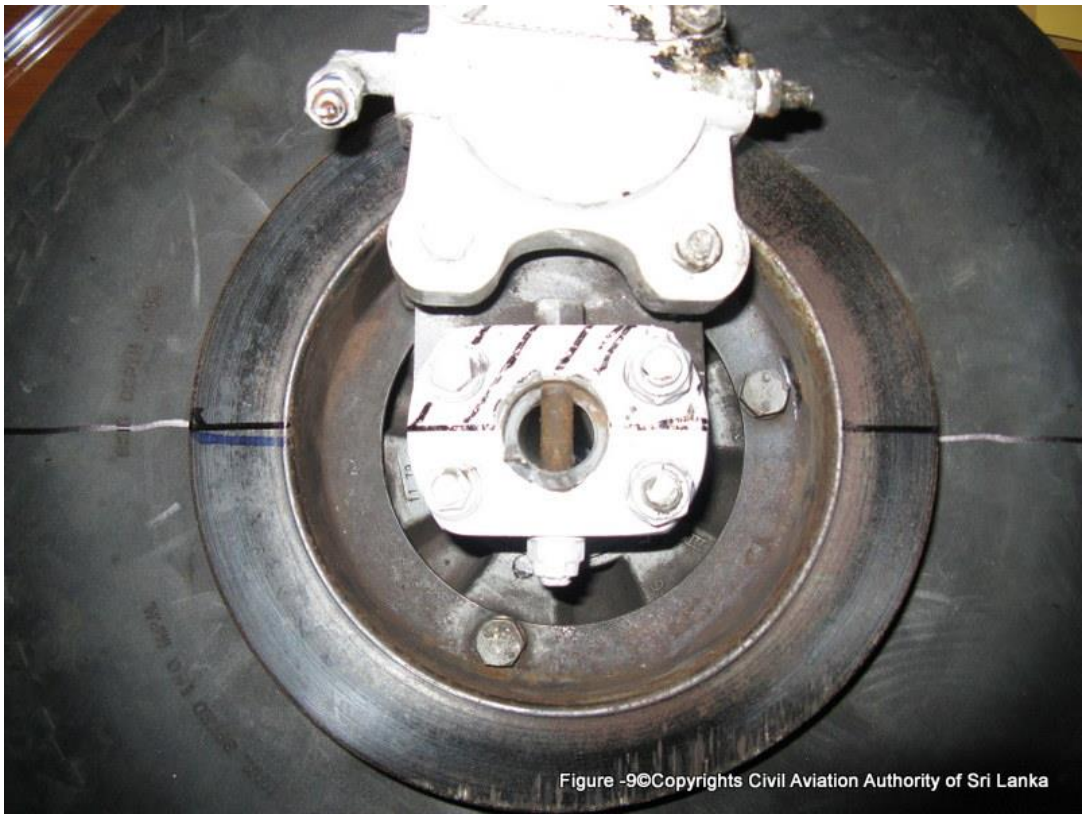
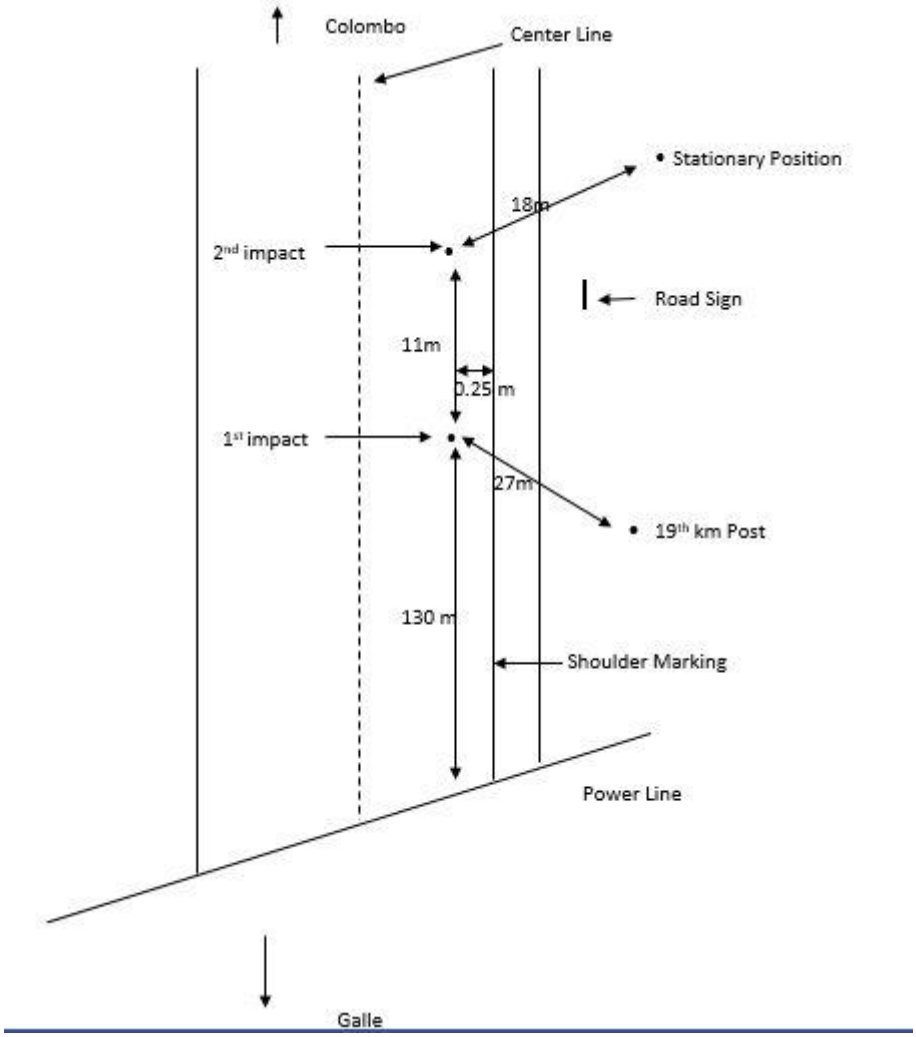


Figure 9: Left wheel of 4R-DJD, Cessna 152 aircraft

Figure 10: View of damaged Strut

Appendix 02 - Site Sketch



Appendix 03- Flight path

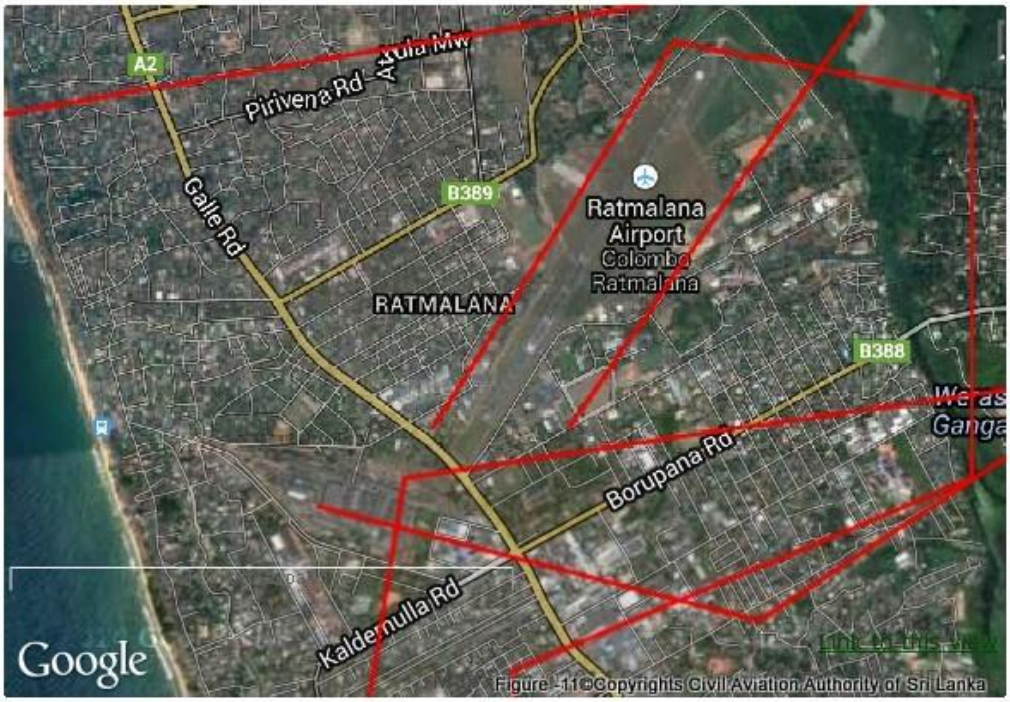


Figure -11©Copyrights Civil Aviation Authority of Sri Lanka

Figure -12©Copyrights Civil Aviation Authority of Sri Lanka

Appendix 04 - Report on the Flight Test

Report on the flight conducted on 15th July 2014 using a C152 aircraft for the investigation

Background

The flight was planned to determine the altitude at which the Cessna 152, bearing registration 4R DJD had been flown at the time of the incident with Mode 'A' information being displayed.

Conduct of the Flight

The flight was conducted using a Cessna 152 aircraft bearing registration 4R – DRA flown by Capt. Hirantha Perera of Millennium Flight Academy with Capt. T.N. Deen of Flight Operations of CAASL who is a member of the Investigation Team. Mr. Mahesh De Silva - ANS Inspector of CAASL was detailed to monitor the progress of the flight on the Secondary Surveillance Radar at BIA Approach Control Centre. The flight took off from Ratmalana at 1005 hrs local time and proceeded to the identified area where the incident was believed to have taken place.

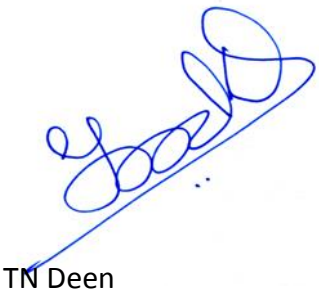
The flight was initially operated with Mode 'A' & 'C' at 2000 feet in the identified area to check the consistency of the radar target at 500 feet intervals up to 1000 feet and there onwards at 100 feet intervals up to 500feet.

The same procedure was repeated with only Mode 'A' with Mode 'C' switched off and also with Mode 'A' switched off position as well.

The flight terminated around 1117hrs local time at Ratmalana.

Observations

1. The SSR Radar detected the aircraft until 800ft on Mode 'A' & 'C'. At 600ft Mode 'C' information was intermittent with Mode 'A' information consistent. The target was completely lost on radar as the aircraft descended below 600 feet.
2. The Primary Radar did not pick up the target all the way up to the identified area.
3. Both Primary and Secondary Radars were serviceable at the time of the operation.



TN Deen

Member Investigation Board

22nd July 2014

Mahesh De Silva

ANS Inspector

22nd July 2014

Appendix 05 – Areal Track

Time	Latitude	Longitude	
03.43.33	06 48 42N	079 52 31E	
03.46.53	06 48 26N	079 53 33E	
03.47.07	06 49 01N	079 54 26E	D
03.49.48	06 48 46N	079 52 43E	A
03.51.10	06 47 56N	079 52 35E	
03.51.29	06 47 29N	079 52 31E	
03.52.00	06 46 16N	079 52 54E	D
03.52.30	06 44 48N	079 54 03E	A
03.53.33	06 43 55N	079 55 05E	D
03.54.45	06 42 23N	079 54 30E	A
03.55.50	06 41 37N	079 56 17E	D
03.56.57	06 40 32N	079 57 57E	A
03.57.05	06 40 13N	079 57 53E	
03.57.14	06 40 05N	079 58 24E	
03.57.24	06 39 57N	079 58 54E	
03.57.38	06 39 42N	079 59 25E	
03.57.55	06 39 53N	079 59 02E	
03.58.36	06 39 34N	080 00 07E	D
04.00.50	06 41 14N	079 59 02E	A
04.00.58	06 41 14N	079 58 31E	A
04.01.02	06 41 18N	079 58 27E	
04.01.17	06 41 25N	079 58 04E	
04.01.57	06 41 41N	079 57 34E	
04.02.26	06 41 48N	079 56 59E	
04.02.46	06 41 56N	079 57 19E	
04.03.50	06 43 09N	079 55 28E	
04.05.03	06 44 10N	079 54 34E	D
04.05.15	06 44 49N	079 54 12E	A
04.06.15	06 46 20N	079 53 17E	
04.07.10	06 47 29N	079 53 06E	
04.07.55	06 48 19N	079 52 58E	
04.08.40	06 48 46N	079 54 03E	
04.09.45	06 49 39N	079 54 03E	
04.10.13	06 49 47N	079 53 21E	D
04.10.32	06 48 53N	079 52 47E	A
04.13.01	06 47 52N	079 52 12E	
04.13.32	06 48 53N	079 53 06E	D
04.14.13	06 49 58N	079 53 52E	A

04.15.15	06 49 20N	079 50 06E	D
Time	**Latitude**	**Longitude**	
03.43.33	06 48 42N	079 52 31E	
03.46.53	06 48 26N	079 53 33E	
03.47.07	06 49 01N	079 54 26E	D
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03.51.29	06 47 29N	079 52 31E	
03.52.00	06 46 16N	079 52 54E	D
03.52.30	06 44 48N	079 54 03E	A
03.53.33	06 43 55N	079 55 05E	D
03.54.45	06 42 23N	079 54 30E	A
03.55.50	06 41 37N	079 56 17E	D
03.56.57	06 40 32N	079 57 57E	A
03.57.05	06 40 13N	079 57 53E	
03.57.14	06 40 05N	079 58 24E	
03.57.24	06 39 57N	079 58 54E	
03.57.38	06 39 42N	079 59 25E	
03.57.55	06 39 53N	079 59 02E	
03.58.36	06 39 34N	080 00 07E	D
04.00.50	06 41 14N	079 59 02E	A
04.00.58	06 41 14N	079 58 31E	A
04.01.02	06 41 18N	079 58 27E	
04.01.17	06 41 25N	079 58 04E	
04.01.57	06 41 41N	079 57 34E	
04.02.26	06 41 48N	079 56 59E	
04.02.46	06 41 56N	079 57 19E	
04.03.50	06 43 09N	079 55 28E	
04.05.03	06 44 10N	079 54 34E	D
04.05.15	06 44 49N	079 54 12E	A
04.06.15	06 46 20N	079 53 17E	
04.07.10	06 47 29N	079 53 06E	
04.07.55	06 48 19N	079 52 58E	
04.08.40	06 48 46N	079 54 03E	
04.09.45	06 49 39N	079 54 03E	
04.10.13	06 49 47N	079 53 21E	D
04.10.32	06 48 53N	079 52 47E	A
04.13.01	06 47 52N	079 52 12E	
04.13.32	06 48 53N	079 53 06E	D
04.14.13	06 49 58N	079 53 52E	A
04.15.15	06 49 20N	079 50 06E	D

Appendix 06 - Failure Analysis Report on Wheel Detachment

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

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FAILURE ANALYSIS REPORT ON WHEEL DETACHMENT OF A CESSNA 152 AIRCRAFT

REPORT NO : UM/MT/FA/01/07/14

Date : 09th September2014

Client : Mr. Susantha De Silva
Director Flight Safety
for Director General of Civil Aviation
& Chief Executive Officer
Civil Aviation Authority of Sri Lanka
No. 04, Hunupitiya Road
Colombo 02

Page 1 of 11

Department of Materials Science and Engineering
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Sri Lanka.

Failure Analysis Report on Wheel Detachment of A Cessna 152 Aircraft

Report No.	:	**UM/MT/FA/01/07/14**
Client	:	Mr. Susantha De Silva Director, Flight Safety for Director General of Civil Aviation & Chief Executive Officer Civil Aviation Authority of Sri Lanka No. 04, Hunupitiya Road Colombo 02
Client's Reference	:	Letter sent by the client on10.07.2014
Items	:	1. Wheel unit 2. Strut Unit 3. Two small metal pieces
Tests Performed	:	- Macro and microstructure investigations - Rockwell Hardness according to ASTM E18
Results	:	Please see the pages 3 to 11

The report refers specifically to the samples, documents and other information submitted for the investigation by the client to the Department of Materials Engineering at University of Moratuwa.

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1. Background

On 14th June, 2014 small training aircraft, Cessna 152, lost its wheel of the left landing gear in midair. The wheel had fallen down close to the Southern expressway and no injuries were reported due to the detachment of the wheel. Subsequently, the aircraft made an emergency landing at Rathmalana airport without any further serious damages to neither the aircraft nor any injuries to the pilot. The detached wheel has been handed over to the Department of Materials Science & Engineering at University of Moratuwaby Civil Aviation Authority of Sri Lanka for metallurgical investigations to find the root cause for the failure.

2. Objectives of the Investigation

The objectives of this investigation is to find the root cause of the failure by performing macro and microstructure analysis and any mechanical testing to the components of the wheel.

3. Macro Observations

According to the information given by the client this aircraft was manufactured in year 1984 and has already completed about 4500 fight hours. No significant incident was reported during this service period. Necessary repairs and maintenance were performed periodically and the records were maintained well.

During landing only with the wheels on the front and right landing gears the left trust was severely damage due to the absence of the wheel (Fig. 1).

Figure 1: Cessna 152 Aircraft after Detachment of the Left Wheel

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The wheel was observed initially by naked eye and it was found that the trust was fractured and completely separated from the fixing location of the wheel hub (Fig. 2). In Figure 2 the indication 'UP' is for the direction showing the upper side wheel attachment and 'Front' is for the flying direction of the aircraft.

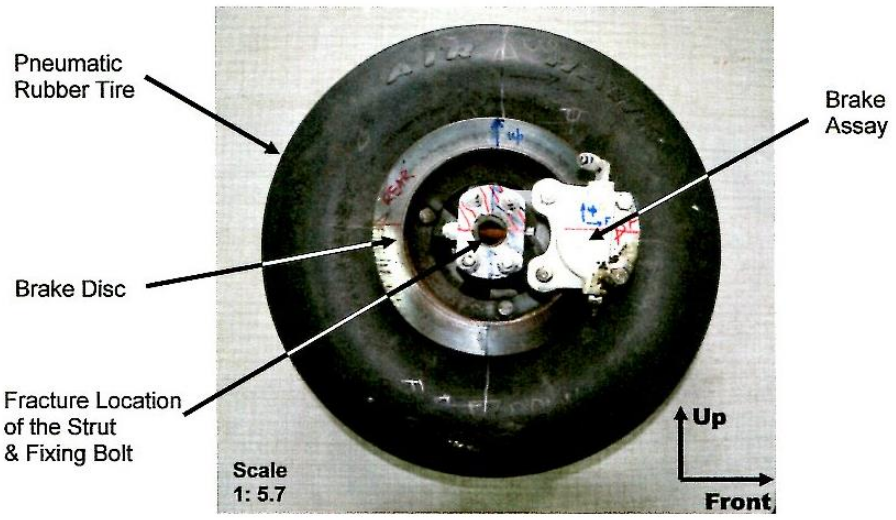
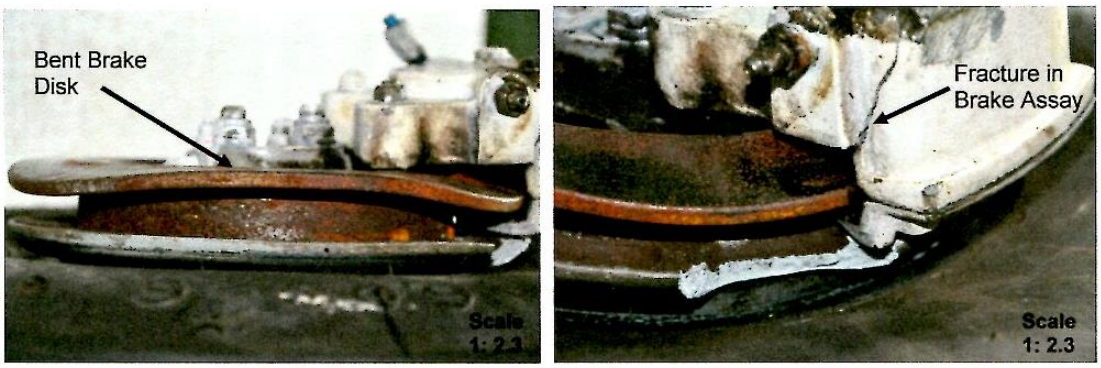


Figure 2: Detached Wheel & Accessories (View from Inside)

The bolt fixing the strut to the hub was not damaged but the brake disc was bent and the housing of the brake assay was fractured (Fig. 3).



(a) Bent Brake Disc (B) Fractured Brake Housing

Figure 3: Damages to the Accessories of the Wheel

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On the outer side of the wheel the rim was severely damaged and all fractured pieces were not available for the investigation (Fig. 4).

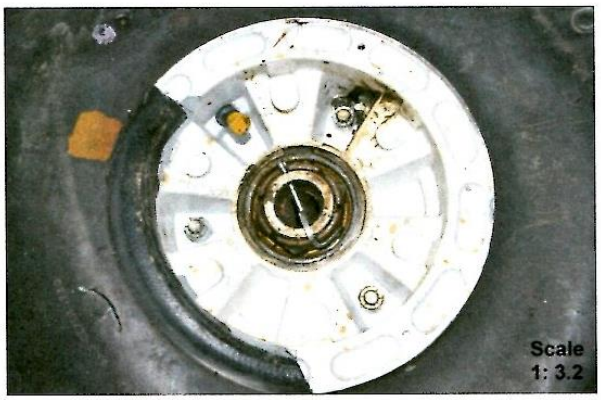

Figure 4: Fractured Rim (View from outside)

During further observation it was found that the fixing bolt was severely corroded, especially the area inside the strut (Fig. 5).

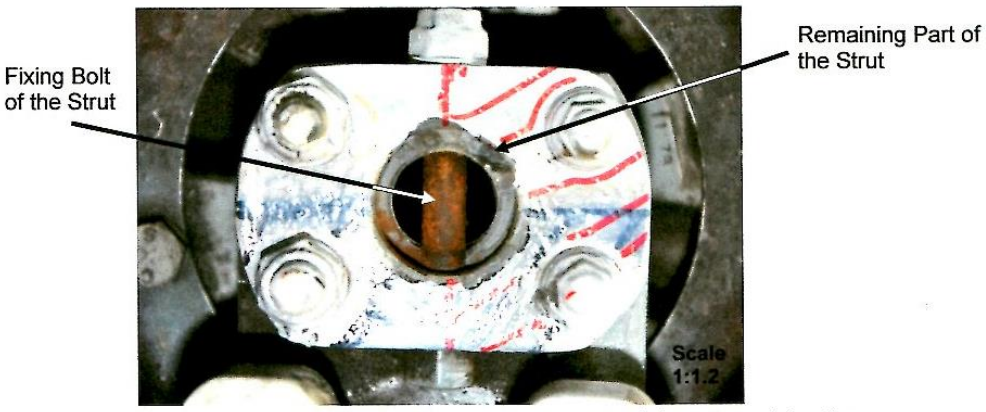

Figure 5: Corroded Fixing Bolt and the Remaining part of the Strut

For detailed investigations the wheel components were dismantled and the remaining part of the strut, which was stuck inside the fixing hole, was taken out. It was tightly fixed to the fractured part of the trust and very difficult to remove. During macroscopic observation it was found that both strut and the bolt, were severely corroded (Fig. 6).

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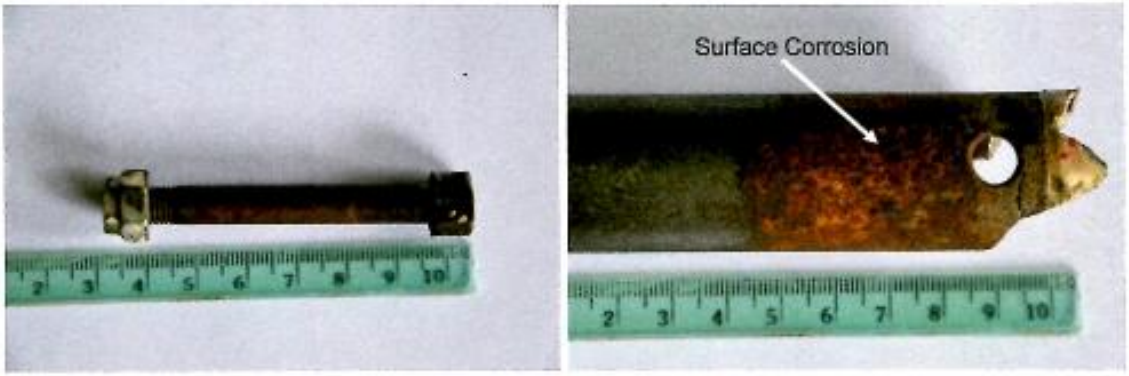

Figure 6: Corroded Fixing Bolt and the Remaining part of the strut

Removed bolt and the remaining part of the strut were closely observed initially with magnifying glass and then with a stereo microscope. Then it was found that the bolt was not fractured but corroded on the surface (corrosion layer is not visible in Figure 6 since that layer was removed during dismantling). In contrast to that the fractured part of the strut was severely corroded. Further, it was observed that the main fracture which has separated the strut from the wheel has propagated across the bolt hole (Fig. 7).

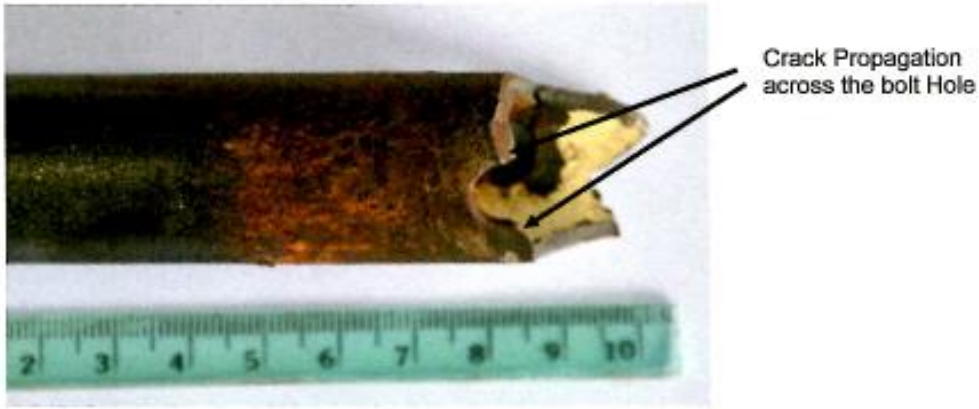

Figure 7: Corroded Remaining part of the Strut with the Crack

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In addition to that on the other side of the fractured strut another crack was observed.

Figure 8: Other side of the Fractured Strut with the Cracks

Under Higher magnification it was possible to identify the fracture initiation and it is the circumference of the bolt hole (Fig. 9). The fracture has propagated through the walls of the strut and final separation was on the other side of the hole showing a brittle nature. Furthermore, a certain area of corrosion was observed on the fracture surface which indicates that the crack was opened some time before the final fracture has been occurred (before the detachment of the wheel from the strut).

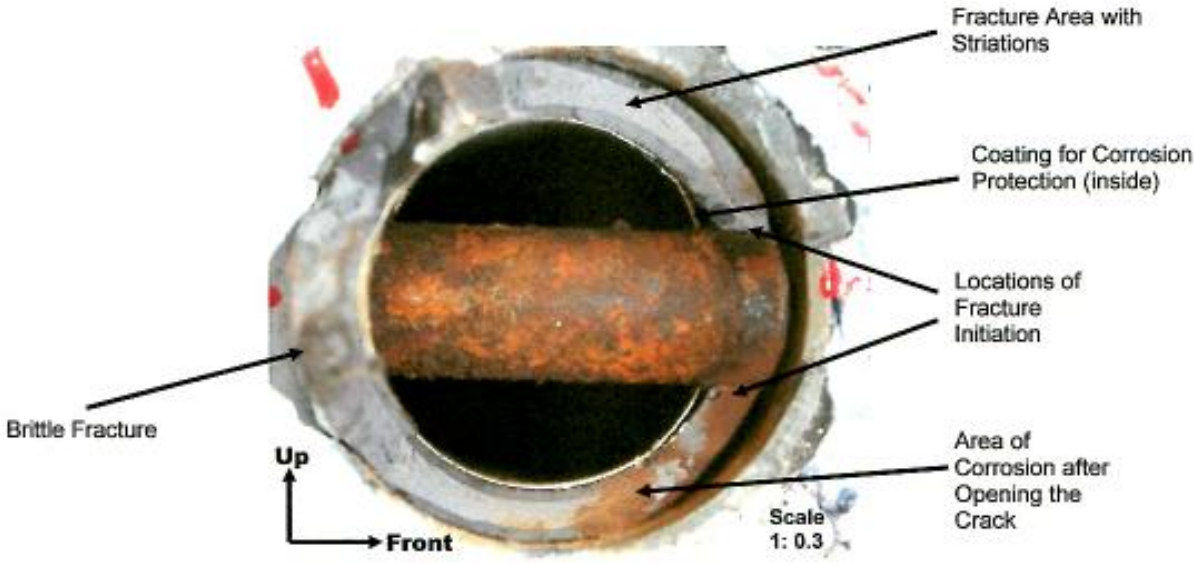

Figure 9: Magnified Image of the Fracture Surface

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4. Microscopic Observations

To investigate the extent of corrosion in the fixing area of the strut a cross section was prepared as indicated in the figure 10.

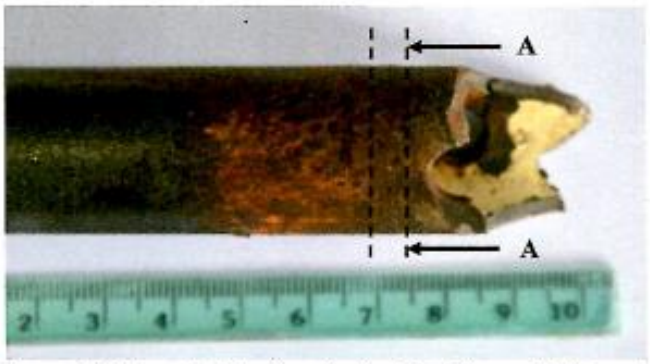
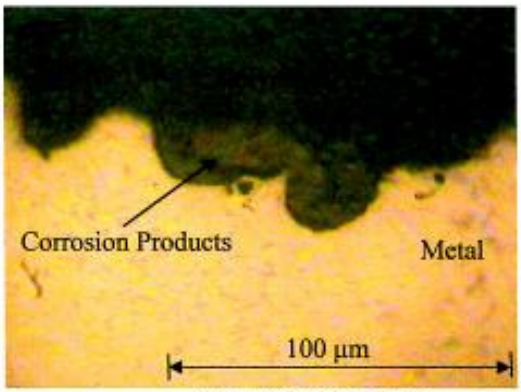
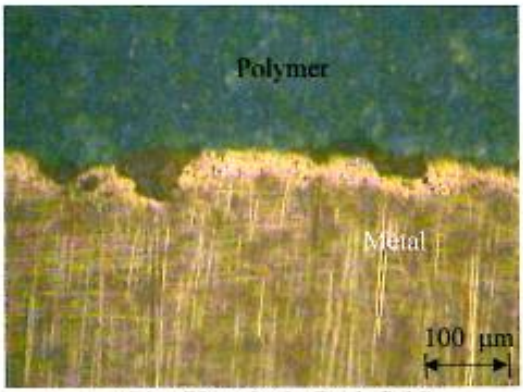


Figure 10: Sample Selection for the Metallographic Investigations

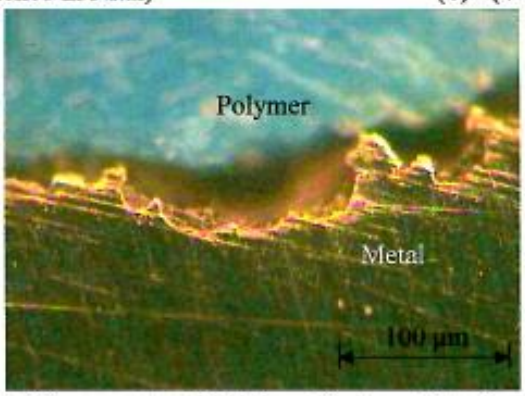
The specimen was separated from the strut piece using a precision diamond cutter to preserve the corrosion layer, mounted in polymeric material and carefully polished the section with 3μ diamond-powder/water emulsion. Then the surface was observed using a optical microscope under different magnifications with normal and dark field.



(a) (etched in Nital)



(b) (Unetched - Dark field)



(c) (Unetched)
(Dark field)

Figure 11: Micrographs of the Cross Section of the Corroded Strut

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With the microscopic observation it was very clear that the surface of the strut was severely corroded. In the Figure 11(a), with higher magnification, it is possible to observe pitting corrosion (wide and shallow pits) in addition to the general corrosion. The surface corrosion attack is very clear in dark field observation also (Fig. 11(c)). With these observations it can be concluded that the corrosion attack on the strut was significantly high, mainly in the area where the strut fixed to the wheel hub (Fig. 6).

A special coating was found on the inner side of the strut which has protected only the inner surface. However, it was found that even that coating was damaged and in damaged places some corrosion has taken place.

5. Hardness Measurements

Rockwell Hardness in different places of the strut was measured and value was 36.8 HRC. This value indicates that the steel used to manufacture the strut has a relatively high hardness and strength. Chemical composition was not analyzed but it can be assumed that this particular material would be a high strength steel.

6. Discussion

The main objective of this investigation was to find the root cause of the detachment of the aircraft wheel from the strut. Main damage was that the strut was completely separated from the wheel. The fracture was at the fixing point of the strut to the wheel (Fig. 2 & 5). Furthermore, the brake disc was bent, brake assay was cracked and the rim of the wheel was cracked. Out of those damages the investigation was focused only on the main damage since other damages may have been occurred due to the collision of the wheel with the ground after detachment.

During observation of the outer side of the wheel it was found that a part of the strut was still inside the wheel hub and the bolt which secure the strut in the wheel was intact (Fig. 5). After dismantling the wheel components it was found that the strut and the bolt was severely corroded especially, the area where strut was inside the hub (Fig. 6). Furthermore, a secondary crack was also observed close to the main crack (Fig. 8). The main fracture propagated from the bolt hole (from right hand side of Fig. 9) in the strut. The other bolt hole was not damaged.

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With higher magnification it was revealed that the main fracture shows striations (beach marks) which were initiated from both sides of the bolt hole and progressed towards the final brittle crack (Fig.9 - left side). This shows a fatigue nature of the fracture and therefore, it can be concluded that the fracture was initiated and propagated well before the accident. This confirms that some corrosion patches on the fracture surface close to the fracture initiation point (Fig. 9 - right side). The main reason for the fracture was the severe corrosion in the strut and the fixing bolt. With metallographic observation it was found that the outer surface of the strut was damaged through general and pitting corrosion. These surface damages have certainly initiated the fracture (possibly Stress Corrosion Cracking with inter-granular crack propagation. However, the facilities available in the laboratory was not sufficient to observe inter-granular corrosion). The corrosion was mainly on the outer side of the strut where inner side was protected by a non metallic coating.

During the discussion with SLCA officers that this aircraft was flying low and the wheel has touched a high tension wire. In that moment the wheel might have been detached although the impact was not severe. That means the fracture of the strut-end has propagated earlier up to the maximum level and given away the final detachment through brittle fracture. The force responsible for the this action may be a force which act slightly at an angle outwards against the flying direction. This force creates a high stress concentration at the location where the strut is fixed to the wheel (increased stress intensity at the location where greater reduction of cross section is present) (Fig. 5).

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7. Conclusions

1. Root cause for the detachment of the wheel was a fatigue crack initiated from the bolt hole of the strut.

2. Severe corrosion was found in the strut-end as well as in the fixing bolt which has contributed to the crack initiation.

8. Recommendations

1. It is recommended to ground all this type of aircrafts and inspect the strut fixing bolt area after dismantling the wheel components.

2. It is also recommended to perform ultrasonic testing for the bolt as well as the strut for micro cracks. Dye penetration or eddy current inspection can also be used for the inspection. This should be included in periodic inspection schedule.

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