FINAL REPORT No. 4-02/4-16 (1-2018) on

THE SERIOUS INCIDENT of AIRCRAFT BOMBARDIER- DHC-8-402, REGISTRATION YL-BAI

ON SEPTEMBER 17, 2016 AT RIGA INTERNATIONAL AIRPORT

CONTENTS

Abbreviations

AFM – Aircraft Flight Manual;
ADU - AIR DATA UNIT;
ALI -Airworthiness Limitation Item;
AMM- Aircraft Maintenance Manual;
CAA - Civil Aviation Authority;
CDS - Central Diagnostic System;
CPL - Commercial Pilot Licence;
CSN- Cycles Since New;
DOI-DRY OPERATING INDEX - index at Dry Operating Weight;
DLI- DEADLOAD INDEX - index at cargo compartment loaded;
DLMAC - DEADLOAD MAC - % MAC at cargo compartment loaded;
EFCP - EFIS CONTROL PANEL;
EPCU - ELECTRICAL POWER CONTROL UNIT;
FIM - Fault Isolation Manual;
FADEC - FULL AUTHORITY DIGITAL ELECTRONIC CONTROLL;
FCU – FLAP CONTROL UNIT;
FGM - FLIGHT GUIDANCE MODULE;
GPWS - GROUND PROXIMITY WARNING SYSTEM;
IFC - INTEGRATED FLIGHT CABINETS;
IOM - INPUT/OUTPUT MODULE;
IOP - INPUT/OUTPUT PROCESSOR;
ICAO - International Civil Aviation Organization;
LG - Landing Gear;
LIZFW - LOADED INDEX at ZERO FUEL WEIGHT - index at ZFW; **LILAW-** LOADED INDEX at LANDING WEIGHT;
LITOW - LOADED INDEX at TAKE OFF WEIGHT - index at TOW;
LLP- Life Limited Part;
MFD - MULTIFUNCTION DISPLAY;
MAC- MEAN AERODYNAMIC CHORD;
MACZFW - % MAC at ZFW;
MACTOW -% MAC at TAKE OFF WEIGHT;
MACLAW - % MAC at LANDING WEIGHT;
MAREP – Maintenance Report;

MRB - MAINTENANCE REVIEW BOARD REPORT;
NITS:
N - nature of the emergency;
I - information to passenger & preparation;
T - time remaining;
S - Signals;
NLR - National Aerospace Laboratory;
Np - prop speed;
NNCL- Non Normal Check List;
OASES- Open Aviation Strategic Engineering System;
OGE- Out of Ground Effect;
PIC- Pilot in Command;
PIREP – Pilot Report;
PM-Pilot Monitoring;
PF-Pilot Flying
PSEU - PROXIMITY SENSOR ELECTRONIC UNIT;
QRH- Quick Reference Handbook;
RCAU - REMOTE CONTROL AUDIO UNIT;
SIA - Safety Investigation Authority;
SHP - Shaft Horse Power;
TSN-Time Since New
TCAS - TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM
UTC - Universal Time Coordinated;
ZFW – Zero Fuel Weight;
WOW- Weight On Wheels.

FINAL REPORT

4-02/4-16 **Aircraft:** Bombardier Q400 **Engines:** Pratt & Whitney PW150A Turboprop Engines **Crew:** 4 **Place:** Riga, Latvia	**Aircraft Registration:** YL-BAI **Type of flight:** Scheduled, IFR **Passengers:** 63 **Date and Time:**17.09.2016 at 05:39

All times in this report are UTC. Local time was UTC + 3 hours.

SYNOPSIS

The Transport Accident incident Investigation Bureau, Latvia (TAIIB) was notified about the incident by the Area Control Centre (LGS) Tower Controller on 17.9.2016 at 5:50 hours. The TAIIB notified the Transport Safety Board (TSB), Canada – investigation body of the State of Manufacture.

The aircraft involved in the serious incident was a scheduled international flight from Riga International airport (EVRA) to Zürich Airport (LSZH). After take off at 05:04 and selecting gear up, nose gear unsafe indication came on, the crew stop climbing to 2500 FT and proceed to holding point REKBI and by ATC request climbed to 5000FT, then performed after take off check list and QRH. The purpose of the QRH is to assist trained pilots verify that the proper procedures have been carried out. The QRH provides the flight crew with abbreviated information derived from the approved AFM to operate the airplane in most normal and non-normal/emergency situations. Alternate gear selection was performed without success. Then after some amount of fuel was burn low pass over runway was performed to confirm with technician that landing gear is down. The technician confirmed that gear is down but he couldn’t confirm that it was locked down. The technician suggested to recycle gear and the crew tried to do it but without success. Then the crew proceed to point REKBI again and prepared for emergency landing.

They emergency –landed safely at RIX with the NLG partially deployed at approximately the positions at which the landing gear got stuck. Landing was smooth with flaps 35 and max N_P, after touched down nose wheel started to rotate and during landing roll-out after receiving weight on wheels the nose landing gear collapsed. Evacuation services and ATC were advised immediately after the aircraft stopped.

TWY **D** **Picture 1 Aircraft stopping after landing**

Summary

TAIIB investigation showed that the Drag Strut Assembly Lower Lock link bushing insufficient retention leads to breaking the sealant and subsequent moisture intrusion in the joint. When the Lock Link bushings are spun (rotated) the sealant is damaged resulting in loss of primer and Cd plating. Penetrated moisture and runway de-icers in the joint leads to corrosion of LLL hole that together with wear of bushing OD leads to excessive clearance in the mechanism, decreasing the total distance between the turning points of the locking mechanism and allow for jamming of the NLG.

Safety recommendations

As a result of the investigation of this serious incident, the TAIIB has issued six recommendations. Two safety initiatives were made during the investigation.

NOTIFICATION

The TAIIB notified the Transport Safety Board (TSB), Canada (State of Design), ICAO, EASA and CAA on 19.9. 2016.

General information of the serious incident

Operator	-	Air Baltic Corporation JSC, Latvia
Aircraft Type	-	DHC-8-402
Nationality	-	Latvia
Registration	-	YL-BAI
Manufacturer	-	Bombardier
Owner	-	Air Baltic, Latvia
Year of manufacture	-	2010
Place of Accident	-	Riga, Latvia;

Date and time - September 17, 2016, approximately at 5:39 UTC

Investigation

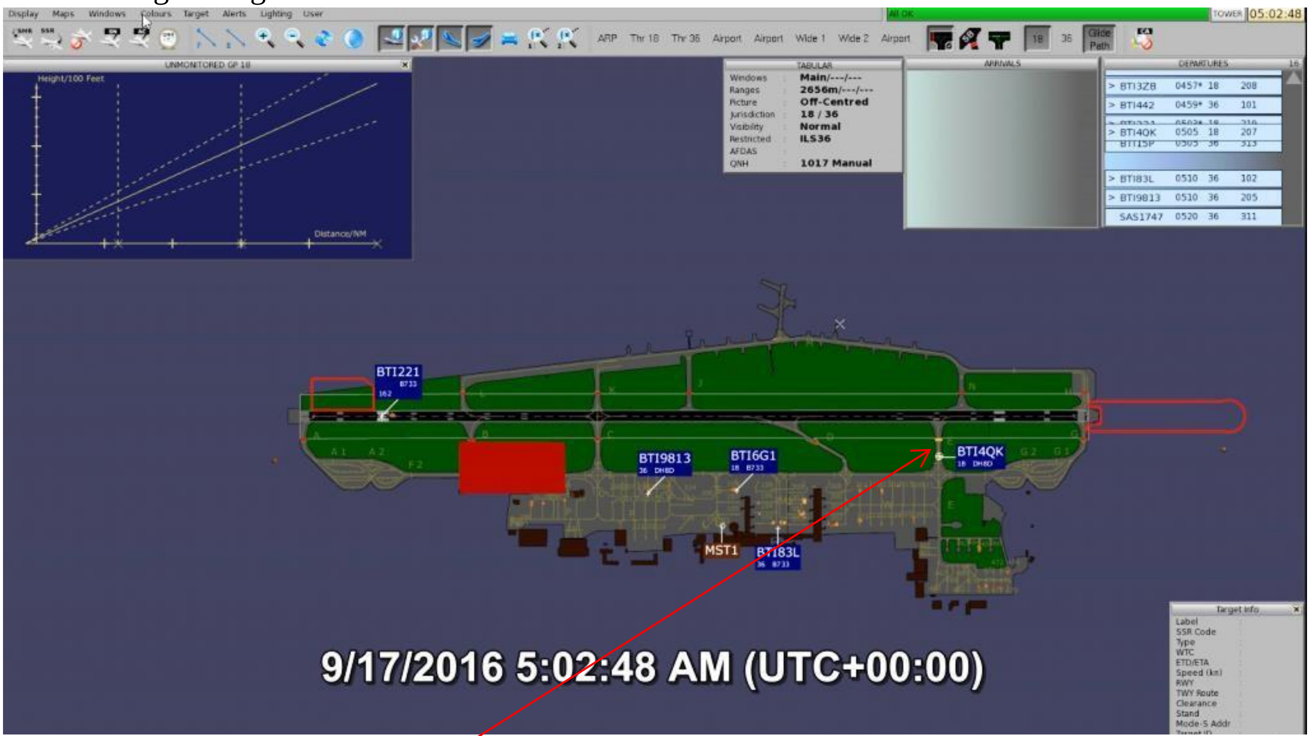
The Transport Accidents & Incidents Investigation Bureau (TAIIB) of the Republic of Latvia as State of Occurrence according to Annex 13, Section 5.1. instituted an investigation into the circumstances of the incident and started to conduct the investigation. TSB Canada appointed accredited representative (ACCREP) to assist this investigation.

1. Factual information

1.1. History of the flight

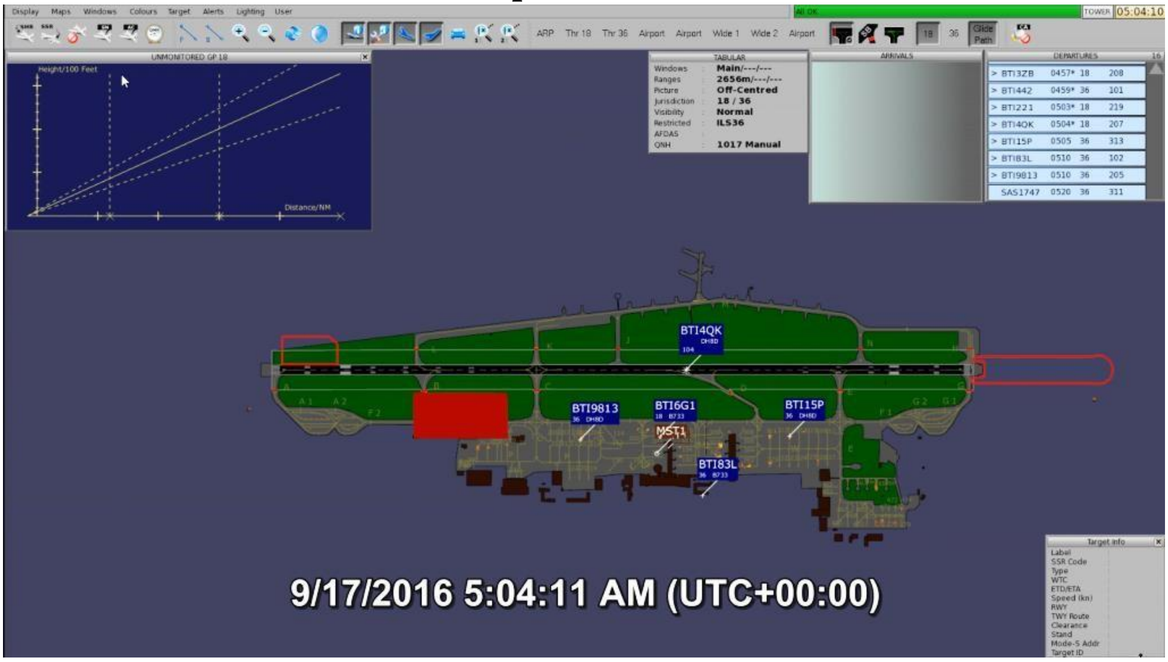
1.1.1. The crew actions

The crew arrived at the aircraft approximately at 04:10 and started the cockpit preparation including the first flight checks, nothing abnormal was noticed, all checks were normal and no advisory lights on the LG panel. At 04:57 during taxiing the crew obtained clearance for RWY 18.



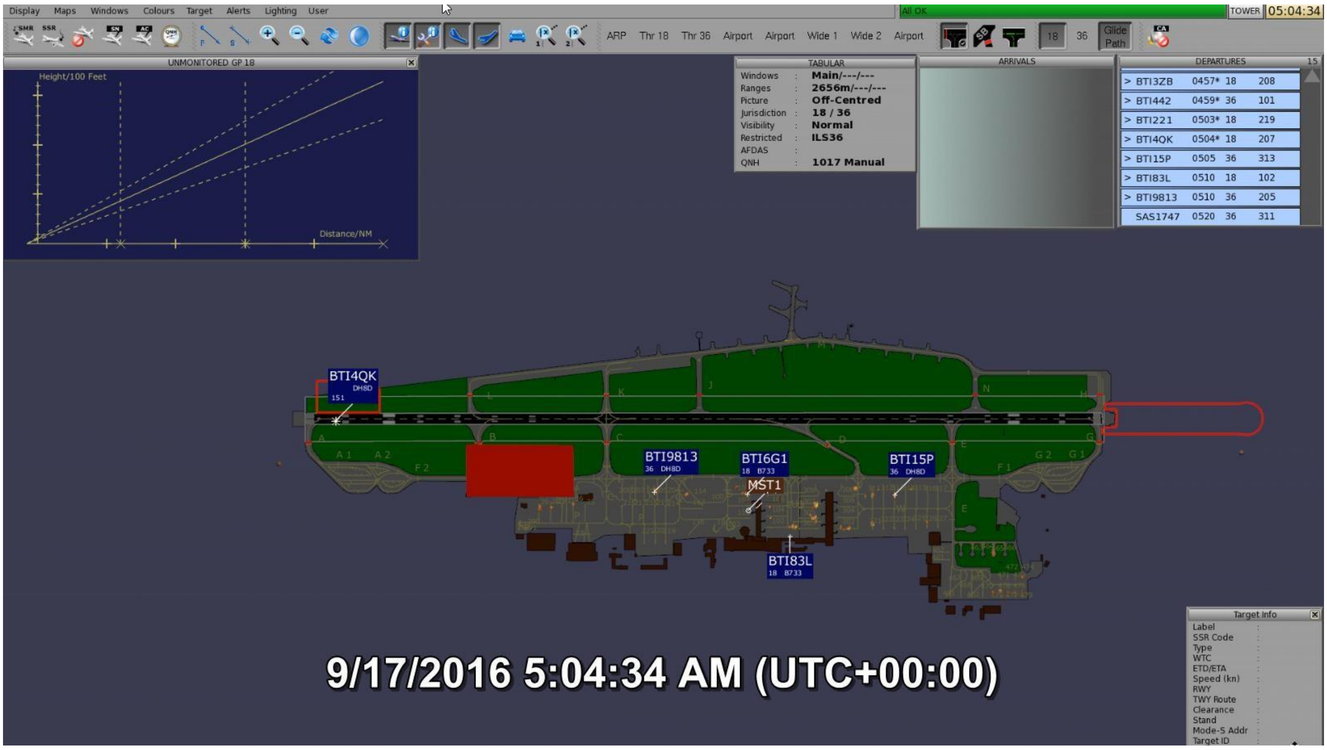
They took intersection E for departure.

Radar picture 2



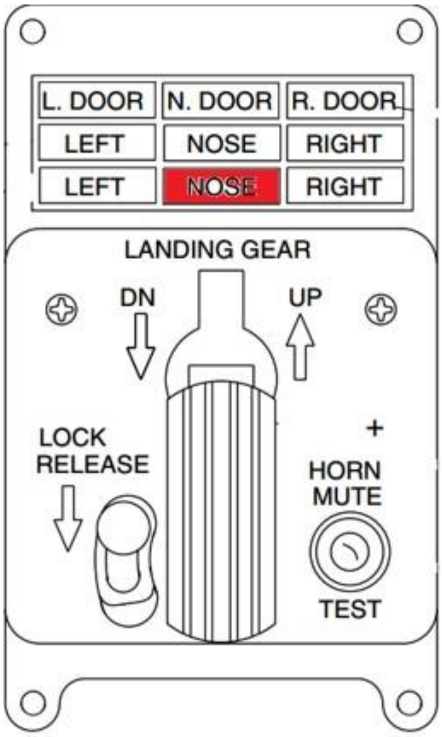
Radar picture 3

Taking off was at 05:04

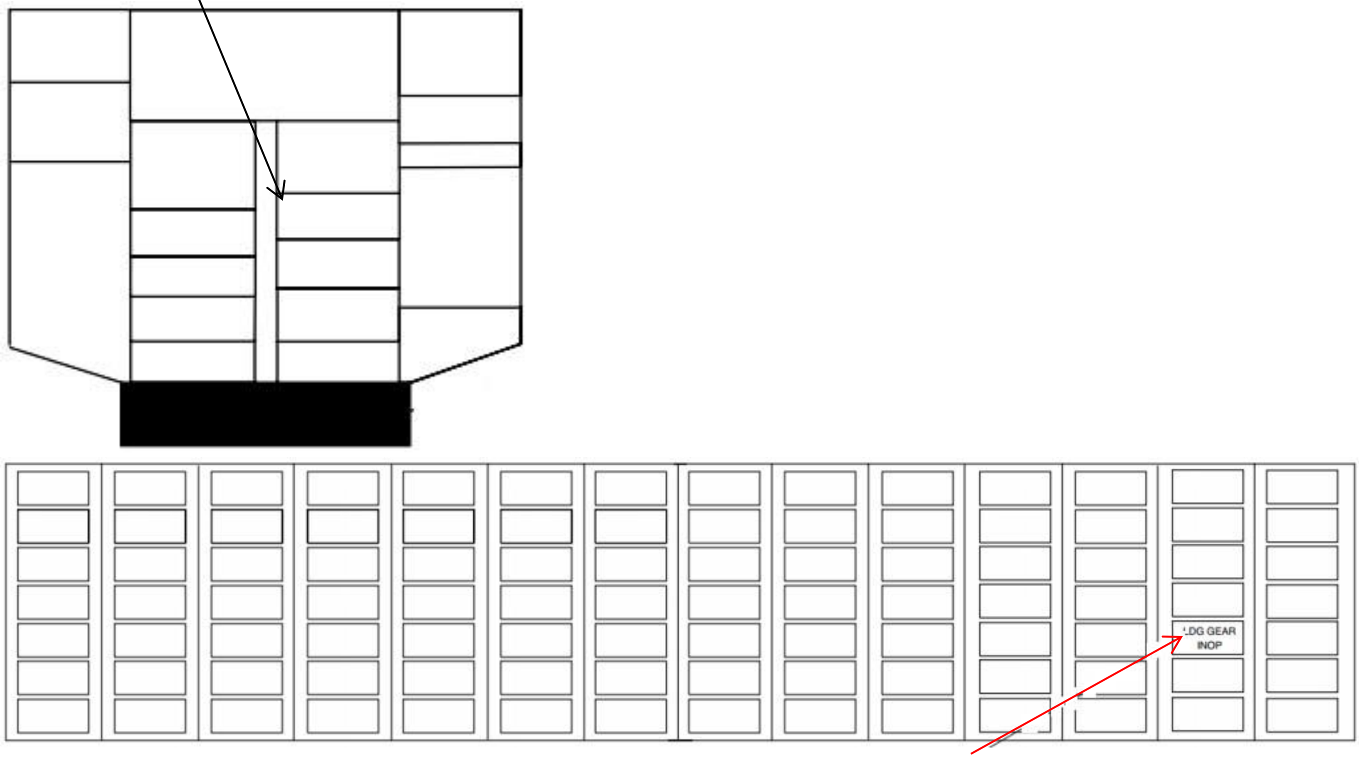


Radar picture 4

The flight was uneventful until the landing gear was selected up, after lift-off the LG was selected was up, the LG retracted but the nose LG unsafe light (**Red**) remained illuminated and the "N DOOR" light remained illuminated (**Yellow**) as indicated on the cockpit landing gear advisory panel.



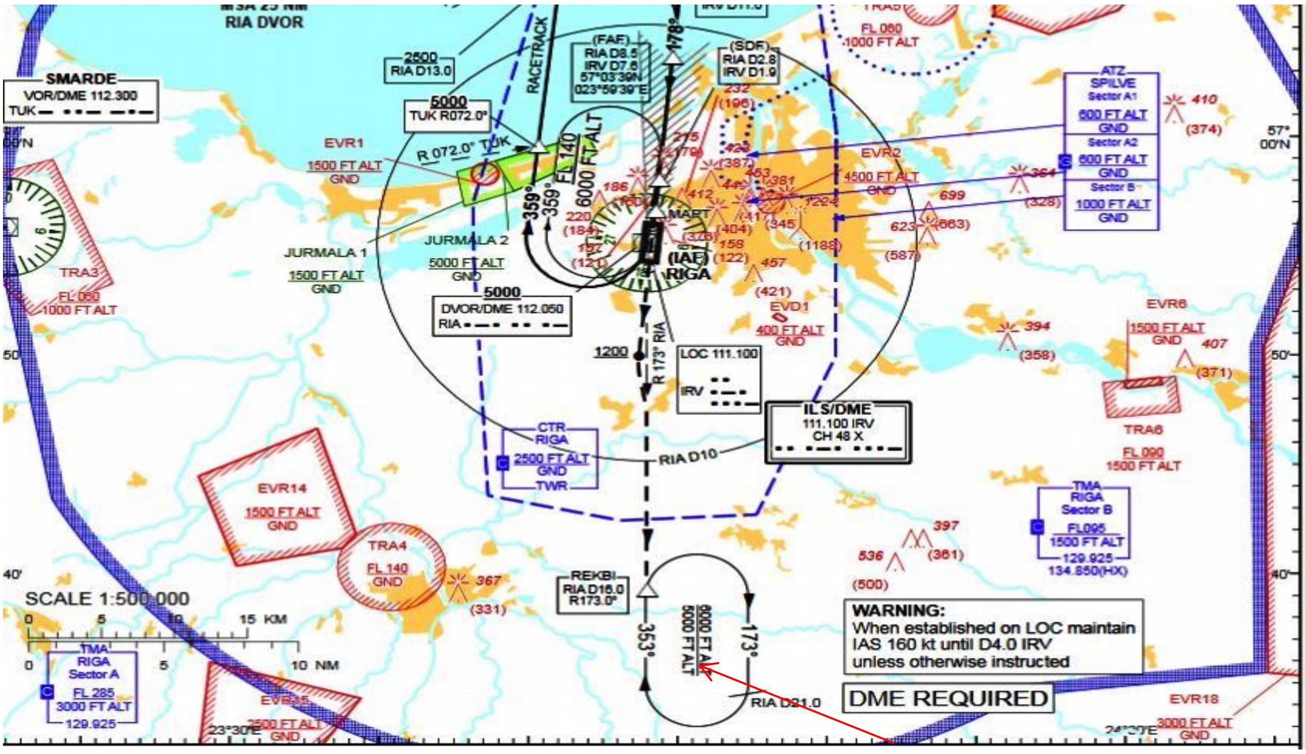
According to the crew statement there was not master caution "LDG GEAR INOP" caution light on the overhead console.



Picture 5 **"LDG GEAR INOP"**

Because after take off procedures just main landing gear retracted PM contacted APP Controller at approximately 2500FT and requested to stop climbing at 4000FT and informed ATC that they have a problem with the LG, then PM asked for REKBI (Holding) and APP Controller cleared

BTI4QK proceed to REKBI (Holding) and climbing at 5000FT. The crew followed controller's instruction.



Picture 6 **REKBI (Holding)**

As crew proceeded to the holding they read all the NNCL and before start any action checked the warning lights, then realize that the HYD, fuel pumps and auto feather were still ON, they turned off and completed the after take off checklist. While in holding the captain (was PF) informed the senior CC as well as NITS briefing was done.

Apart from consulting the QRH (ALTERNATE LANDIG GEAR EXTENSION, NOSE LANDING GEAR DOOR MALFUNTIONS) the crew also check OM Part B Section 3 "Abnormal and Emergency Procedures" Item 3.6.5.2. Alternate Extension as well as they ran through different potential landing gear failure scenarios where the following considerations may also be applicable in the Item 3.6.5.3.1. "Nose Gear Up, Main Landing Gear Down"

Then the crew carried out the Alternate Gear Extension NNCL. The result was that just the MLG was down and locked but the NLG stayed with the same fault.

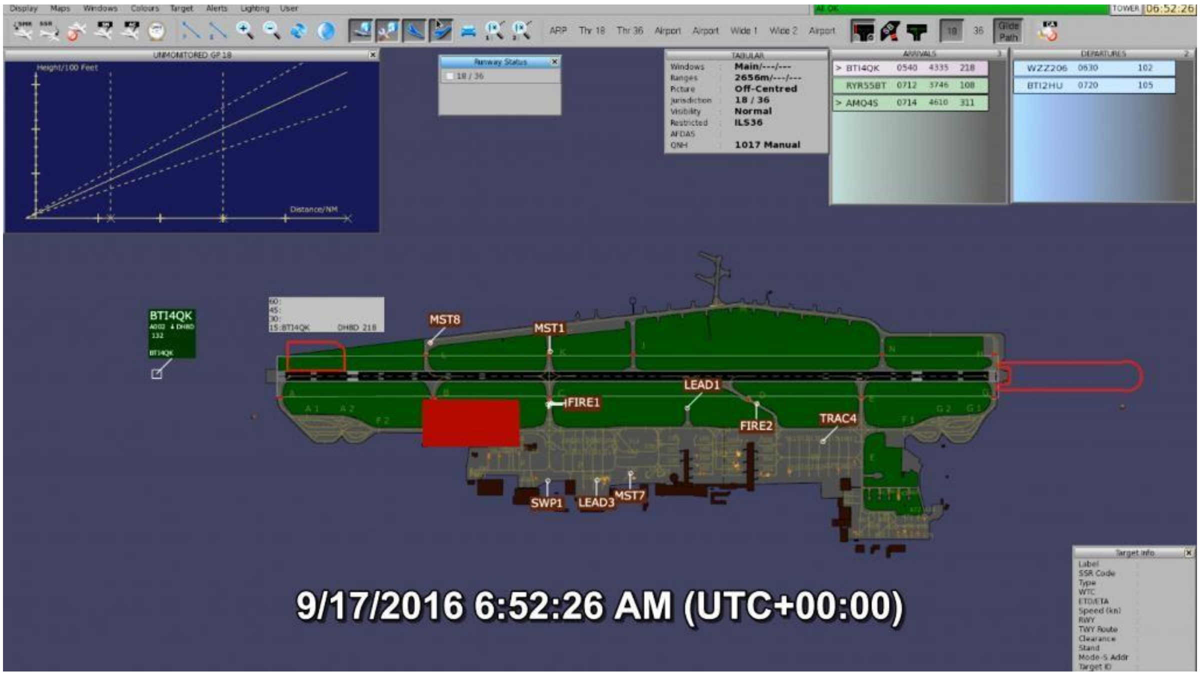
At 05:32:17 the APP controller asked crew:"Will you declare emergency?"

The crew answered: "We don't declare emergency, we want to make "low pass" before emergency landing to check position of NLG as well as we should to prepare for landing if NLG is not down and locked."

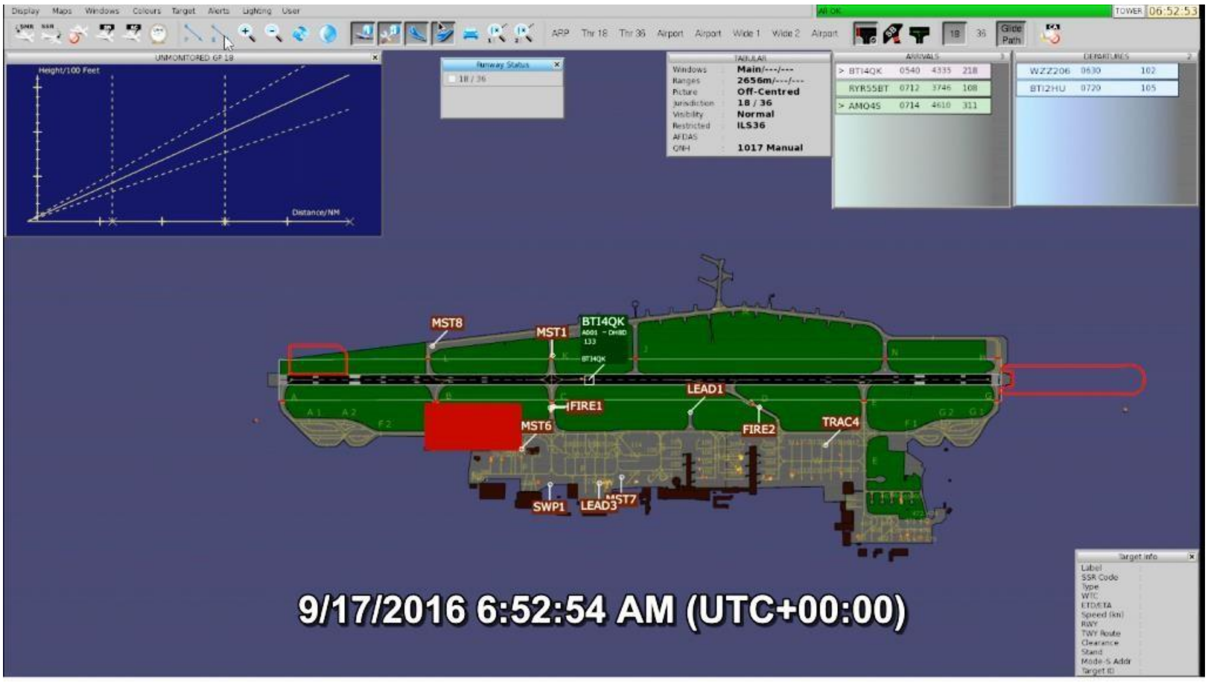
At 06:33:19 the captain contacted TWR controller on frequency 118.1MHz and declared that they would like to start "low pass" in 6 min. for now and that problem is that NLG is unsafe. The captain declared that they want to do low pass, then will land and if landing gear collapses they initiate to carry out evacuation, if not collapse stay on runway and waiting technicians and tow the aircraft to apron.

At 06:47:26 the captain contacted TWR controller on frequency 118.1MHz and declared that they established ILS RWY 36 for "low pass". The TWR controller confirmed: BTI4QK, 360 degrees, cleared for low pass.

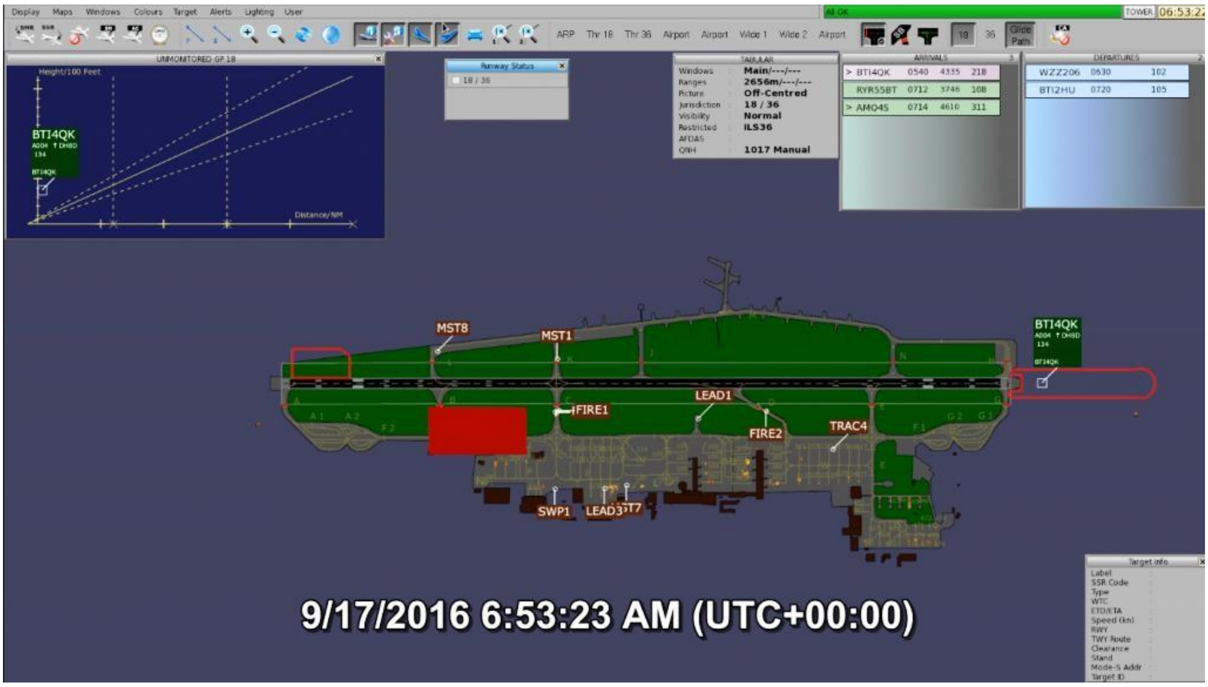
Picture 7 Low pass on RWY 36



Radar Picture 7A Low Pass



Radar Picture 7B Low Pass



Radar Picture 8 Going Around after Low Pass

At 06:52:59 the captain contacted TWR controller and declared "GA" after "low pass."

At 06:56:45 the technician contacted the crew on tower frequency 118.1MHz and asked: "Did you try alternate extension procedure and did you see three green lights."

The captain answered that they did all procedures and the nose gear down and lock green light did not illuminate.

The Captain asked Air Baltic technician: "Did he see gear down or not and technician answered that he saw the wheels but he can't confirm that it is fully down."

The Captain said that they will land anyway and the Air Baltic technician recommended to the crew to perform LG extension-retraction cycle again.

At 06:58:10 The crew tried to explain the problem with NLG to technician. The crew member said:” The problem is that when we make alternate extension, the nose gear when we pull it itself like the cable is not connected, so is not force completely.”

The technician said:” That it is because landing gear is already out of hook, I mean out of, it is not holding.”

The crew member said:” When we make extension alternate, when we pull the nose gear cable, did not happen anything, when we pull the MLG they felt the weight if we have to pull it, but the nose gear if we have to pull it felt if the cable not connected or anything.”

The technician said:” It is clear, it is because landing gear is already partly extended and up hook is not holding the weight of the landing gear. Please try again, if you can according with your procedures, extension-retraction again with main selector.”

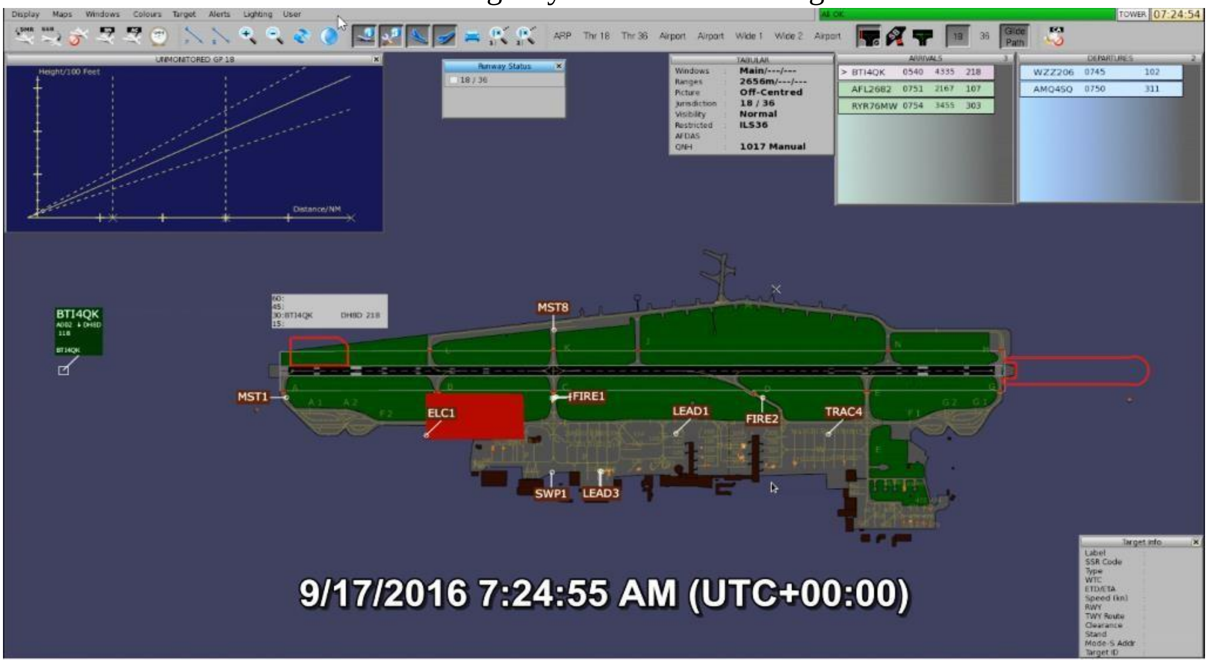
The crew said:” So what you suggest that we put everything back, retract everything and then try to extend again.”

The technician said: “Yes, this is my suggestion.”

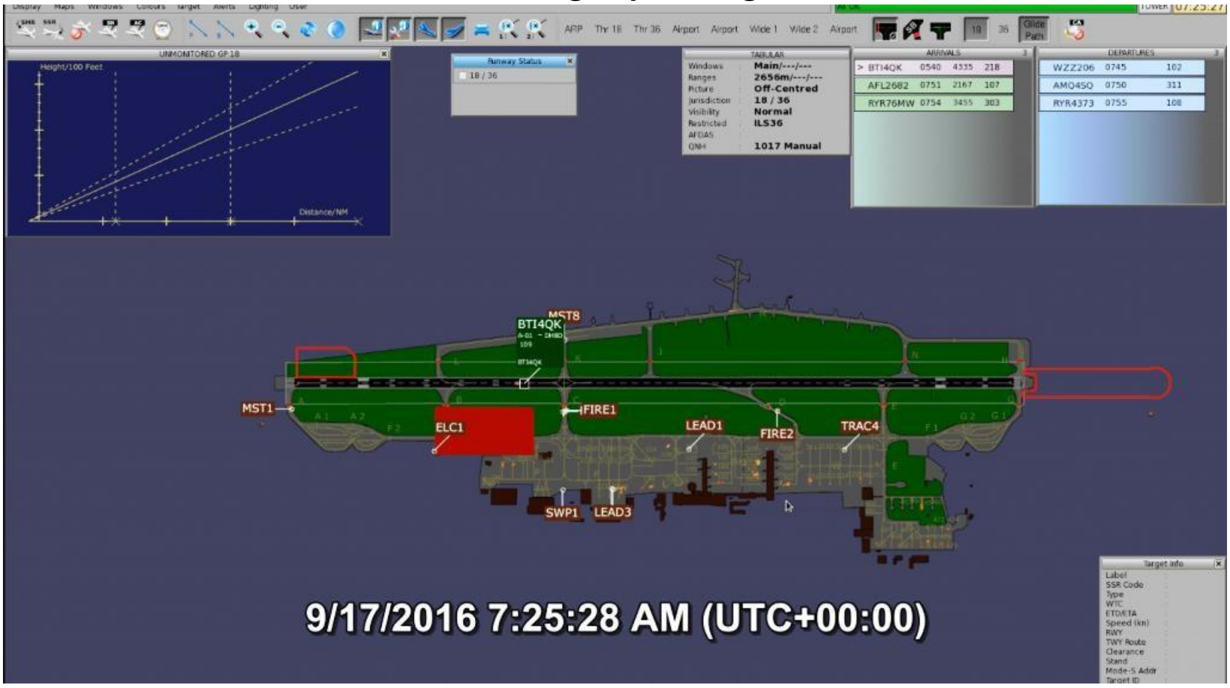
At 07:18:31 APP controller instructed BTI4QK: “BTI4QK 15 miles from touchdown, continue approach.” The crew confirmed clearance.

At 07:20:09 APP controller instructed BTI4QK: “BTI4QK, now contact Riga TWR, 118.1, good luck.” The crew confirmed instruction.

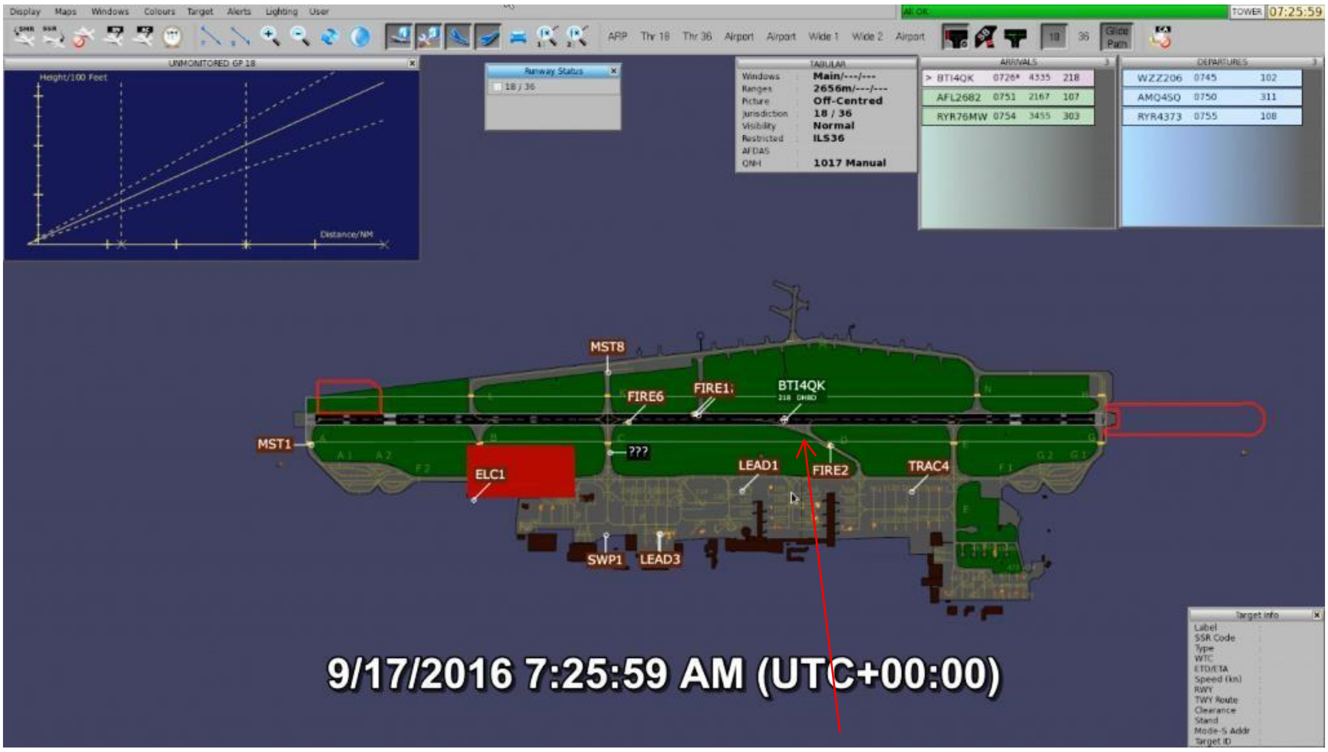
At 07:20:20 the crew of BTI4QK contacted TWR controller on frequency 118.1MHz:” BTI4QK, good morning, establish ILS, 36.” The TWR Controller gave instruction to land on RWY 36 and informed that emergency services are waiting.



Radar Picture 9 Emergency landing



Radar Picture 10 Emergency landing



Radar Picture 11 Aircraft stop on RWY opposite of TWY D

Picture 12 Aircraft stop on RWY opposite of TWY D

Picture 13 Aircraft touched RWY

At the moment of touching RWY NLG wheels are visible outside aircraft fuselage and lower then opened NLG front doors.

Picture 14

Picture 15 After landing the NLG collapsed but not abruptly but progressively, because NLG doors didn’t touch RWY surface right away after touching.

Picture 16 and 16A After the aircraft had come to a complete stop on the runway the NLG appeared to have fully collapsed, which resulted in NLG front door damage.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	-	-		-
Serious	-	-		-
Minor	-	-		-
None	4	63	67	-
TOTAL	4	63	67	-

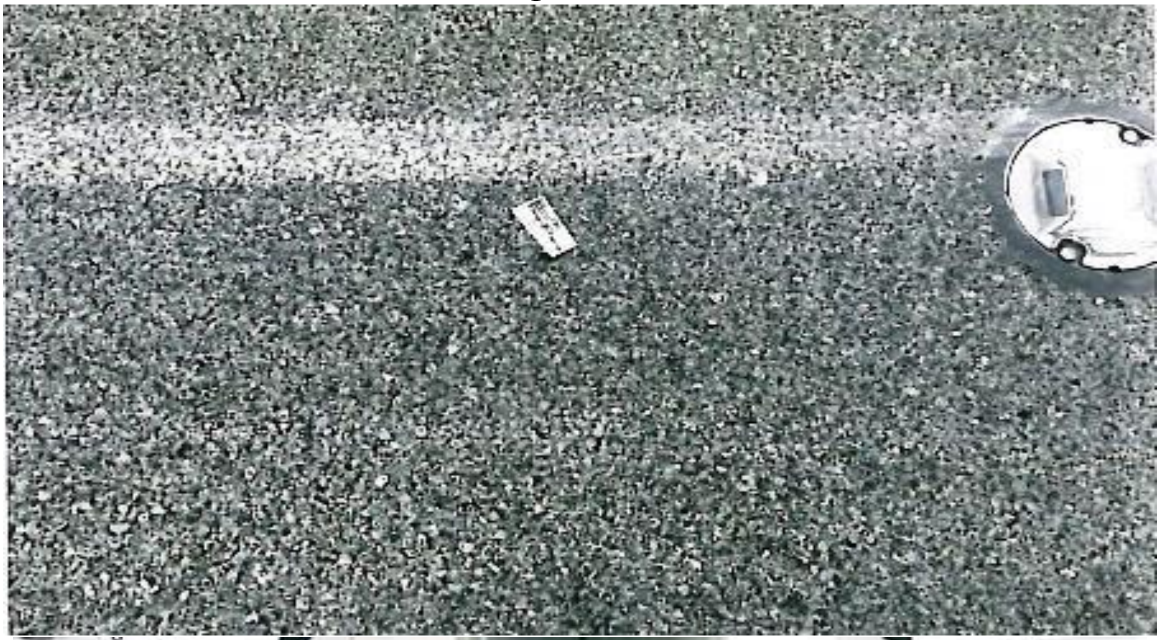
1.3.Damage to aircraft

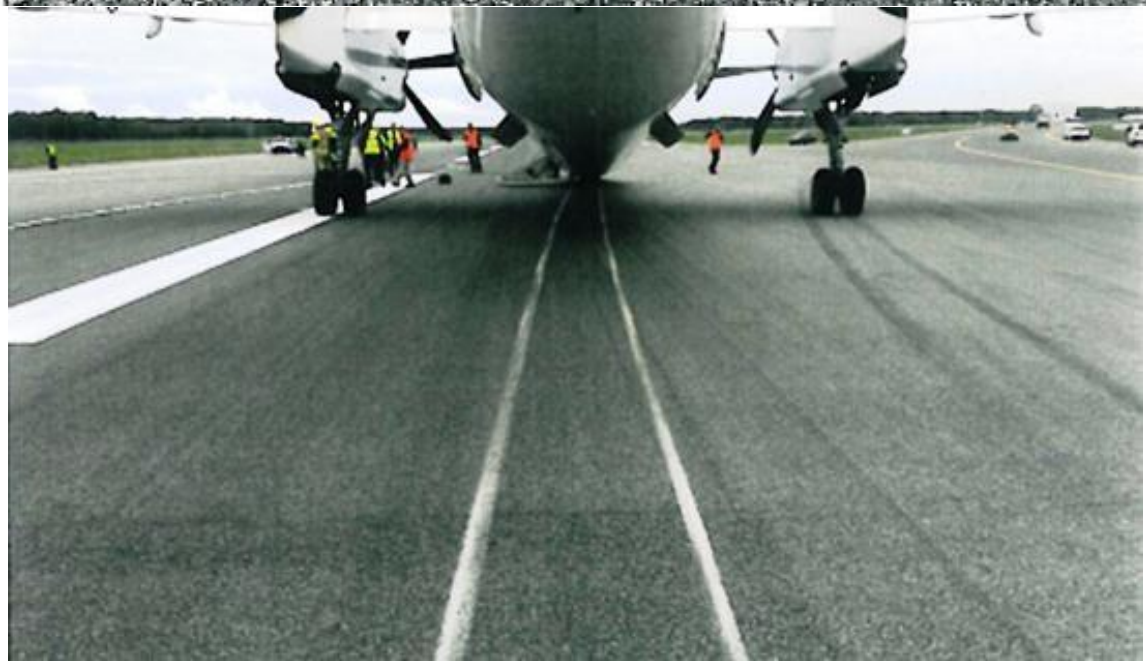
The fuselage of aircraft was not damaged. The NLG front doors were seriously damaged.

Picture 17 Damages of NLG front doors

1.4. Other damage On the runway surface was found different small pieces of the aircraft and traces of braking.

Picture 18 Fragments of aircraft





Picture 19 traces of braking 1. 5. Personnel information

The flight crew certified and qualified for the flight in accordance with existing regulations

PIC -male, age - 39,

Total flying experience -3880.0 hrs

Flying experience on aircraft type DHC - 2237.00 hrs;

Flying hours last 90 days - 236.00 min;

Flying hours last28 days - 69.00 hrs;

Flying hours last 24 hours before incident - 3:41 hrs;

FO -male, age - 59
Total flying experience -10526.00 hrs

Flying experience on aircraft type DHC - 2196.37 hrs;

Flying hours last 90 days - 148.31 min;

Flying hours last28 days - 42.35 hrs;

Flying hours last 24 hours before incident - 6:31 hrs;

1.6. AIRCRAFT INFORMATION

1.6.1. General aircraft information

The DHC-8-402 manufactured by Bombardier Inc. is a twin-engine turboprop transport aircraft in all-metal construction. Year of manufacture: 2010
Serial number: 4302
Engines: Pratt & Whitney, PW 150A
Auxiliary Power Unit (APU) APS 1000 T-62T-46C12-Hamilton Sundstrand Power System
Propellers: Dowty Propellers R408/6-123-F/17
Registration: YL-BAI, registered in Latvia on July 12, 2010
MTOM: 29574kg
Certificate of airworthiness: The certificate No191 was issued by Civil Aviation Agency of the Ministry of Transport Republic of Latvia on December 07, 2010. No Limitations, it was valid.
Airframe TSN – 15.685,64 hrs;
Airframe CSN – 11730 landings;

1.6.1.1. Mass and centre of gravity (extract from Load Sheet Final) The aircraft version: 76 passengers.

RIX	ZRH	LN-RDK	Crew 2/2
DOW dry operating weight (kg):	18,531 kg		
ZFW zero fuel weight (kg):	24,394 kg	MAX	26,308 kg
TOF take-off fuel (kg):	3530 kg		
TOW take-off weight (kg):	27,924 kg	MAX	29574 kg
TIF trip fuel (kg):	2607 kg		
LAW landing weight (kg):	25317 kg	MAX	28,123 kg
UNDLD under load before LMC (kg):	1650 kg		
PAX M passengers:	63	TTL	63
DOI dry operating index:	23.6		
DLI dead load index:	51.2		
LIZFW loaded index at ZFW:	31.8		
MAC ZFW- % MAC at ZFW	24.8		
BALANCE LIMITS BEFORE LMC - FWD and AFT balance limitation for actual loading and configuration			
FWD /ACTL/AFT	16.53/24.76/33.89	ZFMAC	

NOTE: *The loaded fuel on DASH-8 Q400 a/c has very small influence on a/c CG, therefore on LS balance check is required at ZFW only. However on electronic LS there might be balance check at TOW (LITOW) indicated. The balance difference between LIZFW and LITOW is up to 0,5 [Index Units] and considered negligible.*

The aircraft was within the mass and balance limitations during the entire operation. The estimated mass of the aircraft at the time of the accident was approximately 26,000 kg (ZFW plus 1600 kg fuel).

1.6.2 Landing gear system general description

This chapter is extract from manufacturer's AIRCRAFT MAINTENANCE MANUAL - SYSTEM DESCRIPTION

The landing gear is electrically controlled, hydraulically operated and mechanically locked. The tricycle gear is a retractable dual wheel installation. The main gears retract aft into the nacelles and the nose gear retracts forward into the nose section. Gear doors completely enclose the landing gear when it is retracted and partially enclose the gear when it is extended.

The cockpit advisory lights show the position of gear doors and down-locks. An audible warning sounds if the gear is not extended and the aircraft is in a landing configuration.

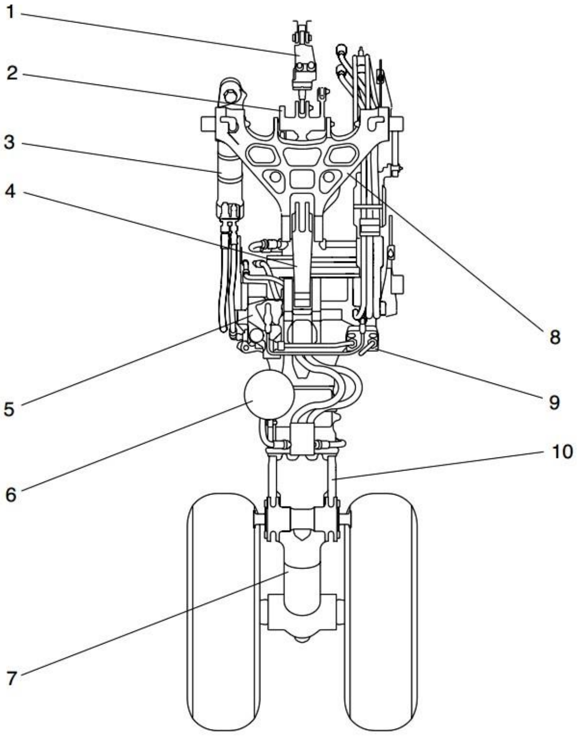
A Proximity Sensor Electronics Unit (PSEU) monitors and controls the operation of the landing gear components.

An alternate landing gear extension method can be used to extend the gear if the primary extension method fails. There is also an alternate down-lock verification system.

Landing gear operation is controlled and monitored from the Landing Gear Control Panel, adjacent to the Engine Display in the cockpit. The landing gear is selected up or down by moving the landing gear selector lever. A Lock Release selector lever must be held down to let the gear selector lever move in either direction. An alternate down-lock verification system confirms downlock engagement if the primary down-lock indication is in doubt. Three green down-lock verification lights are located under the Landing Gear Alternate Extension door in the cockpit floor.

1.6.3. Nose Landing Gear

The nose landing gear (NLG) lets the forward fuselage absorb the shock of landing and gives stability and direction during aircraft taxi. The NLG doors enclose the retracted NLG in the forward fuselage and add to the aerodynamic efficiency of the aircraft.



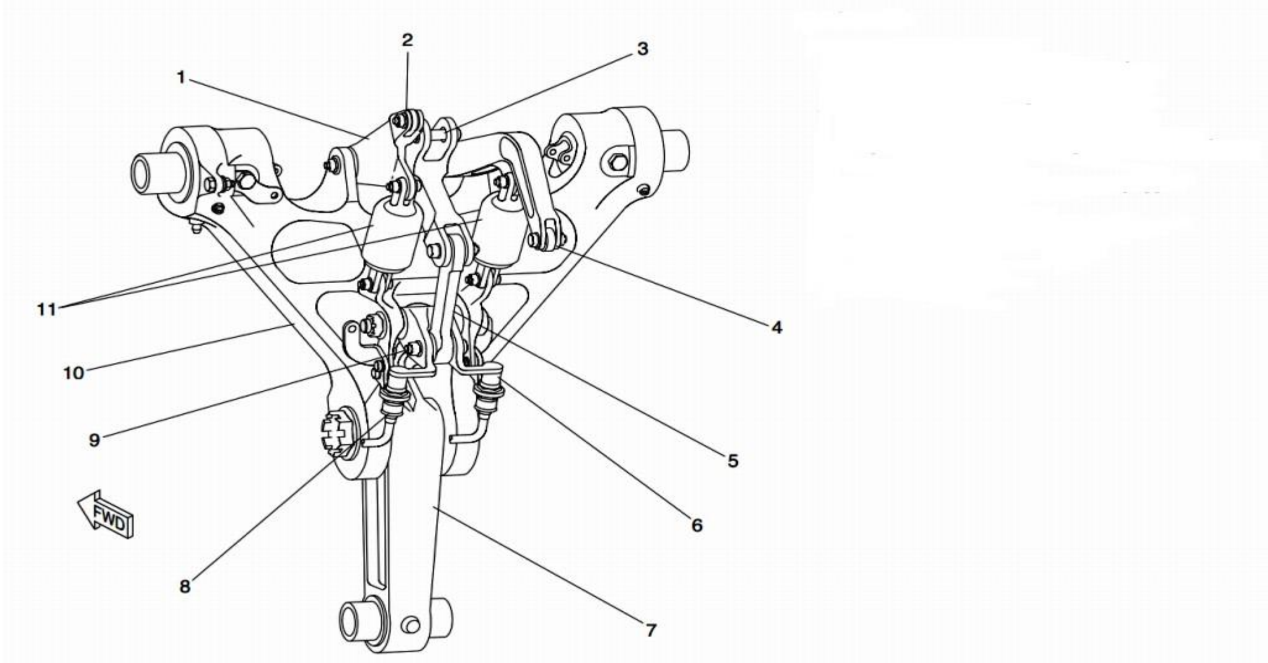
1. Lock Actuator.
2. Pivot Tube Assembly.
3. Retraction Actuator.
4. Lower Drag Strut.
5. Nosewheel Steering Manifold.
6. Taxi Light.
7. Trailing Arm.
8. Upper Drag Strut.
9. Steering Hydraulic Motor.
10. Inner Cylinder.

Nose Landing Gear Aft View Detail

The NLG is installed in the wheelwell in the nose fuselage, located forward of the forward pressure bulkhead. When the NLG retracts the forward and aft doors enclose it in the wheelwell. The GROUND LOCK control handle operates a cable system to engage the downlock safety lever. The nose landing gear assembly has the components that follow:

- Shock Strut Assembly;
- Drag Strut Assembly;
- Harness Electrical.

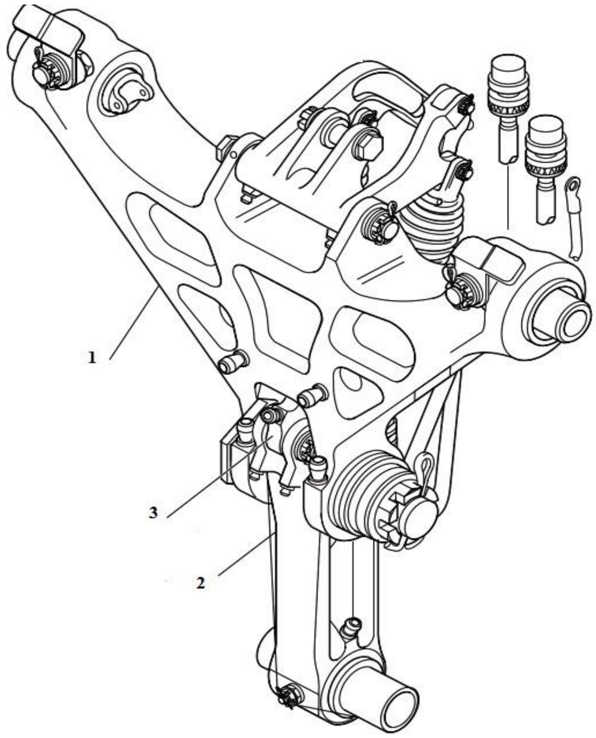
1.6.3.1. Drag Strut Assembly



The drag strut assembly stabilizes the shock strut in either the retracted or the extended position. The drag strut assembly has the components that follow:

- A pivot tube assembly (1);
- Pivot Tube Arm Downlock Actuator for Ground Lock Attachment point (2, 3);
- Pivot Tube Arm for Emergency Uplock Release (4);
- Lock Link Assembly (5);

- NLG Lock Proximity Sensor #2 (6);
- A lower drag strut (7);
- NLG Lock Proximity sensor #1 (8)
- An upper lock link (9);
- An upper drag strut (10);
- Two spring assemblies (11);



The lower lock link (3) is installed on the lower drag strut (2) and is connected to the upper lock link. The upper lock link is installed on the upper drag strut and is connected to the lock link assembly. The over centering action of the upper and lower lock links makes a mechanical lock when the gear is in the retracted and the extended positions.

1.6.4. Landing Gear Control Panel

The landing gear position is controlled by the LANDING GEAR selector lever. The selector lever has a LOCK RELEASE button which must be pushed down before moving the LANDING GEAR selector lever.

Moving the lever to the UP or DN position sends the signal to the Proximity Sensor Electronic Unit (PSEU) to command the LG movement and completes the electrical circuit to the hydraulic selector valve to retract or extend the gear. Gear proximity sensors send signals to the Proximity Sensor Electronic Unit (PSEU) that prevent gear retraction when the aircraft is on the ground. Moving the LANDING GEAR selector lever to the UP position starts landing gear retraction sequence. Moving the LANDING GEAR selector lever to the DN position starts the landing gear extension sequence. An amber light in the selector lever comes on when any of the LANDING GEARS is not up-locked and not down-locked (in transit).

1.6.5. Landing gear advisory lights

Gear and door position is shown by nine advisory lights on the LANDING GEAR control panel, and an amber light in the selector lever.

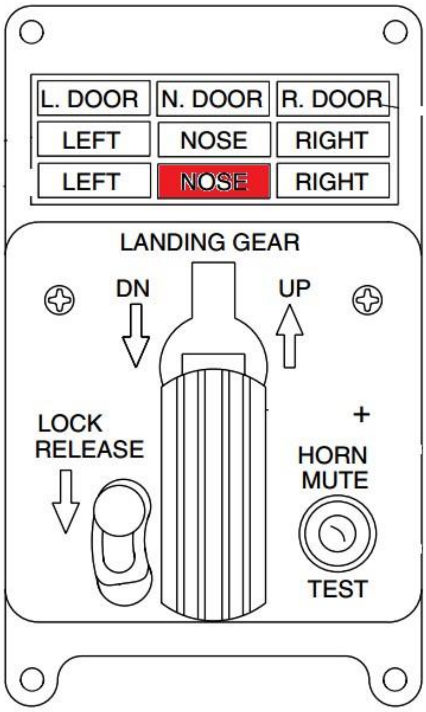


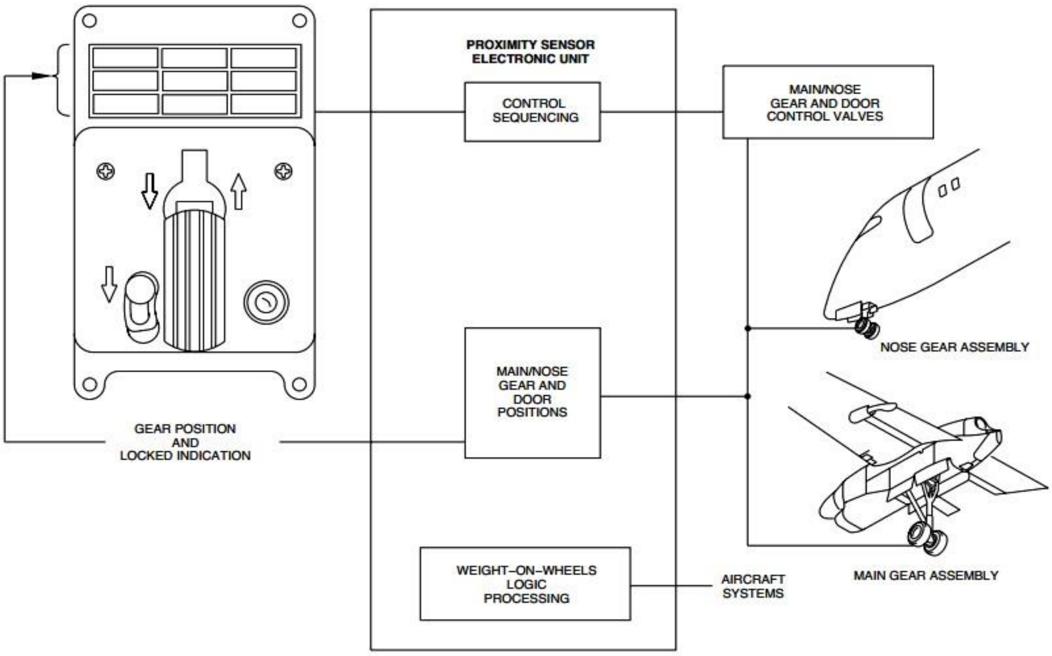
Figure 1

The **L. DOOR, N. DOOR, or R. DOOR amber lights** come on when the related hydraulic **gear door is open.**

The **LEFT, NOSE, RIGHT green lights** are illuminated when the related gear **is fully down and locked.**

The **LEFT, NOSE, RIGHT** red lights come on when the related gear **is not locked in selected position**. When the gear is up and locked all lights on the LANDING GEAR panel go off. Three green lights on the LANDING GEAR ALTERNATE EXTENSION panel, on the flight compartment floor, give backup visual verification of gear downlocking.

1.6.6. General description of Primary Retraction and Extension



Schematic description of the manufacturer (Excerpt 32-00-00) Landing Gear)

1.6.7. Retraction Sequence

When the landing gear selector lever is selected to the UP position, hydraulic pressure from No. 2 system is applied to the retract side of the system through the solenoid selector valve. This opens the nose gear forward doors and retracts the nose gear, it also opens the main gear aft doors and retracts the main gear. The aft nose gear doors are mechanically linked and close with the retracting nose gear. After nose gear retraction, the forward nose gear doors close hydraulically.

With PSEU-0501/-0601/-0602 the sequence is:

The forward main gear doors are mechanically linked and close with the retracting main gear. After main gear retraction, the aft main gear doors close hydraulically.

The advisory light sequence during landing gear retraction starts with the LEFT, NOSE and RIGHT green "safe" lights extinguished and the LEFT, NOSE and RIGHT red "unsafe" lights illuminated. Then the amber door advisory lights coming on to show the hydraulically operated gear doors are open. Then the amber selector handle light is illuminated to indicate LG is not down-locked. When the landing gear is retracted and locked in the up position, the amber selector handle light and red advisory lights go out. Finally, the amber gear door advisory lights go out to show all the hydraulic gear doors have closed. No advisory lights should be on if the gear is up correctly. The solenoid Landing Gear selector valve is then de-energized, hydraulically isolating the landing gear system. The main and nose gear are held in the up position mechanically with uplocks.

1.6.8. Extension Sequence

When the landing gear selector lever is moved to the DN position, hydraulic pressure is applied to the extend side of the system through the solenoid selector valve. The main and nose hydraulic doors open, and the main and nose gear extend. The hydraulic forward nose and aft main gear doors close after the gear is down and locked.

With PSEU-0501/-0601/-0602 the sequence is:

The advisory light sequence during extension starts with the LEFT, NOSE, and RIGHT red unsafe lights coming on. Then the amber door advisory lights coming on to show the hydraulically operated gear doors are open. Then the amber gear selector handle light is illuminated to show LG is not up-locked. When the landing gear is fully extended and locked in the down position, the red unsafe lights, and the selector handle light go out. Then the green LEFT, NOSE, and RIGHT advisory lights come on. Finally, the gear door advisory lights go out when the hydraulically operated doors are closed. The solenoid selector valve stays powered to allow for continued hydraulic pressure acting on the gear when down and locked, however primary downlock is by the overcenter locks. If a landing gear hydraulic sequencing valve fails, or the PSEU is unable to control it, the LDG GEAR INOP caution light comes on. The landing gear selector must not be used to extend the landing gear when the LDG GEAR INOP caution light is on

1.6.9. Nose Landing Gear Retraction

When the landing gear is down and locked with doors closed, the solenoid sequence valves and the down solenoid of the selector valve are kept in an energized condition. This keeps hydraulic pressure on the down side of the lock actuators. The lock actuators are also used to help maintaining the downlock condition. Retraction of the landing gear starts when the LANDING GEAR selector lever is unlocked and moved to the **UP** position.

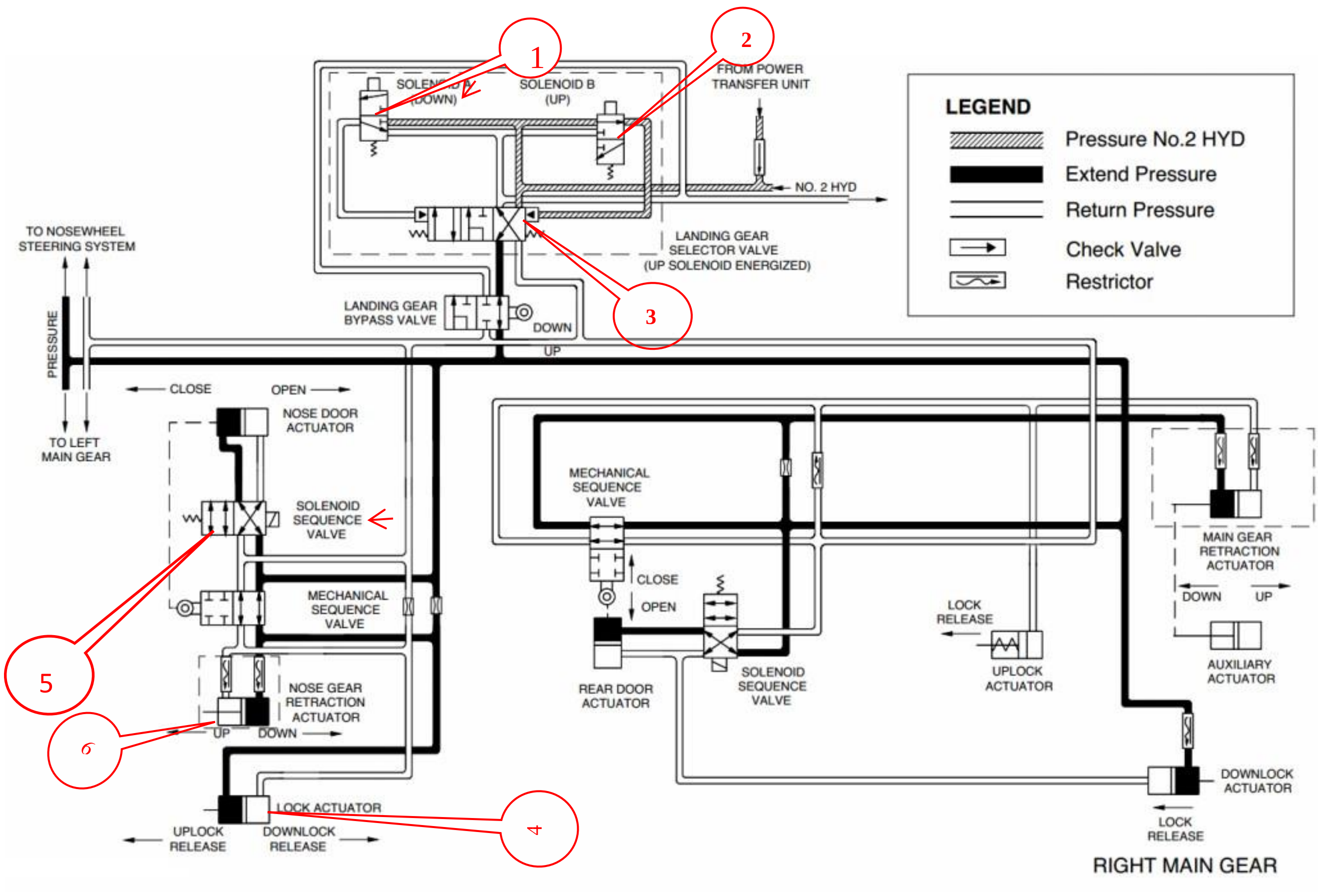


Figure 2 Initial Up Selection Doors Open (before reaching the fully UP position)

When the LANDING GEAR selector lever is moved to the UP position, the down solenoid (1) of the landing gear selector valve is de-energized. The PSEU makes sure that the aircraft is airborne and that the Nose Landing Gear (NLG) is centered. The up solenoid (2) of the landing gear selector valve, now receives electrical power. When the landing gear selector valve receives electrical power, the selector valve spool (3) moves to commanded position. This lets hydraulic system pressure flow into the retract side of the landing gear hydraulic system.

Hydraulic pressure is supplied through an energized solenoid sequence valve (5) to the retract side of the NLG forward doors actuator (6). This causes the NLG forward doors to start to open. The very small restrictors (8) that effectively block the flow to Lock and Retract actuators until MSV is open.

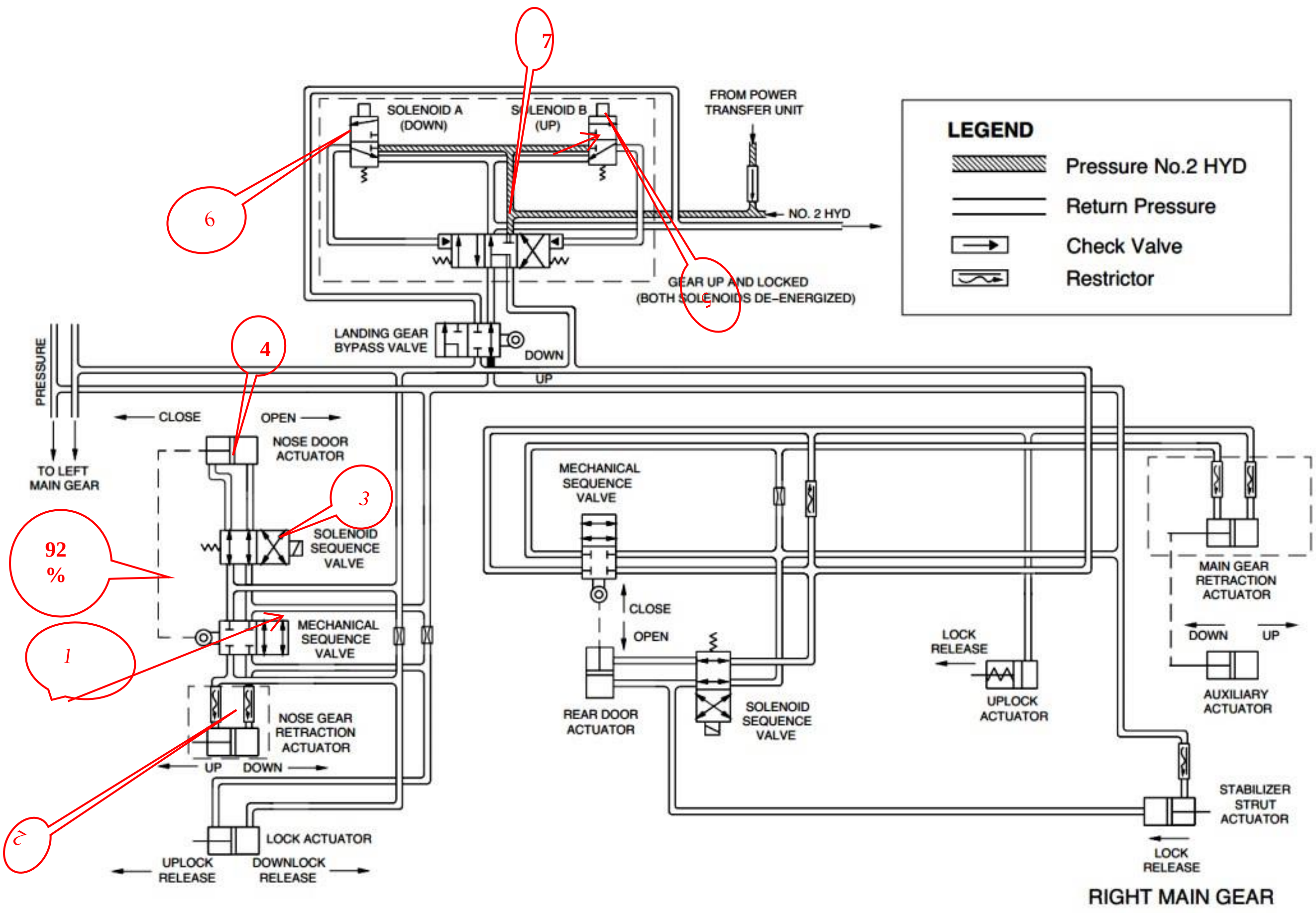


Figure 3 Gear Up and Locked Doors Closed

The operation of the NLG uplock/downlock release actuator and the NLG forward doors actuator is checked by the **proximity sensors.** At approximately **92 percent** travel of the NLG forward doors, the door linkage operates the **mechanical sequence valve (1)**. When the mechanical sequence valve is in operation, it stops to interlock the retraction/extension part of the NLG hydraulic system. Hydraulic pressure is supplied to the up side of the NLG retraction actuator (2). The NLG retraction actuator and unlock actuator receive pressure at the same time, but the flow to them is very small until the mechanical sequence valve is fully opened by the door opening.

The NLG starts to travel to the fully retracted position where it is locked in place by the mechanical uplock. The NLG does not have a separate mechanical uplock. The drag brace and lock link assembly functions to both downlock and uplock the gear. The proximity sensors make sure that these procedures have been completed.

When the PSEU receives the input signals that the NLG is up and locked, the PSEU deenergizes the solenoid sequence valve (**3**). This causes the solenoid sequence valves to pressurize the NLG forward doors actuator (4) to close the doors. At approximately 8 percent reverse travel of the NLG forward doors, the mechanical sequence valve (1) stops its operation. This action removes flow from the up side of the NLG retraction actuator (2). Inline restrictors bypass the mechanical sequence valve (1) and keep the NLG retraction actuator (2) pressurized to **3000 psi (20684 kPa).**

Hydraulic pressure is kept at 3000 psi (20684 kPa) until the landing gear hydraulic system is depressurized upon completion of the retraction cycle. A proximity sensor senses that the NLG forward doors are closed and sends an input signal to the PSEU.

The MLG and NLG proximity sensors sense that the gear is up and locked and that the MLG and NLG doors are closed. The PSEU gives a three second interval before it de-energizes the up (5) and the down (6) solenoid in the selector valve (7). The PSEU then depressurizes the landing gear hydraulic circuit.

1.6.10. Nose Landing Gear Extension

The landing gear starts to extend when the LANDING GEAR selector lever is unlocked and moved to the DN position. The down solenoid (1) of the selector valve (2) receives electrical power. The selector valve now supplies aircraft hydraulic system pressure and flow into the extend side of the landing gear hydraulic system.

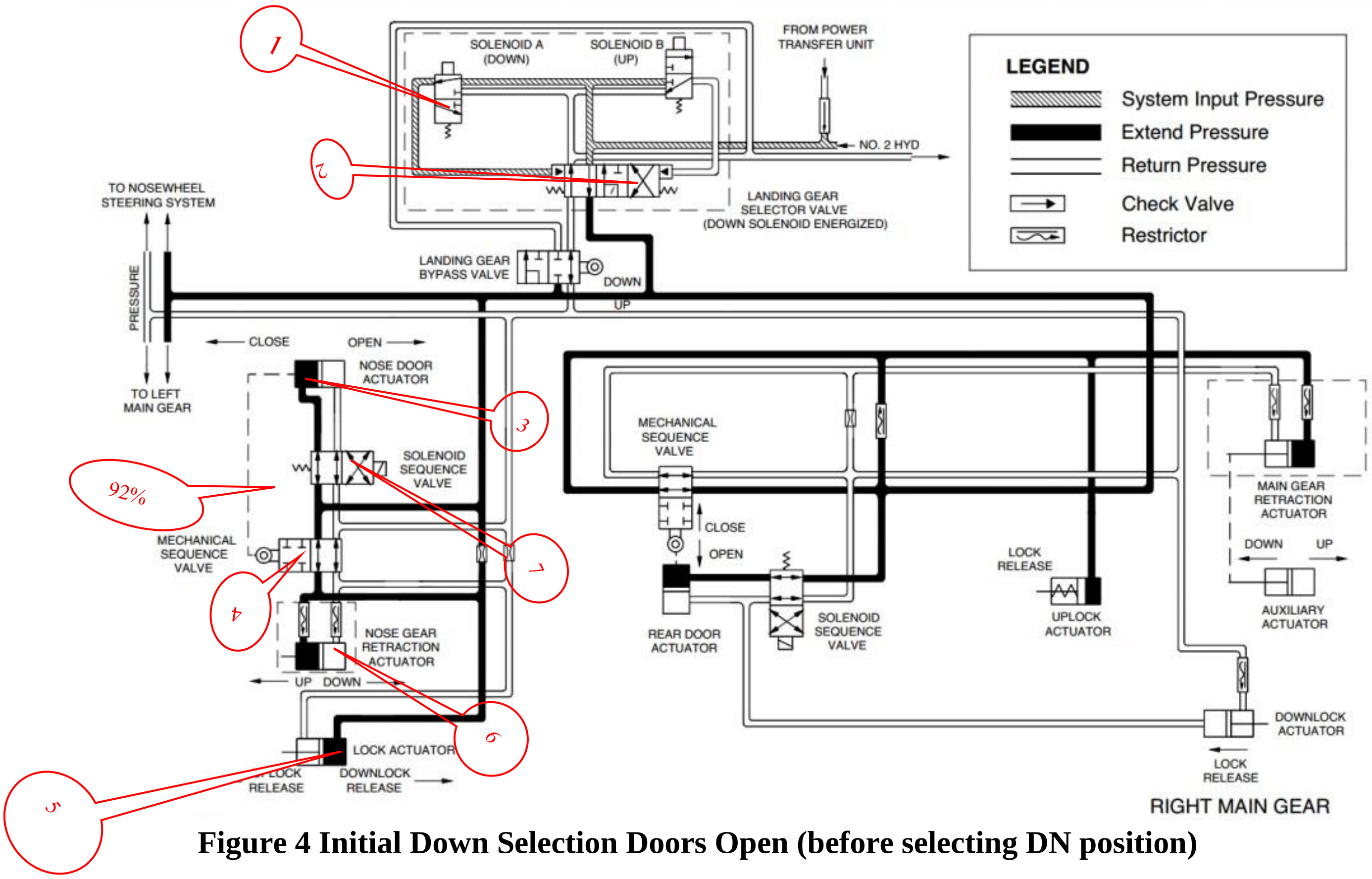


Figure 4 Initial Down Selection Doors Open (before selecting DN position)

The flow is supplied to the pressure side of the NLG doors actuator (**3**) through the deenergized solenoid valve (**2**). This causes the NLG forward doors to open.

At approximately 92 percent travel of the NLG forward doors, a mechanical sequence valve (4) is actuated by the door linkage. When the mechanical sequence valve operates, hydraulic flow is sent to the lock actuator (5) and the down side of the NLG retraction actuator (6). The NLG then starts to travel to the down and locked position.

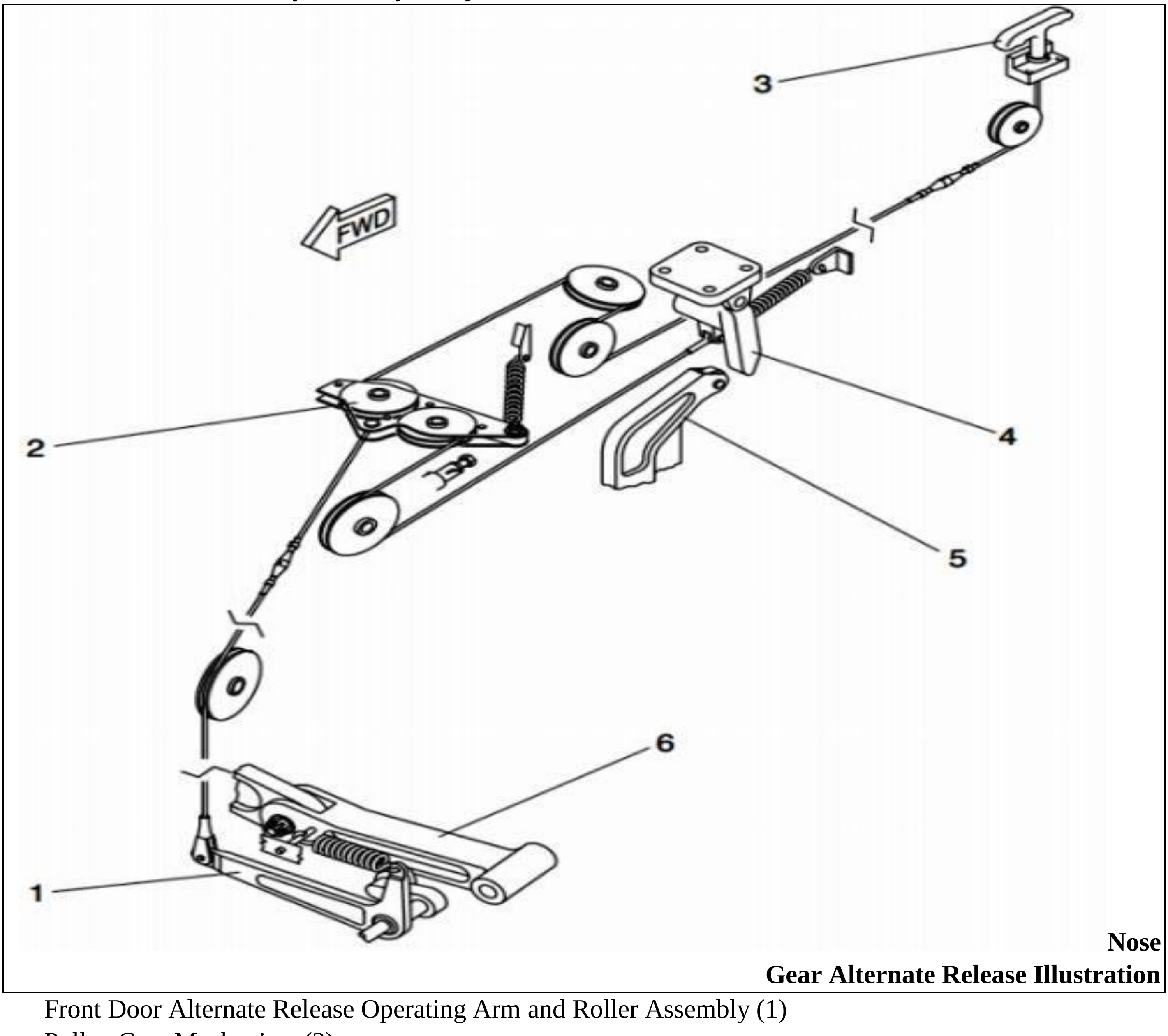
There are five proximity sensors that monitor the NLG extension sequence. The NLG has two down sensors on the NLG trunnion arms, two lock sensors on the NLG drag strut, and one NLG doors closed sensor.

When the PSEU receives the input signals that the NLG is up and locked, the solenoid sequence valve (7) is energized by the PSEU. Hydraulic pressure is supplied to the NLG forward doors actuator (3) to close the doors. At approximately 8 percent reverse travel of the NLG forward doors, the mechanical sequence valve (4) stops its operation. This action removes flow from the uplock/downlock actuator (5) and the NLG retraction actuator (6). An inline restrictor keeps the NLG retraction actuator (6) and the lock actuator (5) pressurized to 3000 psi (20684 kPa) at the end of the extension cycle. A mechanical downlock (5), locks the NLG in the fully extended position. The PSEU keeps power on the down solenoid (1) of the selector valve (2) as long as the LANDING GEAR selector lever is in the DN position.

1.6.11. NLG Alternate Gear Extension

The alternate extension system gives a means of extending the landing gear when the normal system is inoperative. An example of a normal system malfunction may include:

- The LDG GEAR INOP caution light is on;
- The Cockpit Landing Gear Selector Panel indication fails; - There is a Loss of No. 2 hydraulic system pressure.



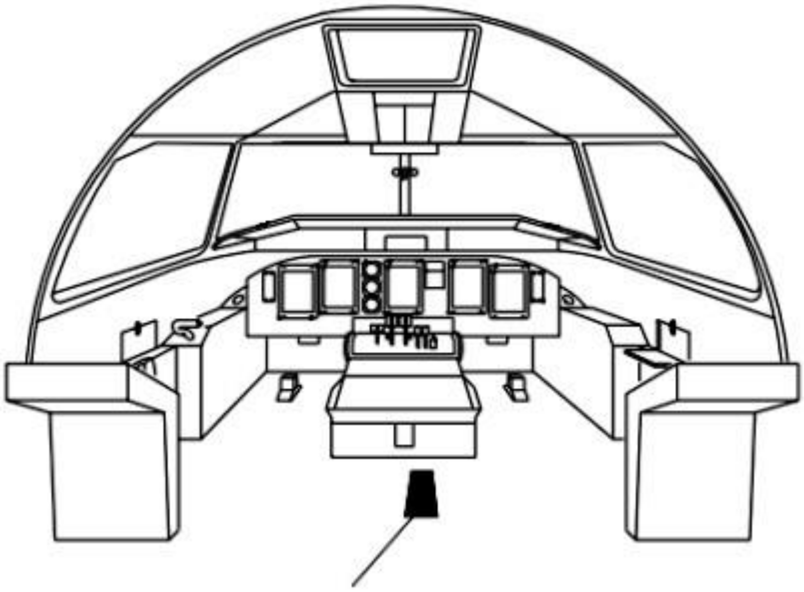
Nose Gear Alternate Release Illustration

Front Door Alternate Release Operating Arm and Roller Assembly (1)
Pulley Cam Mechanism (2)
Nose Gear Alternate Release Handle (Flight Compartment Floor) (3)
NLG Uplock Release Arm (4)
Pivot Tube (5)
Link Assembly (6)

The alternate extension system is a self resetting, cable actuated design. Access to the alternate extension system is through the flight compartment. The alternate extension system includes a bypass valve to isolate the landing gear hydraulics from the No. 2 hydraulic system.

The alternate extension of the landing gear occurs when the Nose Landing Gear (NLG) forward doors, the MLG aft doors, and the landing gear uplocks are mechanically opened. The NLG free-falls to the down and locked position, assisted by the airflow.

The alternate extension of the NLG uses the NLG alternate release handle (3) located in the floor of the flight compartment under the LANDING GEAR ALTERNATE EXTENSION door.



NLG alternate release locator

The handle is connected by cables, turnbuckles and pulleys to the NLG uplock release arm (4), a pulley cam mechanism (2) and to the NLG door release operating arm. The pulley cam mechanism makes sure that the NLG forward doors open before the NLG uplock is opened to release the NLG.

The LANDING GEAR ALTERNATE EXTENSION handle is pulled to unlock the NLG forward doors. Tension springs in the NLG door mechanism pull the doors open. When the doors are fully open, the NLG uplock is released by a further pull on the handle. The NLG free-falls to the fully extended position. Springs installed on the NLG drag strut move the lock links into the down and locked position.

1.6.12. Maintenance activities

The Maintenance Programme (MP) is based upon the Bombardier Maintenance Planning Document (MPD) revision 41, Maintenance Requirements Manual (MRM) revision 13, MRB revision 12 and ALI revision 8 that contains all maintenance requirements for the Dash 8 Series Q400 aircrafts. The tasks are organized by task numbers in accordance with the ATA chapters.

The minimum maintenance programme for the Q400 aircrafts are made up of all Systems/Powerplant, Structural and Zonal Inspection tasks which are detailed in Section 2 of MP. For purposes of organization, several fundamental work packages have been identified as the initial monitoring and maintenance intervals for the Q400 aircrafts.

The airBaltic developed Maintenance Programme for aircraft type DHC-8-402 "**ABC MP Q400, issue 2**" was approved by Latvian Aviation Authority, CAA at March 24, 2015. The data contained in this programme will be reviewed for continued validity at least annually in the light of operating experience.

1.6.12.1. Interval framework

For tasks that are not assigned to a fundamental work package of 'L', 'A', 'C', they have a specific interval listed, such as hours, cycles, calendar, engine change, etc. are considered *Out of Phase (OOP)* and are scheduled individually. These tasks may have abbreviations as follows:

Flight Hours - **FH**
Flight Cycles - **FC**
Engine Hours -**EH**
Calendar -**CA**
APU Hours - **APU H**

1.6.12.2. Line Maintenance

This category contains tasks with interval lower than **6000 FH, 4000 FC** and calendar **2.5 years**, as well as some tasks regardless of its significance of work may be performed within the airBaltic Maintenance facilities. This activity may consist of inspection, servicing, operational tests, and functional tests.

All tasks with the following intervals are included:

- **PRE FLIGHT INSPECTION (PFI).** Prior to each flight (performed by flight crew). - **DAILY CHECK (DLC).** To be carried out each calendar day when an aircraft remains on the ground for sufficient time to warrant a new Daily Check and in any case **not to exceed 48 hours** elapsed time. This is intended for homebase or overnight stops where airBaltic has its maintenance stations or contracted approved maintenance organizations.

- **L-CHECK (L) -** to be carried out within **65 FH or 12 days**.

- **A-CHECK's -** to be carried out within **600 FH or 6 months.** Likewise, **1A, 2A, 4A, 5A, 6A** intervals are **600, 1200, 2400, 3000, 3600 FH** with calendar limits **6, 12, 24, 30, 36** Months respectively.

Intervals→ / Check ↓	600 FH / 6 Months	1200 FH / 12 Months	2400 FH / 24 months	3000 FH / 30 Months	3600 FH / 36 Months
1A	X				
2A		X			
4A			X		
5A				X	
6A					X

- **OUT OF PHASE TASKS (OOP).**

1.6.12.3. Base Maintenance

This category contains tasks with interval higher than 6000 FH, 4000 FC and calendar 2.5 years, as well as some tasks regardless of its significance of work may not be performed within the airBaltic Maintenance facilities. This activity may consist of inspection, repair, restoration or replacement of structure or/and components.

- **C-CHECK's** to be carried out within **6000 FH** or once per **60 months**;

This category contains tasks with interval of **6000 FH** up to. **1C, 2C** intervals are **6000 FH, 12000 FH** with calendar limits 60, 80 Months respectively.

Intervals → / Check ↓	6000 FH / 60 Months	12000 FH / 80 Months
1C	X	X
2C		X

- **OUT OF PHASE TASKS; - FATIGUE DAMAGE TASKS.**
- **UNSCHEDULED MAINTENANCE CHECKS**

For special unscheduled maintenance checks such as inspections after encountering abnormal operational conditions, such as excessive ground or flight loads, bird strike or lightning strike;

1.6.13. Basis of Maintenance Programme

1.6.13.1. MAINTENANCE REVIEW BOARD REPORT – (MRB)

The DHC-8-400 Maintenance Review Board Report is intended to be a "living document", subject to regular review and amendments as required. The revision process for the DHC-8-400 MSG-3 analysis and/or the DHC-8-400 MRB Report is presented in the document "DHC-8-400 Maintenance Programme Development Policy and Procedures Handbook". Revisions to the MRB Report may be initiated by the manufacturer, industry, and/or the MRB.

1.6.13.2. Systems/Powerplant Maintenance Programme

This section covers all the aircraft systems including the Engine and Propeller. Only Maintenance Significant Items (MSI's) for which a maintenance task is specified are covered in this Maintenance Programme.

According to Note 10 of the systems/powerplant maintenance programme within framework **of Systems/Powerplant Maintenance Programme** calendar task intervals for Landing Gear are calculated as the Calendar Time accumulated from the aircraft Certificated of Airworthiness date or date of initial installation on the aircraft (i.e. Total Installed Time).

Storage time (removals from the aircrafts can be deducted (when calculating total installed time) provided the operator has proper documentation of such removals from the aircraft (as specified by the Regulatory Authorities) and the Landing Gear is stored in accordance with the manufacturer's Component Maintenance Manual.

1.6.13.3. Corrosion Prevention Control Programme

The Corrosion Prevention and Control Programme (CPCP) is established to maintain the aircraft's corrosion protection against age-related deterioration caused by environmental interaction. This programme is expected to allow control of the corrosion on the aircraft to Corrosion Level 1 or better.

It has been integrated into the Structural Maintenance Programme of MRB group as Environmental damage inspection tasks and use calendar time. In the development of this MP, these tasks are identified with the word "CPCP" in the end of the task description.

Information from the CPCP tasks is necessary to monitor the corrosion control and to take necessary actions to adjust the programme.

All significant structural damage found during corrosion inspections shall be reported to Bombardier and Latvian CAA using the CPCP Structural Inspection Report.

NO Corrosion	Optional reporting to Bombardier for Structural Programme optimization
Level 1 Corrosion	Optional reporting to Bombardier for Structural Programme optimization. *Corrosion occurring between successive inspections that can be reworked/blended-out within allowable limit.*
Level 2 Corrosion	Report within 30 days to the Bombardier and to the Latvian CAA. *Corrosion occurring between successive inspections that require a single rework/blend-out which exceed the allowable limits: requiring a repair or replacement.*
Level 3 Corrosion	Mandatory reporting within 3 days to the Bombardier and to the Latvian CAA. *Corrosion found during first or subsequent inspection, determined to be an urgent airworthiness concern requiring expeditious action.*

1.6.13.4. MAINTENANCE PROGRAM ATA 32 – LANDIN GEAR

The Maintenance Programme for aircraft type DHC-8-402 "**ABC MP Q400, issue 2**" consists following tasks with intervals for NLG maintenance.

MPD/MRM/BT Task Number	**Task Title - Description**	**Interval**	**Task Code**	**Source**	**Ref. Document**	**Access**
320001-201	LANDING GEAR Lubrication of the Nose and Main Landing Gear	500 FH or 6 Months	LUB	MRB	MTCM 000-32-710-705 MTCM 000-32-720-707 MTCM 000-32-730-707 AMM 32-00-01-640-801 WC 0045, 0046, 0047	Open LG Doors

320001-BT-01	LANDING GEAR Lubrication of the Nose and Main Landing Gear Drag Strut Lock Link P/N 47324-1	275 FH	LUB	BT-MP	AMM 12-20-01-640802 WC 1902	Open NLG Doors

322100-BT-01	NOSE LANDING GEAR Inspection of the NLG	1C	DET	BT-MP	AMM 32-21-00-210-801 AMM 32-21-00-210802 WC 2197	Open NLG Doors
322100-202	NOSE LANDING GEAR Servicing of the Nose Landing Gear Shock Strut	4050FC or 48 Months	SVC	MRB	MTCM 000-32-710-702 AMM 32-21-01-611801 WC 0178	Open NLG Doors
322100-205	NOSE LANDING GEAR Detailed Inspection of the Retraction Actuator Rod End, Jam Nut and Gland Nut	1A	DET	MRB	MTCM 000-32-710-706 AMM 32-21-00-280801 WC 0209	Open NLG Doors
322101-BT-01	NOSE LANDING GEAR Detailed Inspection of the NLG WOW Proximity Sensor Cover	1A	DET	BT-MP	WC1494	-
322111-BT-01	NOSE LANDING GEAR Detailed Inspection od the NLG Electrical Harenesses	1A	DET	BT-MP	WC0832	Open NLG Doors

322200-201	NOSE LANDING GEAR Detailed Inspection od the NLG Door Mechanisms (New task number, original Task 320100-204)	5A	DET	MR B	MTCM 000-32-710-100 AMM 32-22-00-280801 WC 0367	Open NLG Doors
322200-202	NOSE LANDING GEAR Functional Check of the Nose Landing Gear Door Rigging	1C	FNC	MR B	MTCM 000-32-710-708 AMM 32-31-06-720801	-
323100-BT-01	NOSE LANDING GEAR Functional Check of NLG Door Actuator Assy P/N: 47830-1 (Off wing) *NOTE: To be sent to Repair Organization*	6000FH	FNC	BT-MP	AMM 32-31-56-000-801 AMM 32-31-56-400801 WC 2111	Open NLG Doors
326100-102	PROXIMITY SENSOR SYSTEM Operational Check of the Weight On Wheels (WOW) System	2340FH	OPC	ALI	MTCM 000-32-900-700 AMM 32-61-00-710802 WC 0116	-
326100-201	WHEELS AND BRAKES Operational Check of the Proximity Sensor Electronic Unit (PSEU) BITE Panel	1C	OPC	MR B	MTCM 000-32-900-100 AMM 32-61-00-710801 WC 0415	-

326100-301	PROXIMITY SENSOR SYSTEM Inductance Value Check of the Proximity Sensors to identify sudden rate of increase in values (Landing Gear and Fuselage Doors)	1 Month	FNC	MPD (Option. Maint.	AMM 32-61-00-280801 WC 0227	-

Table 1: The Maintenance Programme for aircraft type DHC-8-402

The Airframe TSN are 15.685,64 hrs and Airframe CSN was 11730 landings, respectively the TSN and CSN of the NLG are the same 15686 hours and 11730 landings.

According to MP for aircraft type DHC-8-402 "**ABC MP Q400, issue 2**" the major inspection C-check interval was 6,000 flight hours. The last 1C, 2C-check before incident was completed and the aircraft was released to service on **8 May, 2015** at aircraft flight hours **11,951.37**. Total Cycles/Total Landings **8788**. After last Base Maintenance Aircraft had **3735.27** hours and **2942** landings.

The last maintenance check (line check) was performed on September 9, 2016. The aircraft maintenance records were verified to be in compliance with the established maintenance program.

LLP Status Report

Part Number	Description	Serial Number	Install Date	TSN	CSN	Position
47200-27	NLG ASSEMBLY	MA0332	12Jan2010	15685:46	11730	NLG
Aircraft Reg	**Model**	**MSN**	**Manufactured**	**AC TSN**	**AC CSN**	**Last Flight**
YL-BAI	Q400-	4302	18Mar2010	15685:46	11730	17Sep2016

Component	Part	Serial	Limit	Life Limit		Life at Install		Life Since New		Life Remaining		Due Date
				Hours	Cycles	Hours	Cycles	Hours	Cycles	Hours	Cycles	
NLG UPR DRAG STRUT	47301-3	BFP0385	Discard		60000	0:00	0	15685:46	11730		48270	
NLG LWR DRAG STRUT	47313-1	VAC0038	Discard		60000	0:00	0	15685:46	11730		48270	
DRAG STRUT LINK	47305-1	CPS0237	Discard		60000	0:00	0	15685:46	11730		48270	
LOCK LINK UPPER	47320-3	VAC0018	Discard		60000	0:00	0	15685:46	11730		48270	
LOCK LINK LOWER	47324-1	MBM0056	Discard		60000	0:00	0	15685:46	11730		48270	
NLG PIVOT TUBE	47340-1	MBM0266	Discard		60000	0:00	0	15685:46	11730		48270	
ATTACHMENT PIN	47306-3	ACR0661	Discard		60000	0:00	0	15685:46	11730		48270	
ATTACHMENT PIN	47306-3	ACR0592	Discard		60000	0:00	0	15685:46	11730		48270	
PIN ATTACHMENT	47307-1	VAC0051	Discard		60000	0:00	0	15685:46	11730		48270	
PIN - DRAG STRUT ATT	47308-1	VAC0031	Discard		60000	0:00	0	15685:46	11730		48270	
PIN - LWR LOCK LINK	47309-3	VAC0133	Discard		60000	0:00	0	15685:46	11730		48270	

Component	Part	Serial	Limit	Life Limit		Life at Install		Life Since New		Life Remaining		Due Date
				Hours	Cycles	Hours	Cycles	Hours	Cycles	Hours	Cycles	
PIN - LWR LOCK LINK	47309-3	VAC0129	Discard		60000	0:00	0	15685:46	11730		48270	
PIN - UPR LOCK LINK	47310-1	VAC0027	Discard		60000	0:00	0	15685:46	11730		48270	

ATA	Position	Zone	Part Number	Description	Serial	Last Movement	Batch Number	Unit	Since New	Since Fit	Since Overhaul
32314601	001	7.11	47500-7	NLG RETRACTION ACTUATOR	MAL-0383	18Mar2010		Days Hours Landings	2379 15685:46 11730	2379 15685:46 11730	2379 15685:46 11730
32315101	001	1.14	47400-3	ACTUATOR ASSY LOCK NLG	MAL-0350	18Mar2010		Days Hours Landings	2379 15685:46 11730	2379 15685:46 11730	2379 15685:46 11730
32316601	SEQ VLV	1.14	48303-7	VALVE, MECHANICAL SEQUENCE, NLG	FAH1007	18Mar2010		Days Hours Landings	2379 15685:46 11730	2379 15685:46 11730	2379 15685:46 11730

Table 2: LLP Status Report

13.09.2016; YL-BAI

An error message "IOP2 FAIL" appeared on the display during flight (BT442 Flight). Upon receiving the report, the pilots decided to return to Riga. After returning, the aircraft was defective in accordance with the FIM. The Troubleshooting Guide determines that the CDS data is to be read in the "IOP2 FAIL" error. If the CDS does not indicate the existence of defects, then it must be assumed that the "IOP2 FAIL" message was incorrect and the airplane could be operated without any component replacement. In the particular case, the CDS did not indicate the existence of defects, however, after

security, the Input / Output Processor (IOP) No. 2. The removed IOP will be sent to its supplier for further investigation in the laboratory.
IOP - Input / Output Processor - Freelance Input / Output [Data] Processor - On-board computer that receives, processes and sends data for multiple aircraft systems for further use. Airplane Intermediate System Data Interchange Center. Each aircraft is equipped with two Input / Output Processors, providing duplication (or booking - the system's viability with one component failure).

Records indicate the aircraft was serviced and maintained in accordance with existing directives. At the time of the serious incident, the engine and airframe had accumulated approximately 962 hours 40 min total time since new, and there were no outstanding maintenance issues with either.

1.6.13.5. NLG cleaning drag strut lubrication

Air Baltic for NLG drag strut lubrication uses only Aeroshell Grease 7 and didn't use or intermixed with another brand name during operation. (Certificate of Conformity and package picture in the Appendix G)
For Landing Gear cleaning Air Baltic didn't use pressure equipment and normally is cleaned external surfaces like wheel bays, struts without cleaning moving joints and / or small parts. Landing Gear cleaning tasks was combined / scheduled with Landing Gear lubrication task to comply with requirement of lubrication of LG within 4 hours after Landing Gear cleaning. For cleaning task is used ARDROX6085 (Working cards in the Appendix H)
Runways de-icing fluids used at Air Baltics Q400 aircraft in the Riga International airport:

Kemira Clearway SF3; Kemira Clearway F.

Runways de-icing fluids used at Air Baltics Q400 aircraft in the destination airports (Appendix I)

1.6.13.6. PLUG, MAGNETIC — CHIP DETECTOR − INSPECTION/CHECK

The maintenance procedure for the visual inspection of the chip detector magnetic Plug was performed according to AIRCRAFT MAINTENANCE MANUAL (TASK 79−34−01−200−801). L-Check tasks Operational Check for the Reduction Gear Box, Air Intake Section, Compressor, Turbine Section, Accessory Drive Chip Detector Indications, MTCM card according to which the test was performed, AMM reference according to which the inspection is performed if there were fault codes. (Appendix J)

1.7. Meteorological information

INFO: ATIS DATA - 17-September-2016 from 4:20 (UTC) till 7:50 (UTC)

Date & Time	ATIS VOICE data	ATIS DATALINK data
2016-09-17 04:20:18	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION INDIA.	EVRA ARR ATIS I 0420Z

	AT ZERO FOUR TWO ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO SIX ZERO DEGREES THREE KNOTS. VISIBILITY TEN KILOMETERS OR MORE. CLOUD BROKEN FOUR THOUSAND EIGHT HUNDRED FEET. TEMPERATURE NINER. DEW POINT EIGHT. QNH ONE ZERO TWO ZERO. TREND NOSIG. ACKNOWLEDGE INFORMATION INDIA.	EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 060/3KT VIS 9999 CLD BKN 4800FT. T 9 DP 8 QNH 1020 TREND NOSIG
2016-09-17 04:50:21	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION JULIETT. AT ZERO FOUR FIVE ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO SEVEN ZERO DEGREES THREE KNOTS. CAVOK. TEMPERATURE ONE ZERO. DEW POINT NINER. QNH ONE ZERO TWO ZERO. TREND NOSIG. ACKNOWLEDGE INFORMATION JULIETT.	EVRA ARR ATIS J 0450Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 070/3KT CAVOK T 10 DP 9 QNH 1020 TREND NOSIG
2016-09-17 05:20:21	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION KILO. AT ZERO FIVE TWO ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND VARIABLE THREE KNOTS.	EVRA ARR ATIS K 0520Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND VRB 3KT CAVOK T 11 DP 9

	CAVOK. TEMPERATURE ONE ONE. DEW POINT NINER. QNH ONE ZERO TWO ZERO. TREND NOSIG. ACKNOWLEDGE INFORMATION KILO.	QNH 1020 TREND NOSIG
2016-09-17 05:50:17	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION LIMA. AT ZERO FIVE FIVE ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO EIGHT ZERO DEGREES FOUR KNOTS. CAVOK. TEMPERATURE ONE ONE. DEW POINT NINER. QNH ONE ZERO TWO ZERO. TREND NOSIG. ACKNOWLEDGE INFORMATION LIMA.	EVRA ARR ATIS L 0550Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 080/4KT CAVOK T 11 DP 9 QNH 1020 TREND NOSIGEVRA ARR ATIS M 0620Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 070/5KT CAVOK T 12 DP 9 QNH 1020 TREND NOSIG
2016-09-17 06:20:19	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION MIKE. AT ZERO SIX TWO ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO SEVEN ZERO DEGREES FIVE KNOTS. CAVOK. TEMPERATURE ONE TWO. DEW POINT NINER. QNH ONE ZERO TWO ZERO.	EVRA ARR ATIS M 0620Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 070/5KT CAVOK T 12 DP 9 QNH 1020 TREND NOSIG

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2016-09-17 06:50:19	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION NOVEMBER. AT ZERO SIX FIVE ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO SEVEN ZERO DEGREES SIX KNOTS VARIABLE BETWEEN ZERO FOUR ZERO DEGREES AND ONE ZERO ZERO DEGREES. CAVOK. TEMPERATURE ONE TWO. DEW POINT NINER. QNH ONE ZERO TWO ONE. TREND NOSIG. ACKNOWLEDGE INFORMATION NOVEMBER.	EVRA ARR ATIS N 0650Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 070/6KT 040/ V 100/ CAVOK T 12 DP 9 QNH 1021 TREND NOSIG

2016-09-17 07:20:19	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION OSCAR. AT ZERO SEVEN TWO ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO EIGHT ZERO DEGREES THREE KNOTS VARIABLE BETWEEN ZERO FIVE ZERO DEGREES AND ONE ONE ZERO DEGREES. CAVOK. TEMPERATURE ONE TWO. DEW POINT NINER. QNH ONE ZERO TWO ONE. TREND NOSIG. ACKNOWLEDGE INFORMATION OSCAR.	EVRA ARR ATIS O 0720Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 080/3KT 050/ V 110/ CAVOK T 12 DP 9 QNH 1021 TREND NOSIG
2016-09-17 07:50:19	THIS IS RIGA INTERNATIONAL AIRPORT INFORMATION PAPA. AT ZERO SEVEN FIVE ZERO ZULU. EXPECT I.L.S APPROACH. RUNWAY IN USE THREE SIX. RUNWAY SURFACE IS DRY. BRAKING ACTION IS GOOD. TRANSITION LEVEL SIX ZERO. TAXIWAY BRAVO OUT OF OPERATIONS. WIND ZERO NINER ZERO DEGREES FOUR KNOTS. CAVOK. TEMPERATURE ONE THREE. DEW POINT NINER. QNH ONE ZERO TWO ONE. TREND NOSIG. ACKNOWLEDGE INFORMATION PAPA.	EVRA ARR ATIS P 0750Z EXP ILS APCH RWY IN USE 36 RWY SFC DRY BA GOOD TRL 60 TWY B OUT OF OPS WIND 090/4KT CAVOK T 13 DP 9 QNH 1021 TREND NOSIG

Table 3: Meteo information

1.8. Aids to Navigation

At the time of the incident, Riga International Airport had the following radio navigation and landing aids for runway 36: ILS CAT II, GP, DME and VOR. All navigation aids were functioning at time of the accident without any remarks.

1.9. Communications

Radio communications between the crew and Riga Tower on frequency 118.1MHz, APP controller on frequency 129.925MHz, Ground Controller on frequency 118.8MHz were recorded and made available to the TAIIB for evaluation.

1.10. Aerodrome information

Riga International airport (EVRA) has been approved for VFR and IFR operations. The airport has one runway 18/36. The dimensions of runway 18/36 is 3200 x 45 meters, CONC+ASPH composite construction. The runway used for landing during the incident was 36 (True BRG 005.17°).

1.10.1. Fire Service

EVRA has an approved ICAO category 8, foam meeting performance level C - Rescue and Fire Fighting Service. According to this requirement the aerodrome must have firefighting services with a capacity to discharge 12,800 litres of water and 5,100 litres of foam per minute respectively to aircraft of up to an overall length of eters and a fuselage width up to 7 meters. (For more information refer to ICAO Annex 14).

1.10.2. Emergency plan

1.10.2.1. General information

Riga International Airport had a detailed emergency plan (Emergency Action Plan KV 1135 P, confirmed by State share company "International Airport Riga" board on June 8, 2015, protocol No.30) in place to be applied in the event of an accident or incident.

The purpose of the plan is to ensure an efficient and effective transfer of airport services from normal operations to emergency operations. Maintain the airport service readiness and capacity for all types of emergency in the Airport Controlled Area, as well as outside, if the Airport Fire Team is able to provide promptly arrival at the place of occurrence in accordance with the defined response area (in the Attachment 1) to perform:

(a) the salvation of persons in emergency situations;

(b) the protection of property;

(c) facilitation the return to normal operation of the airport as soon as possible.

Airport procedures for emergency plan provide effective coordination between the participating Airport departments, tenants and State institutions in the event of an emergency.

The plan identifies each involved in the crisis liquidation service (institution) role, function, responsibility and necessary action in the emergency situation, orderly and efficient transfer from the Airport normal operating mode to emergency procedures and crises liquidation measures management, the provision of airport functionality unforeseen situations.

The plan provides the basic principles of liquidation of the emergency situation - management, communication and coordination. According to the annual Emergency training plan approved by the Chairman of the Board, for all crisis liquidation teams are continuously organized both theoretical and practical training at the Airport Training Center.

The airport provides public services and municipality institutions involved in the liquidation of the Emergency situation with information about the rescue measures mentioned in the plan as well as on the plan changes made.

Emergency categories and levels

Emergency situation - a situation that causes harm or threat to human health, life, prosperity, property, an environment that needs to be urgently stopped or prevented or managed it is necessary to involve the operational services.

Emergency situations, by their nature and potential damage, are divided into the following categories and levels:

Category A Emergencies

Technical disruption to aircraft operations / aircraft crashes.

Levels:

A-1 READINESS (GATAVĪBA)

Introduced if it becomes known whether there is a reason to believe that the ACFT approaching to the aerodrome has such damages as usual however, does not prevent safe landing. Readiness is a special signal, which is communicated if it becomes known or there is reason to believe that the aircraft, which is approaching to the aerodrome, are damaged, which in normal circumstances, however, does not interfere with safe landing operation. **A-1 ALARM (TRAUKSME)**

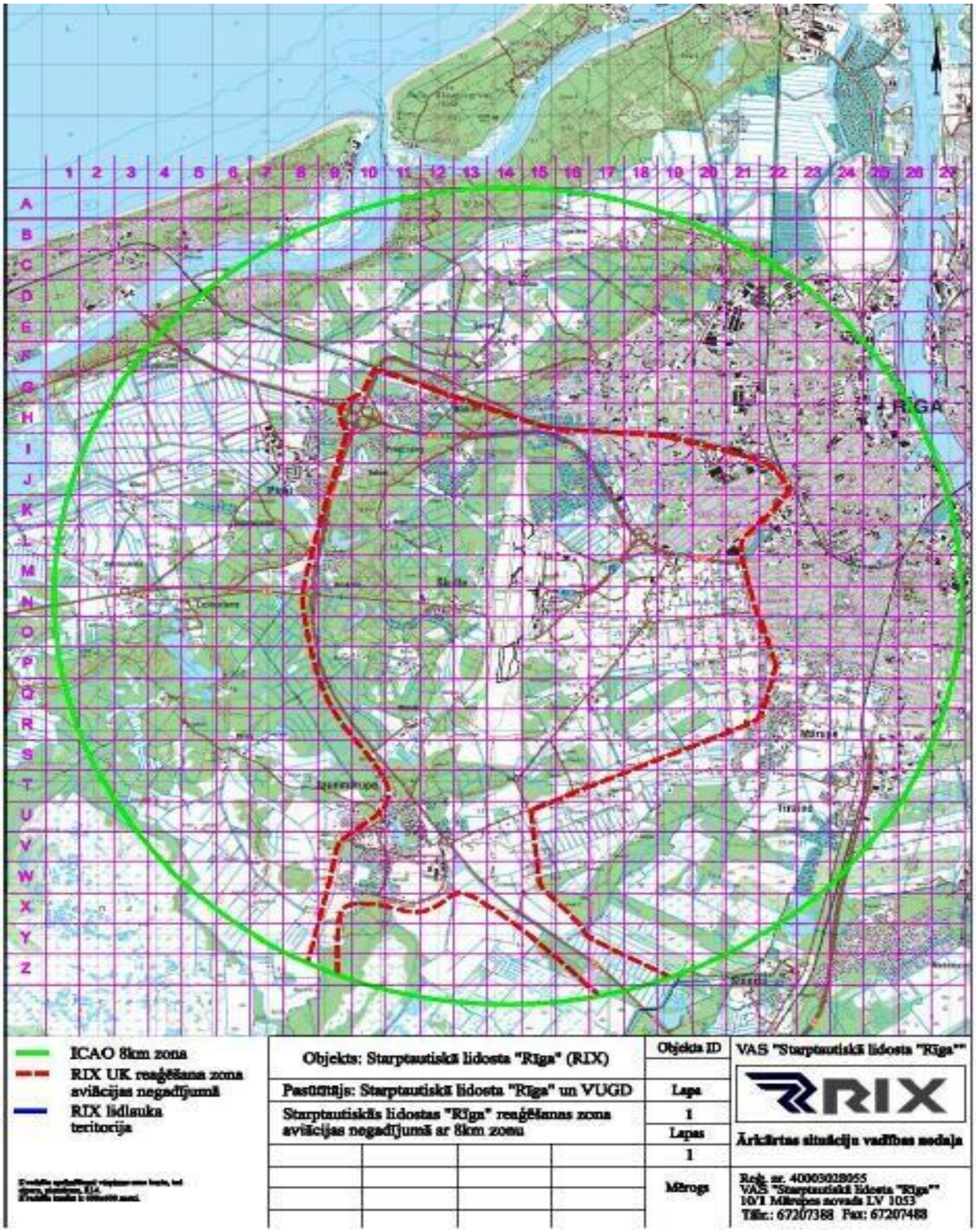
Introduced if it becomes known whether there is reason to have the ACFT approaching to the aerodrome, it has the damage that may be caused aviation accident.

A-2 AVIATION ACCIDENT IN THE AIRPORT (AVIĀCIJAS NEGADĪJUMS LIDOSTĀ)

Introduced when it becomes known that the aircraft in an airport controlled area (Attachment No 1) has damaged or occurred the destruction of its constructions, as well as the passengers' have injuries with fatal outcomes or serious injuries caused being in the aircraft or contact with any part of the aircraft.

A-3 AVIATION ACCIDENT IN THE AIRPORT RESPONSE AREA (AVIĀCIJAS NEGADĪJUMS LIDOSTAS REAĢĒŠANAS ZONĀ)

Introduced if it becomes known that the aircraft has damaged in the airport response zone outside the airport's control area (Attachment No. 1) or occurred the destruction of its constructions, as well as the passengers' have injuries with fatal outcomes or serious injuries caused being in the aircraft or contact with any part of the aircraft.



Picture 20 Response area

At the time of the accident the emergency plan was a collection of measures, regulations and procedures elaborated to minimize the effects of an emergency situation in the airport or other areas defined in this plan. The main objectives of this plan were:

- To save human lives
- The protection of property
- To sustain airport operations for aircraft and airport installations

According to the plan, the staff of the various departments of the airport, as well as the State, are involved in emergency situations institutions and operational services in achieving these objectives when an accident occurs:

- The Area Control Centre, Riga (ACC);
- The Rescue and Fire Fighting Services (airport Riga);
- National Fire Fighting and Rescue Service (VUGD);
- Aerodrome Management Department (LVD);
- Emergency Medical Service (NMPD);
- The Police;
- Airport Customs Control Station;
- Airport Border Control Station;
- Airline (Operator);
- Transport Accident and Incident Investigation Bureau (TAIIB)

Essential justification is needed for the introduction and notification at the airport of an Emergency. There must be at least one of the conditions mentioned in paragraph **1.10. 2.1.** of this Report.

An order for the introduction of Emergency procedures at the Airport there are entitled such Air Navigation Service provider's (LGS) and Airport officials:

- LGS Controllers (Ground Controller / Tower Controller / Tower Flight Manager);
- Fire Fighter Team shift manager;
- Airport Fire Fighter Service chief;
- Airport Security Department Aviation Security Operations Manager - R 12;
- Airport Chairman of Board (or the person who replaces);
- Director of the Airport Security Department (or the person who replaces);

In each section of the Emergency there are designated officials who are the initiators of the right to introduce a specific Emergency category.

To establish a unitary Emergency notification system, all Emergency situations in the airport are notified and canceled by Aerodrome ManagementDepartment (LVD) dispatcher, cancellation only after the order of Crisis Coordination Team (KKK) manager.

Under the emergency plan, the Tower informs simultaneously for:

- The Rescue and Fire Fighting Services (Fire Fighter team - UK); - The Airport Office (Aerodrome Management Department - LVD).

Responsibility of rescue procedures, if a civil aircraft accident occurred in the Response Area of a Civil Aviation Airport (Airdrome), according to Cabinet Regulation No. 331, May 31, 2016 "Regulations on measures relating to civil aviation accidents" Article 9.4.2, human search and rescue work in accordance with its competence under the **Civil Aviation (Airport) Emergency Plan** shall be performed by the Civil Aviation (Airport) Rescue Service **by the time the National Fire and Rescue Service arrives** but the support is provided by the State Police, the Emergency Medical Service and the State Border Guard;

1.10.2.2. Emergency Teams and services participated for resolution Emergency situation according to Emergency Action Plan KV 1135 P, version 08:

• **The Mobile Crisis Coordination Team (KKK)**

Created in the accident site in cases where are required several airports structural units and the organizations working in the airport activities coordination and gathering information at the accident site. Consisting of Team Leaders for the Crisis liquidation.

Crisis Coordination Team (KKK) operation and operational management of all resources at the accident site provides KKK manager.

Composition of the Mobile Crisis Coordination Team (KKK) according to Emergency Action Plan KV 1135 P:

- **Crisis Coordination Team manager** (The Fire Fighting team "UK" manager (Fire Fighting team shift chief, Radiuss-40);
- **Crisis Coordination Team deputy manager** (Security Department Aviation Security Operations Manager, Radio code - Radiuss 12);
- **The Blocking team - BK** – Blocking team manager (Internal Security Unit security inspector);
- **The Medical Assistance Team -ĀPK** - Medical Assistance Team manager (Medical station officer on duty);
- **The Victim Relocation Team - CPK** – Victim Relocation Team manager (Ground handling shift chief);
- **The Passenger assistance team (PPK)** – **Passenger assistance team manager** (Ground handling department passenger service division shift senior officer);
- **The Technical Team (TK)** - technical team manager (Aerodrome Control Department (LVD) aerodrome shift chief); - **Airport Police Station -LPK;** - **Other participants**:
- **Airport Ground Handling Department (VAD)** - **The Responsible Airport Coordinator for Removal of Disabled ACFT** – Airport Airfield Control Department technical manager;
- **NMPD** (National Emergency Medical Service);
- **VUGD** (National Fire Fighter & Rescue Service);
- **State police (VP);**

1.10.2.3. Actions of Aerodrome Emergency Teams

At **8:37** the Tower Controller provides information to the Fire Fighter team (UK) and at **8:39** to the Aerodrome Management Department (LVD) dispatcher. **At 08:40 Emergency A-1 READINESS** was announced by Aerodrome Management Department dispatcher: "*airBaltic ACFT DH4, a problem with the front chassis, returns, heading 360. Approximate landing time is **9:10**. The number of people on board is 67 (63 passengers, 4 crew).*"

Emergency active participants were notified. Informed VUGD, NMPD and the airline (operator) as well as Emergency passive members.

Designated gathering place – stand 110th, where the manager of the Crisis Coordination Team (KKK) arrived and managers of R12 (Security Department Aviation Security Operations), BK (Blocking team), CPK (Victim Relocation Team) and (Technical Team) TK. The rest for communication on radio. Planned ACFT parking - stand 218. Fire fighting team Fire1, Fire2, Fire5, Fire6 at readiness position - depot doors open, staff in the cars.

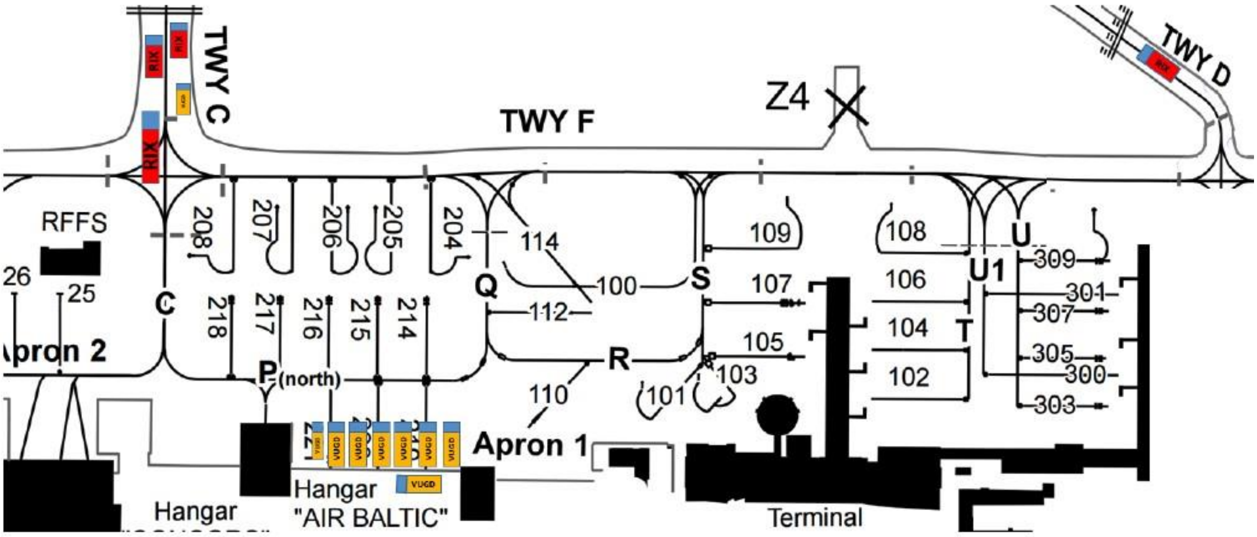
At 9:00 Aerodrome Control Department (LVD) dispatcher announced: Emergency level is changed to **A-1 Alarm -** landing time **10:20**. Fuel - 2000 t. No dangerous goods.

Emergency active participants were notified. Called VUGD, NMPD. Informed the airline (operator). Emergency passive members were informed. Meeting place -stand 110th.

At meeting place arrived -Medical Assistance Team (ĀPK)-3, BK ((Blocking team)-22 (8 - Internal Security Unit (IDN) +14 Aviation Security Division (ADN), Victim Relocation Team (CPK) - 30, Passenger assistance team (PPK) - 18, State police (VP)- 1 airport crew at the intersection at Lukoil. Parking for urban services – stand 219.

The Internal Security Unit (IDN) patrol provides escorting, driving route no.1.

In order to better visually observe the position of the aircraft landing gear so that after the landing the aircraft could be reached as soon as possible Firefighting team (UK) manager decided to deploy the technique closer to the runway, **Fire1, Fire 5, Fire 6** on the **TWY C,** that would be at the landing site of the ACFT and **Fire 2** on the **TWY D** which might be behind the aircraft's stopping place. **At 9:12** Firefighting team (UK) manager agreed his decision with KKK manager and Tower Controller.

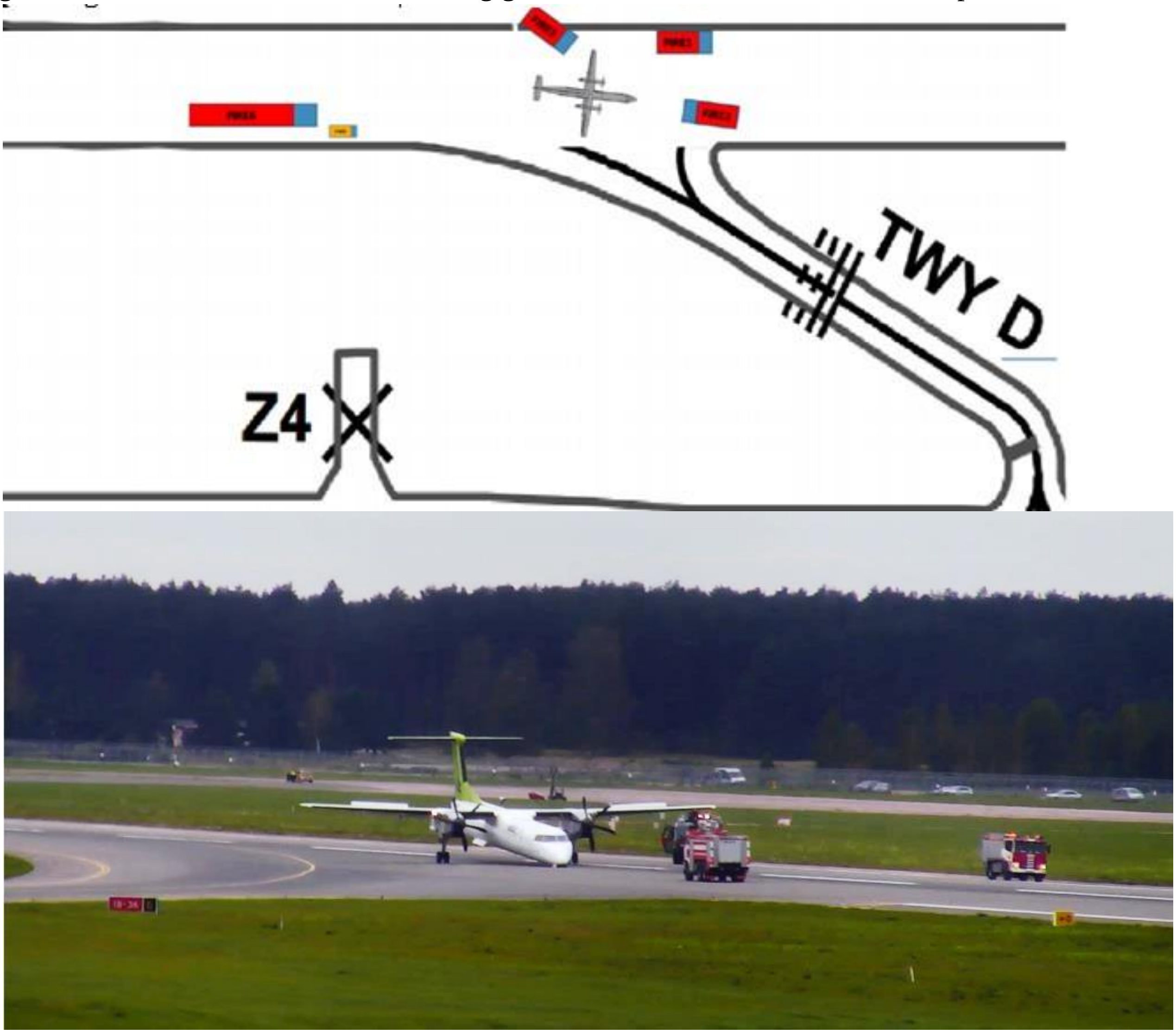


Picture 21 Arrangement of the firefighting team and the VUGD additional forces at the aerodrome, pending the arrival of the ACFT.

At **9:15** AM arrived NMPD (Emergency Medical Service) - 5 brigades, VUGD (National Fire Fighter & Rescue Service) - 8 vehicles. At **9:17** AM, the VUGD was provided with the Fire team radio 328, at 9:23, another one simplex radio “COOPERATION”.
At 9:39 Firefighting team (UK) manager informed contacted Tower Controller and after informed KKK that aircraft will perform “low pass”
At 10:15 Aerodrome Management Department (LVD) dispatcher announced: “Will perform landing after 5 min. Fuel 1200.”
At 10: 28 the Aerodrome Management Department (LVD) dispatcher announced **Emergency A-2 Aviation accident** (*according to recordings in the dispatcher checklist*), the initiator - the LGS Tower. Were notified Emergency active participants. Informed VUGD, NMPD and the airline (operator) as well as Emergency passive members.
At **10:26** ACFT landed with not fixed nose landing gear on RWY 36, close to TWY D. No fire. Fire-1, 5, 6. followed to ACFT by RWY and Fire-2 to TWY D.

At **10:27** 2 (two) firefighting hose nozles were supplied on chassis for ACFT protection’

When arriving at ACFT, Fire-1 => 10, Fire-2 => 12, Fire-5 => 8 and Fire-6 => 5 were placed. While ACFT engines worked, the fire fighter shift chief (R40- Crisis Coordination Team Manager) performed the observation and found that the rear exit door was not open and were more than 2m in height due to the fracture of the nose landing gear and the ACFT nose was on the asphalt.



Picture 22 Airport Fire fighter team's (UK) car disposition at ACFT

After the engine stops, they started to evacuate passengers from the ACFT. Analyzing video recordings it was determined how the responsible person from the airport (Orange Vest) for rescue work and the person responsible for the rescue work from the VUGD party took place (dark blue outfit). At the moment when they crossed the rear door, the rear door was closed, they started to evacuate passengers and focused only to the front door, did not even look at what was happening at the rear door where passengers started to leave aircraft without assistance. *(See snapshots from video).*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Passengers started to leave the ACFT by the rear door unattended

Picture 23

Picture 24

The fire fighter team (UK) chief was at the front door, which the cabin crew opened from the inside. The UK chief asked the cabin crew is in the cabin everything in order - it was confirmed that everything is OK and the evacuation from the front door started. Unfortunately they continued to focus only on the front door and **did not see what was going on behind at the rear door**, because they themselves made the reception of passengers at the front door.

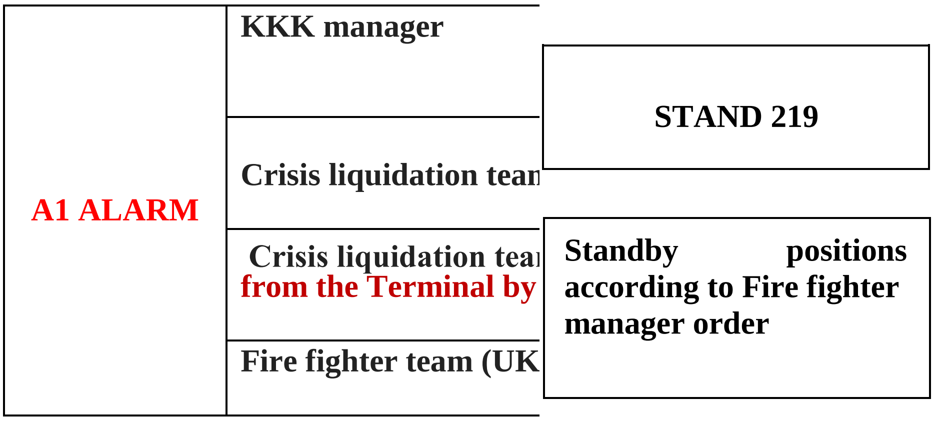
Probably if there needed more rescuers at the scene of the event (those who were at the airport but stayed in the starting positions), then the rescue work manager should not be able to get passengers on the front door himself and he could concentrate on the general scene of the event, and then there would be a rescuer's resource, who could help to help evacuate the passengers at the back door. According to the information provided to the investigation (evidence interview of airport fire fighter team chief in writing form), the VUGD units arrived at **9:23** approximately 1 hour before the actual landing of the ACFT.

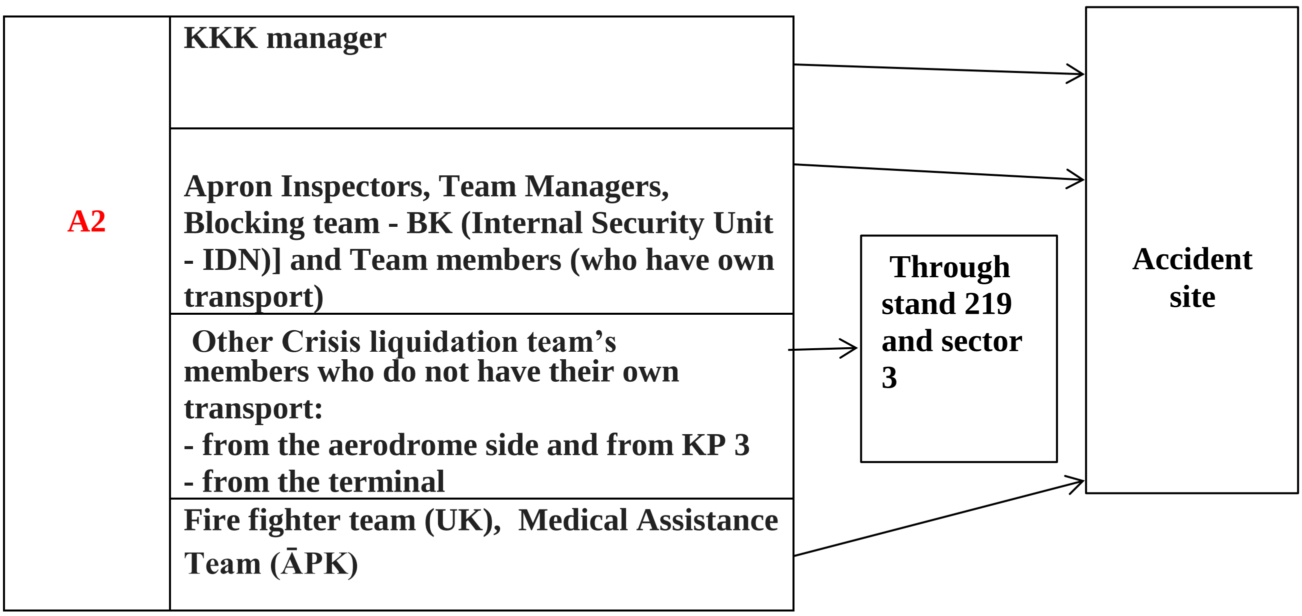
Analysing witness testimony in writing form of airport fire fighter team chief in writing form, his completed checklists, as well as information provided of the fire fighter team staff (UK) during interview, the person in charge of the emergency was the fire fighter team (UK) chief who took over the emergency situation, but then this function was taken over by the VUGD headquarters operational officer.

How exactly this procedure of responsibility was taken over, the UK staff informed that it happens automatically when certain VUGD officials arrived, because according to the provisions of the 31.

May, 2016 Cabinet Regulation 331 "Regulations on measures relating to civil aviation accidents" the responsibility of the airport services is limited to the time of arrival of the VUGD.
During the interview, UK staff informed that the location of the technical units at the ACFT were determined by the VUGD officer who was physically located in the Airport Firefighter and rescue car Fire5 together with the Fire Fighter Team manager..
The UK staff during the interview confirms that information on risk areas was handed over to the Crisis Coordination Team Channel - 20m firefighters, 50m doctors and 100m other active participants.
About the passenger's evacuation process **was responsible State Fire Fighter and Rescue Service (VUGD) staff,** but the VUGD did not participate with all the manpower at the place, therefore there was not provided the help to the passengers who evacuated through the rear door. During the evacuation responsible officer for the rescue work did not monitor **the overall situation**.

Meeting place Scheme for the Emergency active participants





1.10.2.4. Crisis Coordination Team manger's training drill

Crisis Coordination Team manager (Airport Firefighting Team shift chief):

- Firefighting team emergency response (PD 0507 P) - training completed on 08.12.2015, training valid until 08.12.2016;

- Evacuation providing from ACFT (PD 0638 P) - training completed on June 5, 2016, training valid until June 5, 2017;

- Aircraft familiarization (PD 0603 P) - Training performed on June 5, 2016, training valid until June 5, 2017;

- Crisis management personnel Emergency response (PD 0508 P) - training completed on 02/22/2016, training valid until 02/24/2017.

Firefighting team manager (Airport Firefighting Team shift Deputy Chief (Senior Firefighter)):

- Firefighting team emergency response (PD 0507 P) - training completed on April 1, 2015, training valid until April 1, 2016. - the training has expired;

- Evacuation providing from ACFT (PD 0638 P) - training completed on May 28, 2016; training valid until May 28, 2017;

- Familiarization with aircraft (PD 0603 P) - Training performed on 05.20.2016, training valid until May 20, 2017;

- Crisis management personnel Emergency response (PD 0508 P) - **there is no evidence**.

Crisis Coordination Team deputy manager (Security Department Aviation Security Operations Manager):

- Crisis management personnel Emergency response PD 0508 P - training completed on 02/24/2016, training valid until 02/24/2017;

- Actions of the Blocking Team Participants in Emergency Situations (PD 0582 P) - there is no evidence of training. This training is compulsory, as required for training required by PDA 1462 F, approved on January 13, 2015. The last of these types of training took place on August 24, 2011;

The Technical Team - technical team manager (Aerodrome Control Department (LVD) aerodrome shift chief);

- Crisis management personnel Emergency response (PD 0508 P) - training completed on 02/17/2016, training valid until February 17, 2017.

The Passenger assistance team manager (Ground handling department passenger service division shift senior officer);

- Crisis management personnel Emergency response (PD 0508 P) - training completed on 02/25/2016, training valid until February 25, 2017;

- The Passenger Assistance Team participants Emergency response (PD 0564 P) - training completed on 10.11.2015, training valid until 10.11.2016.

The Victim Relocation Team manager (The shift chief of Airport Ground Handling Department):

- The Victim Relocation Team participants Emergency response (PD 0559 P) - Training Executed 12.11.2015, training valid until 12.11.2016;

- Crisis management personnel Emergency response (PD 0508 P) - training completed on 02/25/2016, training valid until February 25, 2017.

Blocking team manager (Airport Internal Security Unit security inspector):

- The Blocking Team participants Emergency response (PD 0582 P) - training completed on 12.11.2015, training valid until 12.11.2016;

- Crisis management personnel Emergency response (PD 0508 P - there is no evidence of training.

- **The Medical Assistance Team manager (**Medical station officer on duty)**:**

Crisis management personnel Emergency response (PD 0508 P) - **there is no evidence of training**

The Responsible Airport Coordinator for Removal of Disabled ACFT – Aerodrome Control Department aerodrome technical manager;

- Aircraft Recovery course / IATA - training on September 19, 2014.

1.10.3. Removal of Disabled Aircraft process

1.10.3.1. Procedures of Removal Disabled Aircraft from runway at Riga International Airport

According to ICAO Annex 14 — *Aerodromes,* Volume I — *Aerodrome Design and Operations,* 9.3.1, each aerodrome must draw up a comprehensive plan for the removal of a disabled aircraft on, or adjacent to, the movement area and a coordinator designated to implement the plan, when necessary. The relevant aerodrome disabled aircraft removal plan should include the following:

- a list of equipment and personnel available on or in the vicinity of the aerodrome;

- a list of additional equipment available from other aerodromes on request;

- a list of nominated agents acting on behalf of each operator at the aerodrome;

- a statement of the airlines arrangements for the use of pooled specialist equipment; and

- a list of local contractors (with names and telephone numbers) able to supply heavy removal equipment on hire.

The Riga International Airport **Removal Disabled Aircraft plan** (hereinafter referred to as the Plan) is drawn up as Appendix 19 to Emergency Action Plan KV 1135 P according to the International Civil Aviation Organization (hereinafter - ICAO) Airport Service Guides (Doc.9137AN / 898), Part 5, "Removal of Disabled aircraft" requirements.

1.10.3.2. Liability

According to Plan ACFT registered owner or operator involved in the company's assets, equipment and staff is responsible for lifting and evacuating disabled ACFT, as well as using all possible means to evacuate the wrecked ACFT as soon as possible from the aerodrome movement area or the immediate vicinity of the area.

For ACFT, its parts, freight, mail and all records kept to the extent that it is really possible is responsible the ACFT registered owner or operator.

Airport Administration, after coordination with the Transport Accident and Incident Investigation Bureau (hereinafter - TNGIIB) is entitled to make ACFT evacuation measures in case if the ACFT registered owner or operator:

- Unable to evacuate ACFT; - Doing it too slowly.

Airport departments involved in the evacuation of an aircraft mentioned actions in section 2.3 of this plan may be initiated only upon receipt of written consent from the ACFT registered owner or operator. Reporting to the Airport Legal Department, according to the insurance case reporting procedure (JN 0365 P) is the responsibility of the Director of the LVD.

1.10.3.3. Procedures for airport personnel

Responsible for removal disabled ACFT according to Plan is **Aerodrome Control Department (LVD) Technical Manager**-Responsible Airport Coordinator (hereinafter-**Coordinator**).

If it is determined that the ACFT has disabled and is thus restricted or blocked Coordinator:

- Initially communicates with the ACFT registered owner or operator in order to find out planned activities, opportunities, deadlines;
- Coordinates communication and activities between TAIIB, Emergency Operational Management Group (KOVG)/ Airport Administration, ACFT registered owner or operator and actual ACFT evacuation worker;
- Provide the resources available to the Removal Disabled Aircraft at the Airport if necessary.

In case if the ACFT **registered owner or operator** unable to evacuate ACFT the Coordinator shall commence following operations to arrange evacuation without ACFT registered owner or operator involvement:

- receive a written authorization from the ACFT registered owner/operator for the commencement of removal;
- coordinate communication and activities between TAIIB, Aerodrome Control Department (LVD) Director / Emergency Operational Management Group (KOVG) and actual ACFT registered owner or operator workers;
- assess the availability and adequacy of the equipment at airport disposal;
- compile bids for existing offers;

- inform the Director of the Aerodrome Control Department (LVD) / Emergency Operational Management Group (KOVG) of the need for the ACFT removal costs.

Facilities and technical equipment at disposal of Riga International airport

- Tow bar for **DASH8-Q400 -1**;

- Companies nearby airport with which operational co-operation agreements have been concluded for special technical services:

SIA "ARSAVA" - cranes with a lifting capacity up to 220 t and special straps according to cooperation agreement D-11/234.

According to ICAO Doc 9137 AN 898 Airport Service Manual Part 5 Removal of Disabled Aircraft there are three general terms used in the removal of disabled aircraft: aircraft debogging, aircraft recovery and aircraft salvage. These terms are defined as follows:

1.Aircraft debogging. The removal of an aircraft from a runway or taxiway excursion where the aircraft has become bogged down but has relatively little or no damage is considered a “debogg”.

2.Aircraft recovery. Any aircraft that **is unable to move under its own power or through the normal use of an appropriate tow tractor and tow bar** will be considered an “aircraft recovery”, examples are:

- one or more landing gear off the hard surface of a runway, taxiway or apron;
- aircraft bogged down in mud or snow;
- **one or more landing gear collapsed or damaged**;
- an aircraft that is considered to be economically repairable; and

3.Aircraft salvage. An accident or incident in which the aircraft sustains substantial damage and the insurer considers the hull a constructive loss will be considered “aircraft salvage”.

1.10.4. Procedures of Removal Disabled Aircraft from runway of Aircraft Operator

The registered owner or aircraft operator retains complete responsibility for the removal. Notification of the accident or incident must also be transmitted to the operator’s insurance representative. The aircraft operator **must have an aircraft recovery process document available for review**. Information within the document must be filed with the aerodrome operator and include all relevant contact numbers as well as information on who the aircraft operator will use to remove the aircraft.

The aircraft Operator airBaltic on the date of incident had Emergency Response Manual (hereinafter referred to as the Manual) signed by VP Ground Operations and Customer Care and Emergency Response Coordinator at August 8, 2016. Manual is drawn up according to the International Civil Aviation Organization (hereinafter - ICAO) Airport Service Guides (Doc.9137AN / 898), Part 5, "Removal of Disabled aircraft" requirements.

Accordingly to information shown in the Manual airBaltic doesn’t have any special aircraft recovery equipment, with remark that equipment contain will be discussed within Technician Department and budgeted for purchasing in year2016-2017.

List of some equipment available for evacuation of Air Baltic are shown in the Appendix 19 to Emergency Action Plan KV 1135 P of Riga International airport:

Aircraft Q-400	Quantity
Towbar 01A1201-0010	4
Jack – Tripod NOSE, 10 T (CE), 02A7848C0120	1
Main axle jack 35T 35-0240	5
Support-Tail Q40003-5829-0000	1

1.10.5. Aircraft removal from runway process

Unserviceable landing gear generally refers to aircraft with damaged landing gear that either cannot be made serviceable or that have one or more landing gear missing.
First, every attempt must be made to make as many landing gear serviceable as possible. In most cases it will take more time to move an aircraft with unserviceable landing gear on to some form of trailer system, which will cause the aircraft to be more susceptible to secondary damage, than it would be to use one of the following alternatives:

- install a dummy landing gear (one which can support the weight of the aircraft but does not contain all the accessories such as brakes and hydraulic systems);
- make repairs or install temporary bracing to a damaged landing gear; or
- install a replacement landing gear assembly.

When **repairs or replacement of the landing gear is not possible** and all other methods have been investigated, there are a number of ways of moving and supporting the aircraft, using one or more of the following equipment types:

- flat bed trailers;
- general purpose multi-wheel trailers;
- specialized aircraft recovery transport systems;
- moveable cranes (only in certain cases)

After inspection there was clear that not possible to repair faulty NLG to move aircraft with unserviceable landing gear to hangar or stand by towing.
Neither at disposal of Airport Aerodrome Operator, neither Aircraft Operator airBaltic for moving and supporting the aircraft had not abovementioned equipment types.

When **only the nose gear is missing, a flatbed trailer can be installed under the forward fuselage**. It is preferable that this trailer has some form of turntable to allow for the turning of the tow vehicle and trailer. Adequate protection must be installed to prevent secondary damage to the aircraft.

Airport and airBaltic cooperation and information exchange in case of emergency announced for airBaltic aircraft, is regulated by the Agreement No. J-14/1 “Mutual cooperation in emergency situations” signed on January 16, 2014.

Picture 25

Offered facility (picture 25) by Riga International Airport for Removal commercial aircraft that **is unable to move under its own power or through the normal use of an appropriate tow tractor and tow bar** was only self-made equipment that was not suitable for the commercial aircraft with which will cause the aircraft to be more susceptible to secondary damage.

At **10:30** Aircraft landed on RWY 36 with not fully extended and locked NLG.
At **10:45** NOTAM has been issued that RWY is closed till 14:00.
At **11:15** Investigation Bureau TAIIB signed the permit to remove aircraft from incident site. At **12:15** the crane of company "ARSAVA" arrived for lifting aircraft and work for removal begin. At **12:25** the lifting of aircraft has been started.

Picture 26 Preparation of aircraft lifting

Picture 27

Technicians of aircraft Operator airBaltic worked at aircraft, made NLG condition inspection and due to lack of special equipment tried to find possible technical solutions for removing aircraft from

RWY.
At **13:20** did not yet clear solution what to remove aircraft and NOTAM has been issued that RWY is closed till **15:30**.
At **14:30** NOTAM has been prolonged that RWY is closed till **16:30**.

At **15:40** it was decided to support mechanism of NLG with wooden board which was fed with straps to NLG strut.(picture 27) and in a such way using “push-back” has been started removing aircraft to aerodrome stand 207 and later to airBaltic hangar.

Picture 28 Removing aircraft from RWY procedure

At **15:57** NOTAM has been canceled and airport was open.

Since 11:15 when Investigation Bureau permits to remove aircraft were gone **4 hours and 42 minutes.**

1.10.6. Used de-icers for aerodrome of Riga International airport

"Riga International Airport" uses Nordway liquid and granular (solid) de-icers for aerodrome.

- Nordway™ KF liquid de-icer melts ice and snow effectively and provides protection against re-freezing;
- Nordway™ NF solid de-icer is easily applied on snow and ice to give long-term protection;

The Nordway™ products are certified according to SAE AMS 1431 (Solid) and SEA AMS 1435 (Liquid). Products are with strong environmental profile, biodegradable, non-toxic, a very low COD, and a uniquely low carbon footprint.
The liquid de-icer is a 50% solution of potassium formate in water, the solid de-icer is with at least 90% sodium formate. Corrosive inhibitors, which are essentially the most important ingredient in the product, are also compulsory for both products.

The product technical data sheets and safety data sheets for the Nordway brand de-icers and corrosion testing results according to SAE AIR 6130 which were used in the "Riga International Airport" at the winter seasons last 5 years, are attached in the Appendix I.

1.11. Flight recorders

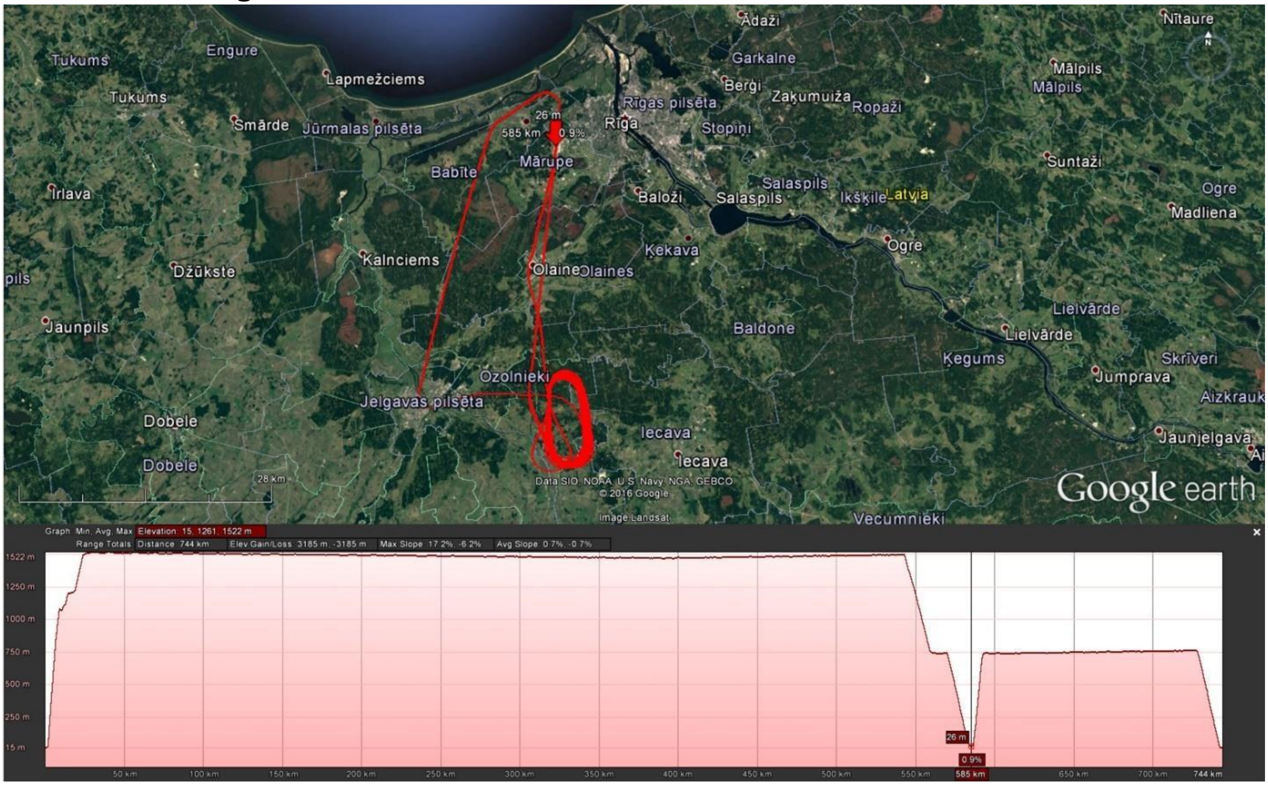
1.11.1 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a Honeywell CVR, type SSCVR part number 980-6022-011 serial number CVR120-13305. The CVR was removed from the aircraft on the day of the accident. The data from the CVR was of good quality and was used in the investigation.

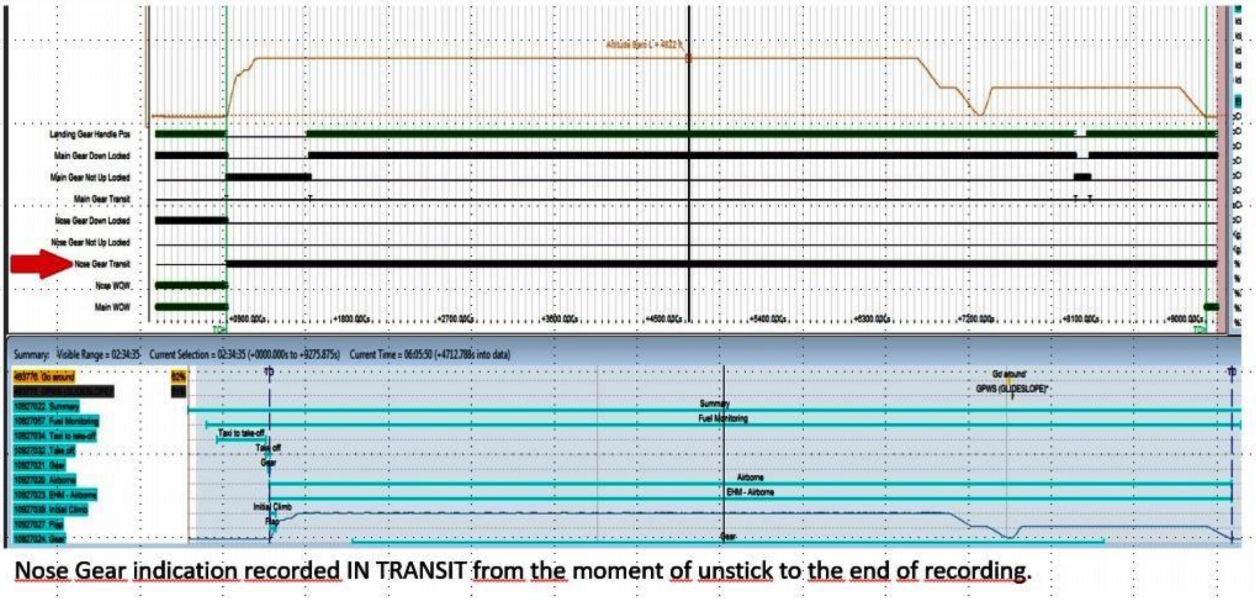
1.11.2 Flight Data Recorder (FDR)

The aircraft was equipped with a Honeywell FDR, type SSFDR part number 980-4700-027, serial number 18376. The FDR was removed from the aircraft on the day of the accident. The data from the FDR was of good quality and was used in the investigation.

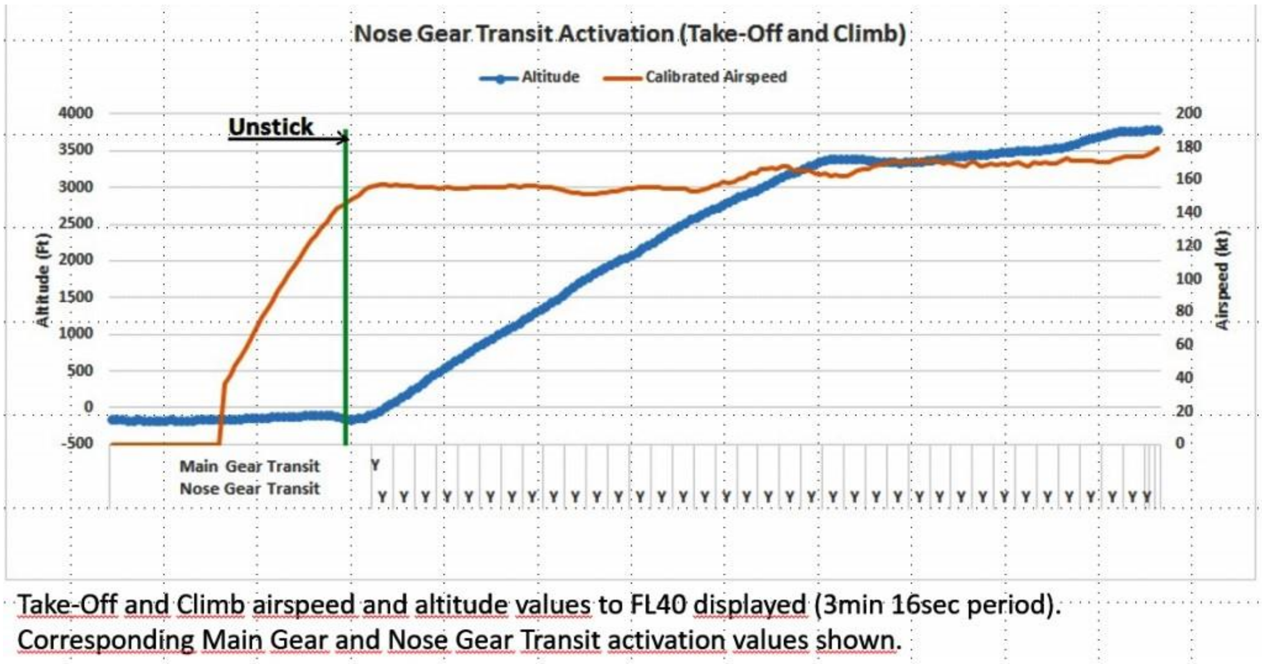
1.11.3. FDM Data flight BTI 641, YL-BTI on 17.09.2016



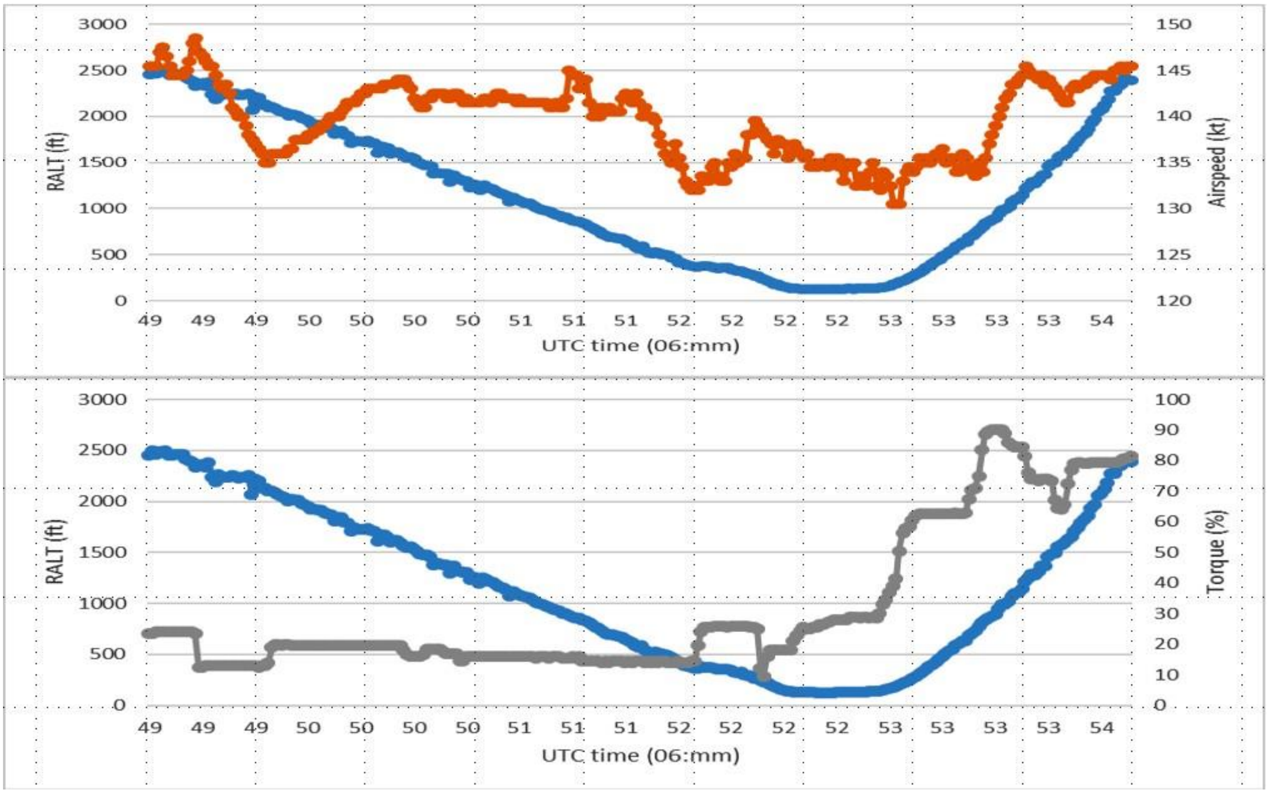
BT641 FDM Map View (Full Flight)



BT641 FDM Gear Position Indication (Full Flight)

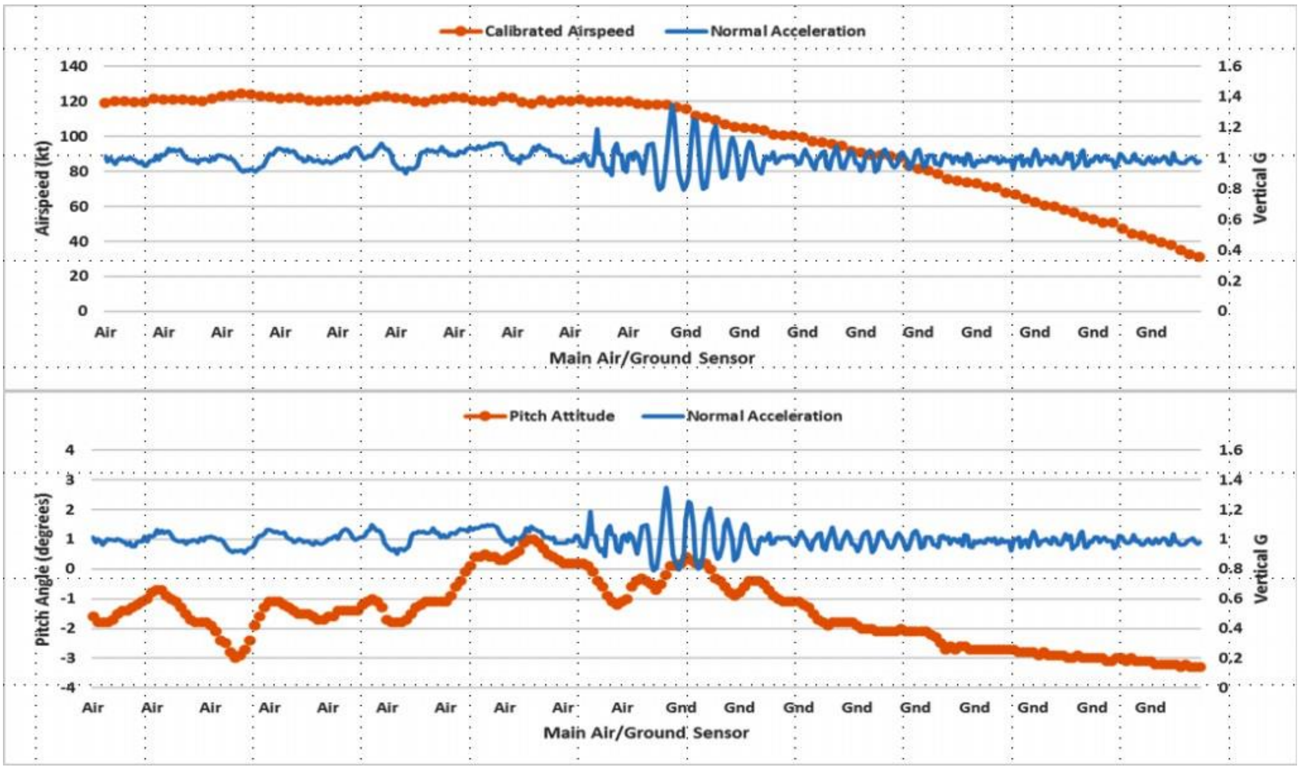


BT641 Take-Off FDM Data



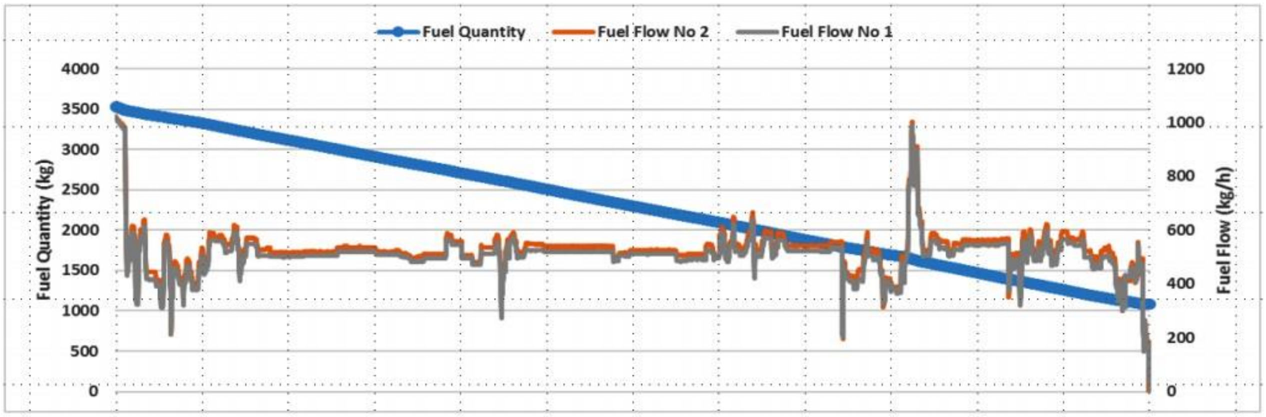
Low pass at minimum 126FT Radio altitude flown. Airspeed and torque values for time period 06:49 – 06:54 UTC displayed.

BT641 Low Pass FDM Data



Final Approach and Landing from 250FT to airspeed inactive (30 KT airspeed) displayed.

Corresponding vertical acceleration values (max 1.35G) pitch angle and airspeed values shown **BT641 Landing FDM Data**



Fuel on landing based on FDM data was ~1050kg.

BT641 Fuel Information FDM Data

1.11.3. Nosewheel landing events on airBaltic Q400 fleet.

To support investigation available data sample from 2012 to 2016.

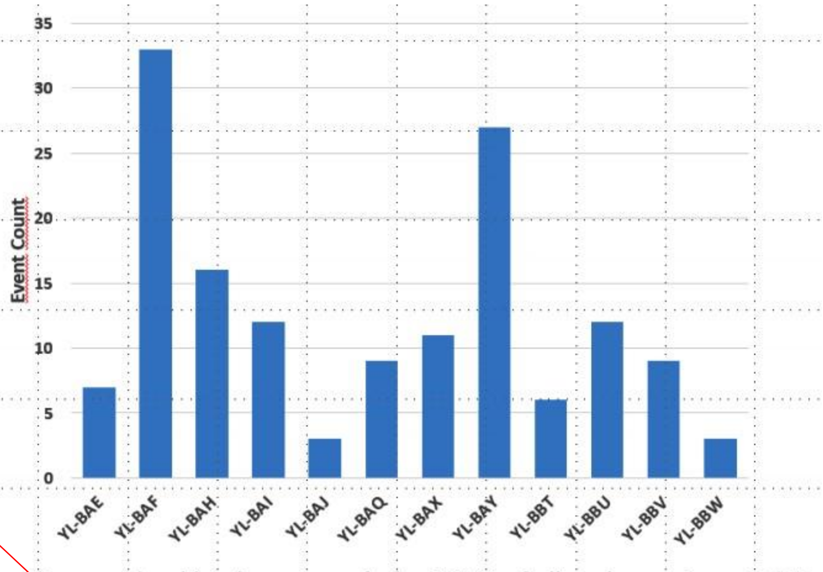
Year	2012	2013	2014	2015	2016
Event Count	7	49	25	34	33
Average Vertical G	1.22	1.29	1.25	1.27	1.27
Maximum Vertical G	1.32	1.61	1.43	1.57	1.55

Event Criteria – Duration of Nose WOW before Main WOW sensor activation at least **1.5** seconds.

- In average 0.14% of airBaltic Q400 flights have nosewheel landing events present.

Wheelbarrow Landing Events (by Year)

A/C	Total Events (2012-2016)	Average Vertical G	Maximum Vertical G
YL-BAE	7	1.28	1.4
YL-BAF	33	1.26	1.61
YL-BAH	16	1.26	1.43
YL-BAI	12	1.31	1.57
YL-BAJ	3	1.29	1.31
YL-BAQ	9	1.25	1.43
YL-BAX	11	1.28	1.49
YL-BAY	27	1.23	1.37
YL-BBT	6	1.22	1.26
YL-BBU	12	1.32	1.55
YL-BBV	9	1.29	1.48
YL-BBW	3	1.41	1.47

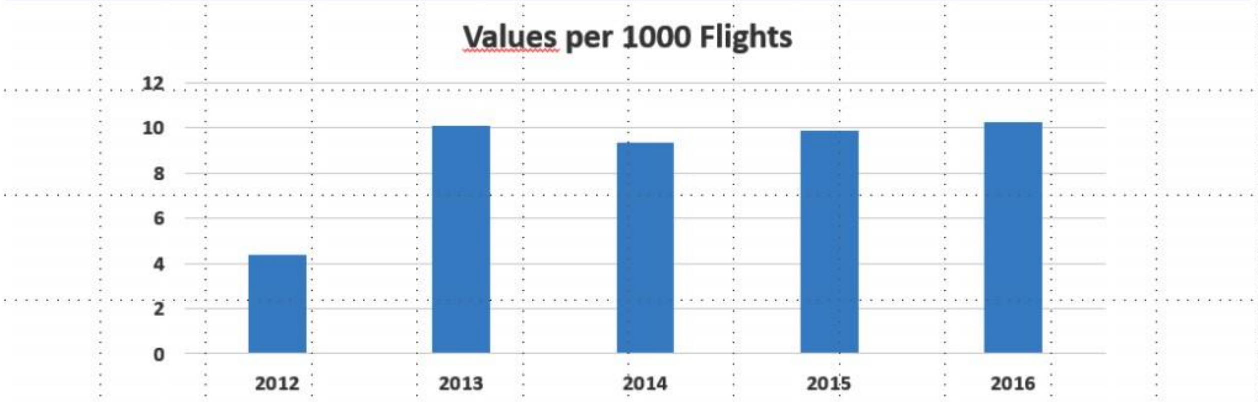


- YL-BAI aircraft since Year 2012 have 12 nosewheel landings recorded – 8.12% of all such events on Q400.

Wheelbarrow Landing Events (by A/C)

Year	2012	2013	2014	2015	2016
Value Count	73	213	242	252	189
Average Vertical G	1.24	1.27	1.24	1.26	1.26
Maximum Vertical G	1.74	1.61	1.59	1.73	1.66

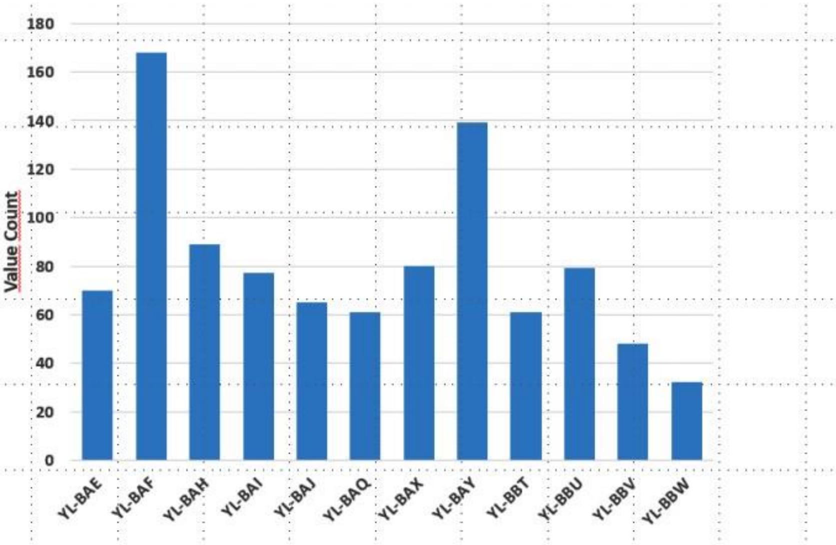
Value Criteria – Duration of Nose WOW before Main WOW sensor activation at least **0.25** seconds.



- In average 0.88% of airBaltic Q400 flights have nosewheel landing values present.

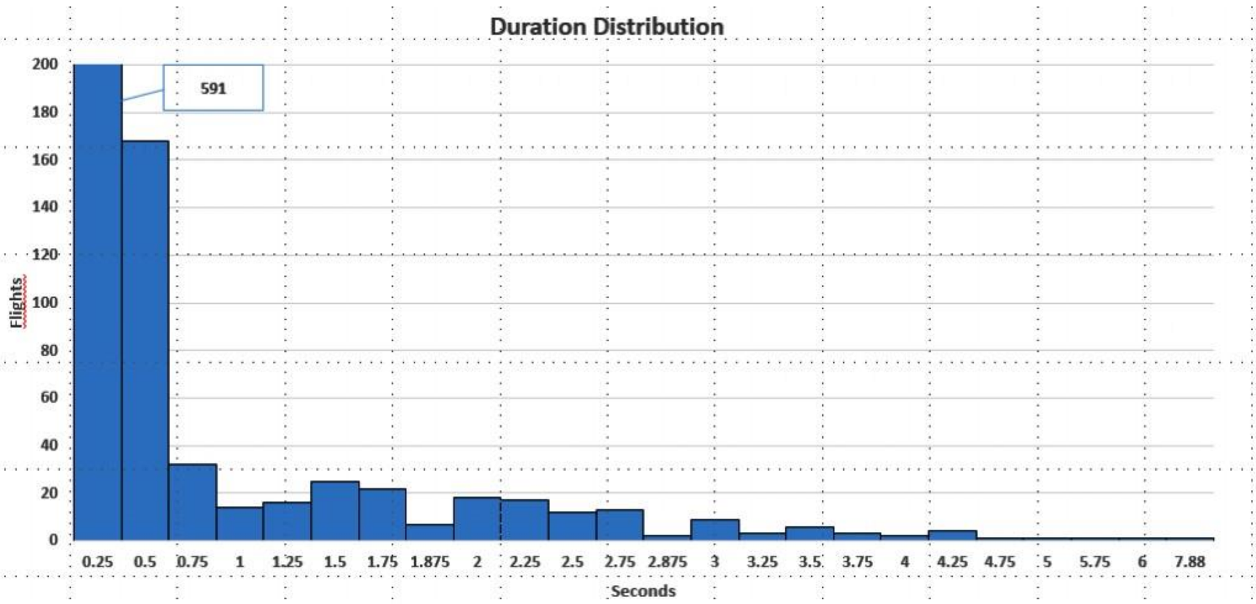
Wheelbarrow Landing Values (by Year)

A/C	Total Values (2012-2016)	Average Vertical G	Maximum Vertical G
YL-BAE	70	1.24	1.55
YL-BAF	168	1.26	1.61
YL-BAH	89	1.27	1.54
YL-BAI	77	1.25	1.57
YL-BAJ	65	1.26	1.73
YL-BAQ	61	1.23	1.43
YL-BAX	80	1.25	1.49
YL-BAY	139	1.26	1.74
YL-BBT	61	1.23	1.48
YL-BBU	79	1.27	1.55
YL-BBV	48	1.29	1.59
YL-BBW	32	1.26	1.47



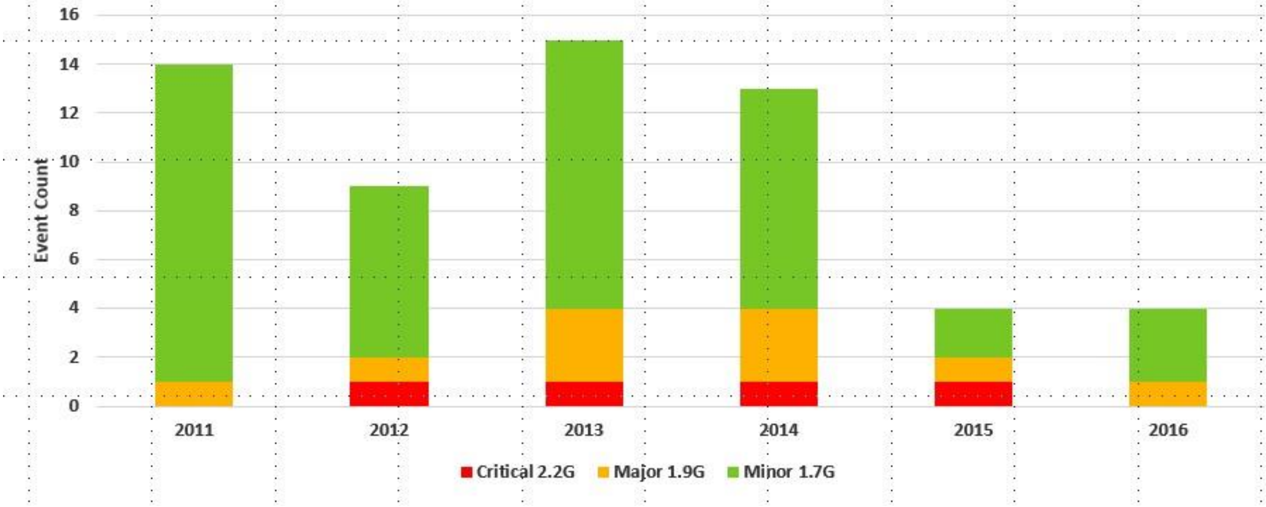
- YL-BAI aircraft since Year 2012 have 77 nosewheel landing values recorded – 7.95% of all such cases on Q400.

Wheelbarrow Landing Values (by A/C)



On YL-BAI maximum duration from Nose WOW sensor activation to Main WOW sensor activation was 3.75 seconds with corresponding 1.15G landing acceleration value (October 2015).

Duration of Nose WOW before Main WOW Q400



YL-BAI High Acceleration Landings FDM Data

1. 0.5% of YL-BAI landings have maximum Vertical G value equal to or exceeding 1.7G – minimum threshold to consider landing G as value of interest;
2. Since Year 2011 in FDM have been recorded 4 hard landings with Vertical G value equal to or exceeding 2.2G – threshold to carry out hard landing maintenance actions.

No Overweight landings on YL-BAI in FDM recorded.

1.12. Wreckage and impact information

1.12.1. General

During the first visual inspection after landing it was stated that there are not serious aircraft fuselage damage, except NLG front doors. After fixing NLG aircraft was towed to hangar for further inspection and NLG parts removing.

Picture 21 NLG front doors damage

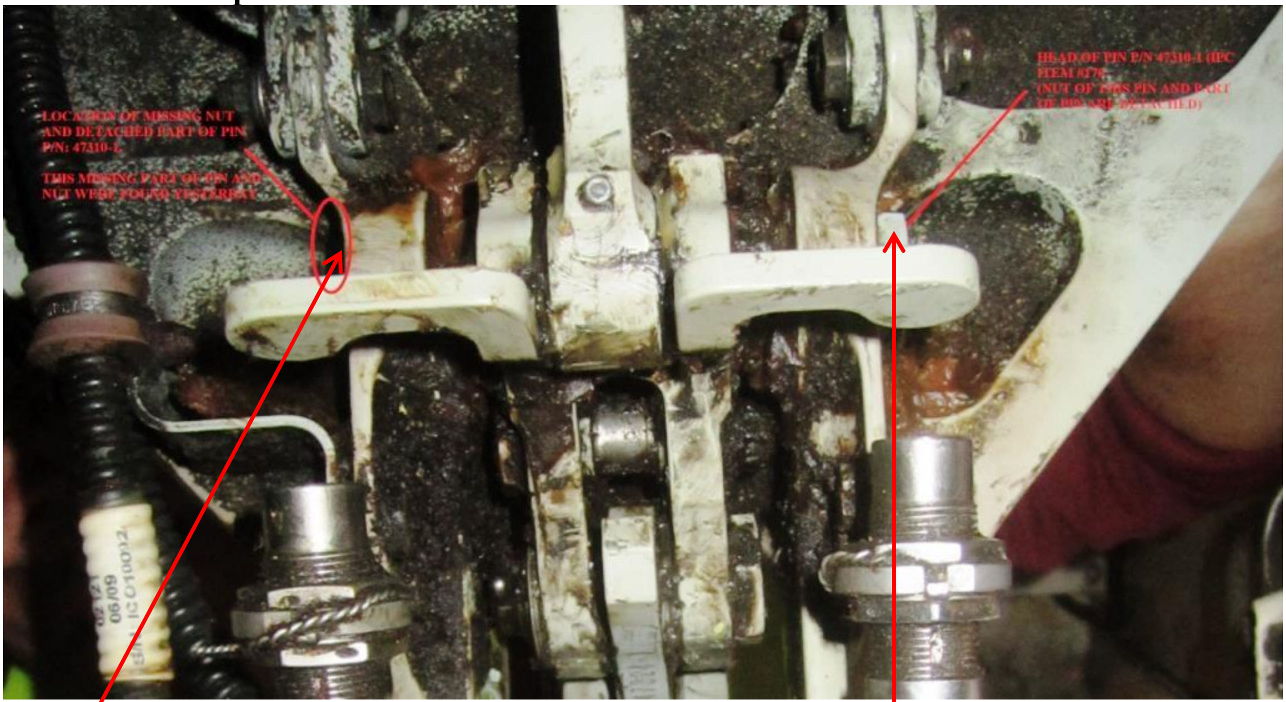
Picture22 NLG front doors damage

Picture 23 NLG front doors damage

Picture 24 View of NLG front doors damage from inside NLG compartment

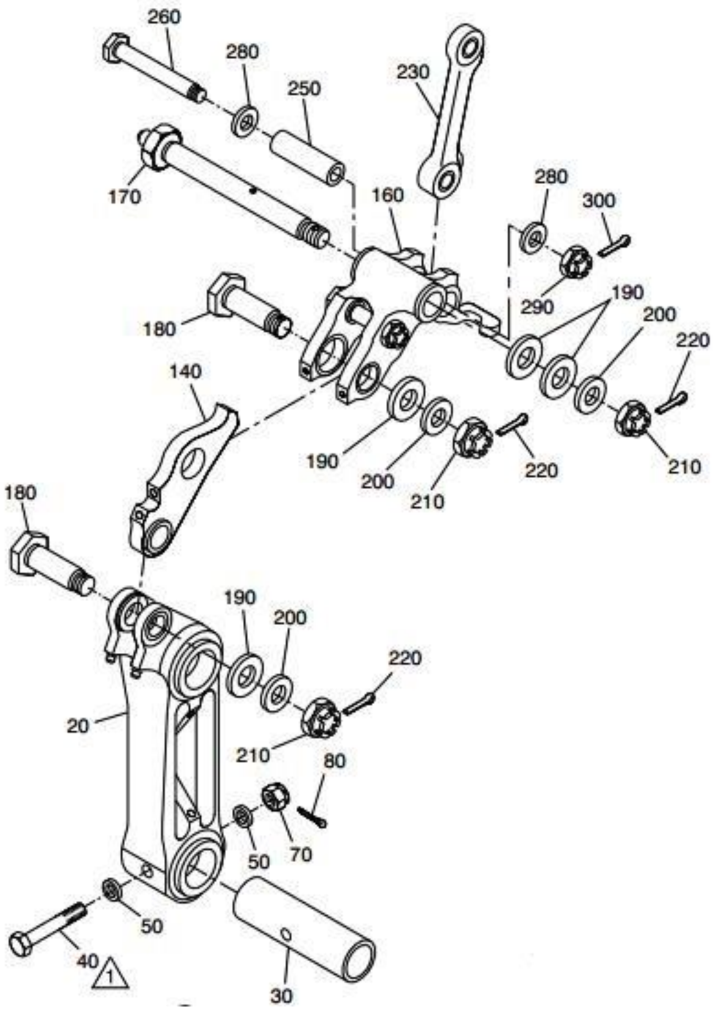
Picture 25 NLG front doors damage

1.12.2. NLG components

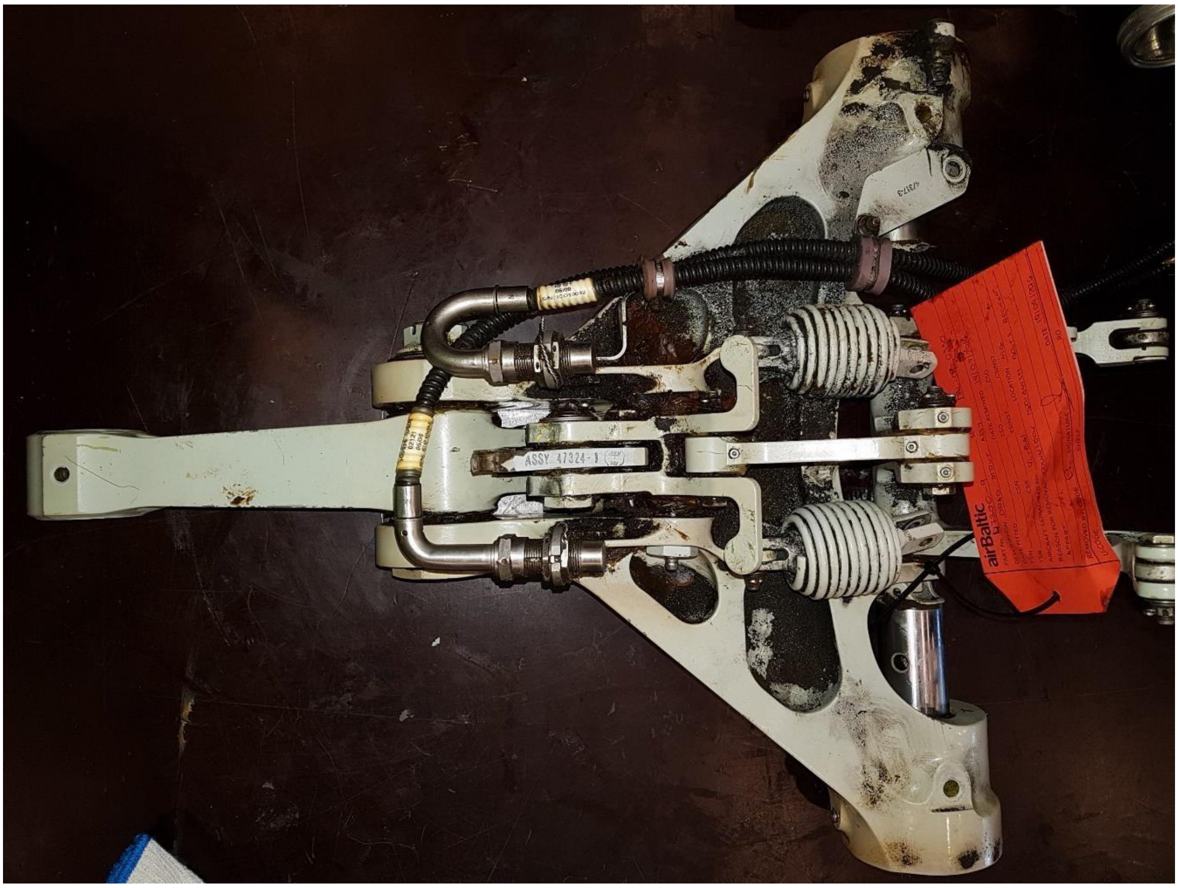


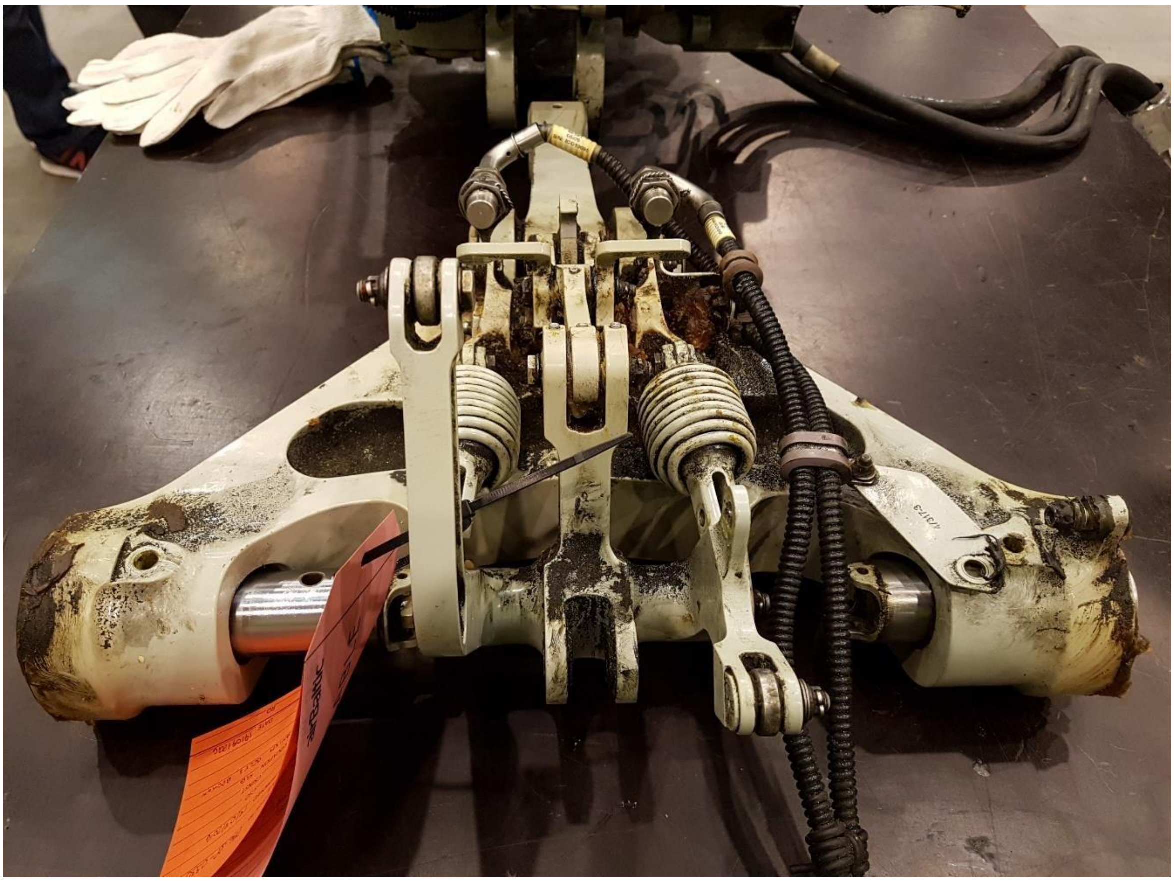
Location of missing nut and detached part of pin P/N47310-1

Head of pin P/N47310-1, IPC item 170 (nut of this pin and part of pin was detached)

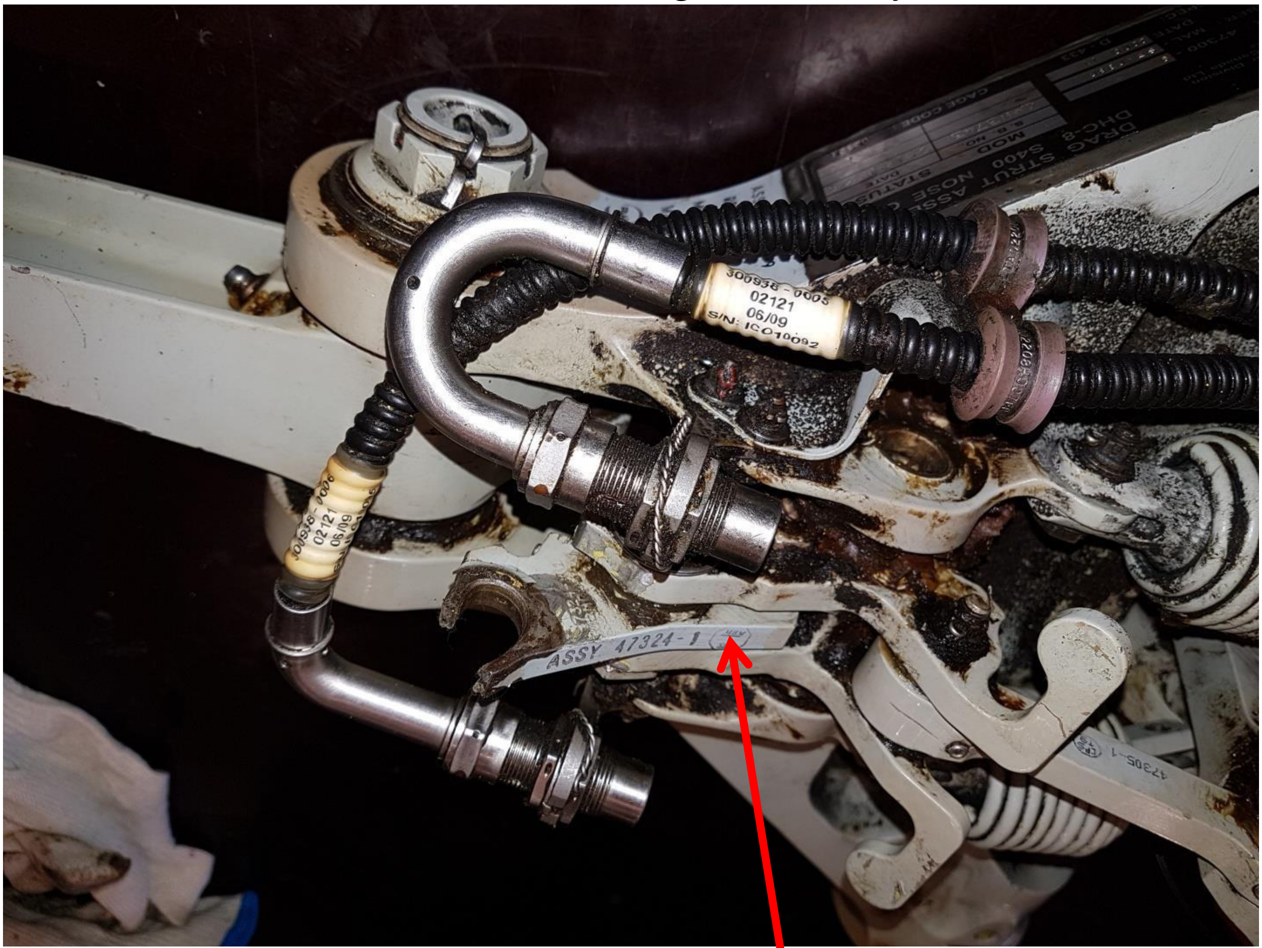


Picture 25 NLG Drag Strut Assembly, Ilustrated Parts Catalog (IPC) During the first inspection was found that nut 210 of pin 170 of upper lock drag strut and part of pin was detached. NLG Drag Strut Assembly was removed from aircraft for inspection.


ASSY 47324-1
airBaltic



Picture 26 NLG Drag Strut Assembly

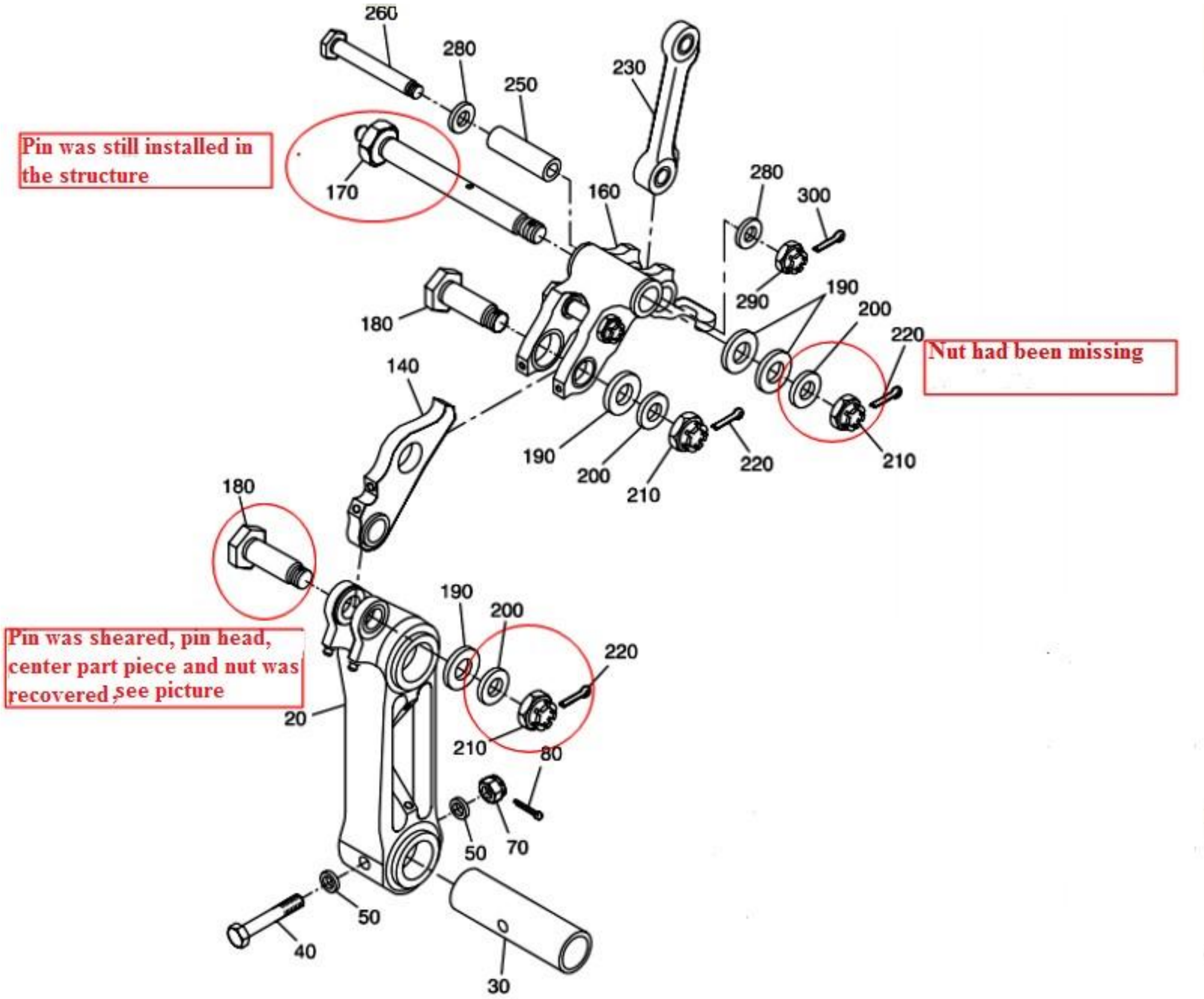


Picture 27 Lower Lock Link

By visual inspection it was stated that the Lower Lock Link ASSY P/N 47324-1 is damaged at the place of hole/lug where it is connected to the Lower Drug Strut P/N 47313 -1.

Picture 28 Lower Drag Strut

After removing from aircraft it was stated that the lugs of the Lower Drug Strut for the Lower Lock Link was damaged.



Picture 29 Lower Lock Pin, P/N47309-3

Lower Lock Pin (Ilustrated Parts Catalog, 180) was sheared. Pin (Illustrated Parts Catalog, 170) was still installed in the structure.

Picture 30 NLG compartment after components removing.

There were found fragments of broken details from not identified material, probably pieces of washers or bushings at the place of joint Lower Lock Link (Illustrated Parts Catalog, 140).

Picture 31Fragments of broken details from not identified material

NLG Drag Strut Assembly, NLG Unlock Actuator (P/N 47400-3, S/N MAL-0350), NLG Retract Actuator (P/N 47500-7, S/N MAL-0383), NLG Mechanical Sequence Valve, (P/N 48303-7, S/N FAH1007) after dismounting from aircraft and previous visual inspection were sent for expertise to NLR.
The investigation focused on the NLG Drag Strut Assembly which had significant fracture damage:

- The stabilizer brace link was fractured and separated at both joint lugs;
- The aft stabilizer brace torque tube was bent, and a large section had broken and separated;
- The aft stabilizer brace link was connected to the forward stabilizer brace link by the downlock springs only;
- The down-lock proximity sensors were displaced from their respective targets (figure A).

1.13. Medical and pathological information

The TAIIB has decided not to undertake any medical or pathological investigations.

1.14. Fire

NIL

1.15. Survival aspects

NIL

1.16. Tests and research

1.16.1. Hydraulic Liquid analyze

Hydraulic fluid samples for testing were sent to laboratory of company "SPECTRO", United Kingdom. Sample No1 of Lock Actuator UP, Sample No2 of Lock Actuator Down, Sample No3 of Restrictor UP, Sample No4 of Restrictor Down.

Certified Hydraulic Fluids: The followings are Bombardier's certified hydraulic fluids to be used separately or freely mixed at any ratios or different portions to replenish the aircraft hydraulic systems and the hydraulic ground equipment.

Testing was performed according to the SAE AS4059 Hydraulic System Cleanliness Classification system.

Recommended hydraulic system fluid characteristics for in−service aircraft according to Bombardier's Standard for Hydraulic System Cleanliness for aircraft hydraulic systems during service life should be at a "Cleanliness Level" of at least **NAS 1638/SAE AS 4059 Class 8. (AIRCRAFT MAINTENANCE MANUAL, TASK 29−00−00−220−801, 1.General, C).**

Maximum solid **particle contamination limits** (Based on a 100 ML sample size) based on SAE AS4059 Table 1 Cleanless Clasification System (Interval Counts):

Particle Size range (microns).	NAS 1638/SAE AS 4059 CLASSES: maximum allowed Count or number of particles in 100 ML sample size.
	CLASS 8 − aircraft
5 to 15	64000
15 to 25	11400
25 to 50	2025
50 to 100	360
over 100	64
Water Content, % H2O by weight.	0.60max

Water Content, % H2O by weight determined by Karl Fischer Method-**1946 ppm or 0.1946%**

Hydraulic fluids Analysis Reports attached at APPENDIX E.

1.17. Organizational and management information

The operator's maintenance organization has subsequently made an inspection of its DHC-8-400 fleet-wide and identified that corrosion on NLG Drag Strut Lock Link P/N 47324-1 has been on several aircrafts during dedicated fleet wide inspections. NLG Drag Strut Detailed inspections with disassembly were completed on all airline Q400 fleet.

Inspections on the following aircrafts were performed, affected parts have been replaced and respective aircrafts have been released to service.

Corrosion has been found on the affected lock links lower hole accompanied to the separation of bushings from the assembly. The corrosion is the result loss of sealant due to dislodged bushings (Photos of corrosion on links P/N: 47321-1 splitted by aircrafts according Table).

Tabulation

No	Aircraft reg.No	MSN	s/n of Lock Link P/N 47324-1	TSN (FH)	CSN (FC)	Inspection results
1.	YL-BAY	4331	MBM0073	16931:33	12376	Revealed corrosion of the Lock Link; Corrosion/loose bushings of NLG Drag Strut Lock Link was found
2.	YL-BAX	4324	MBM0040	16653:09	12338	
3.	YL-BAQ	4313	MBM0053	16014:39	12084	
4.	YL-BAJ	4309	MBM0011	16667:49	12098	
5.	YL-BAF	4293	MBM0035	17018:29	12703	
6.	YL-BAH	4296	MBM0029	17468:20	12925	
7.	YL-BAE	4289	MBM0021	17419:12	13302	
8.	YL-BBT	4438	MBM0197	11482:45	8131	
9.	YL-BBU	4439		10812	7745	No corrosion/loose bushings of NLG Drag Strut Lock Link was found
10.	YL-BBV	4444				
11.	YL-BBW	4448				

Where a corrosion was found on LOCK LINK **P/N: 47324-1** detailed inspection of the NLG with Drug Strut disassembly has been performed in accordance with **Bombardier RD 84-32-0303 Iss.2** and **Goodrich ISQ-0649-16** on operator DHC-8-402 aircrafts as listed in Tabulation:

No	Aircraft reg.No	Drag Strut ASSY			Upper Lock Link		
		p/n	s/n	TSN/CSN	p/n	s/n	Pic. No
1.	YL-BAY	47300-9	MAL-SP0358	16931:33FH/12376FC	47324-1	MBM0073	32-36
2.	YL-BAX	47300-9	MAL-SP0353	16653:09FH/12338FC	47324-1	MBM0040	37-43
3.	YL-BAQ	47300-9	MAL-SP0345	16014:39FH/12084FC	47324-1	MBM0053	44-48
4.	YL-BAJ	47300-9	MAL-SP0307	16667:49FH/12098FC	47324-1	MBM0011	49-54
5.	YL-BAF	47300-9	MAL-SP0322	17018:29FH/12703FC	47324-1	MBM0035	55-60
6.	YL-BAH	47300-9	MAL-SP0325	17468:20FH/12925FC	47324-1	MBM0029	61-66
7.	YL-BAE	47300-9	MAL-SP0299	17419:12FH/13302FC	47324-1	MBM0021	67-72
8.	YL-BBT	47300-9	MAL-SP0478	11482:45FH/8131FC	47324-1	MBM0197	73-75

Table 4: Lock Link from different aircraft inspection results

Picture 32

Picture 33

Picture 34

Picture 35

Picture 36

Picture 37

Picture 38

Picture 39

Picture 40

Picture 41

Picture 42

Picture 43

Picture 44

Picture 45

Picture 46

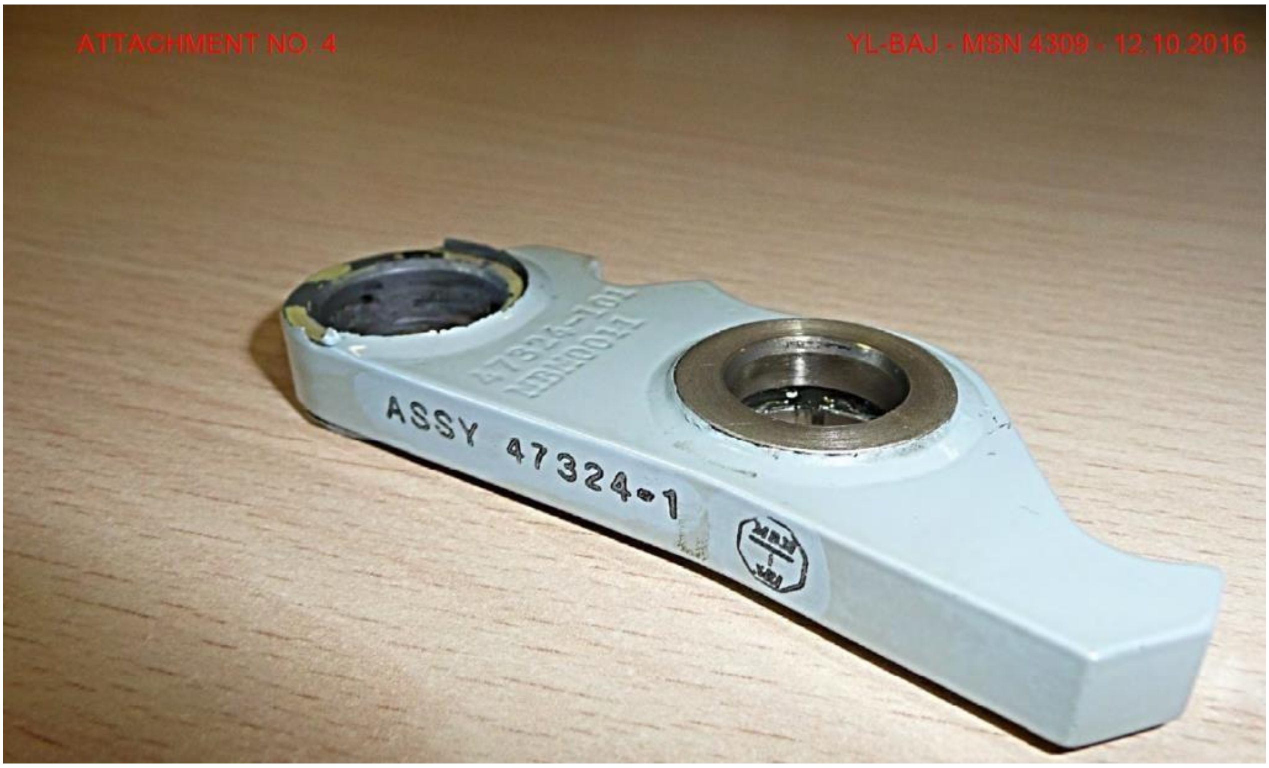
Picture 47

Picture 48

Picture 49

Picture 50

Picture 51

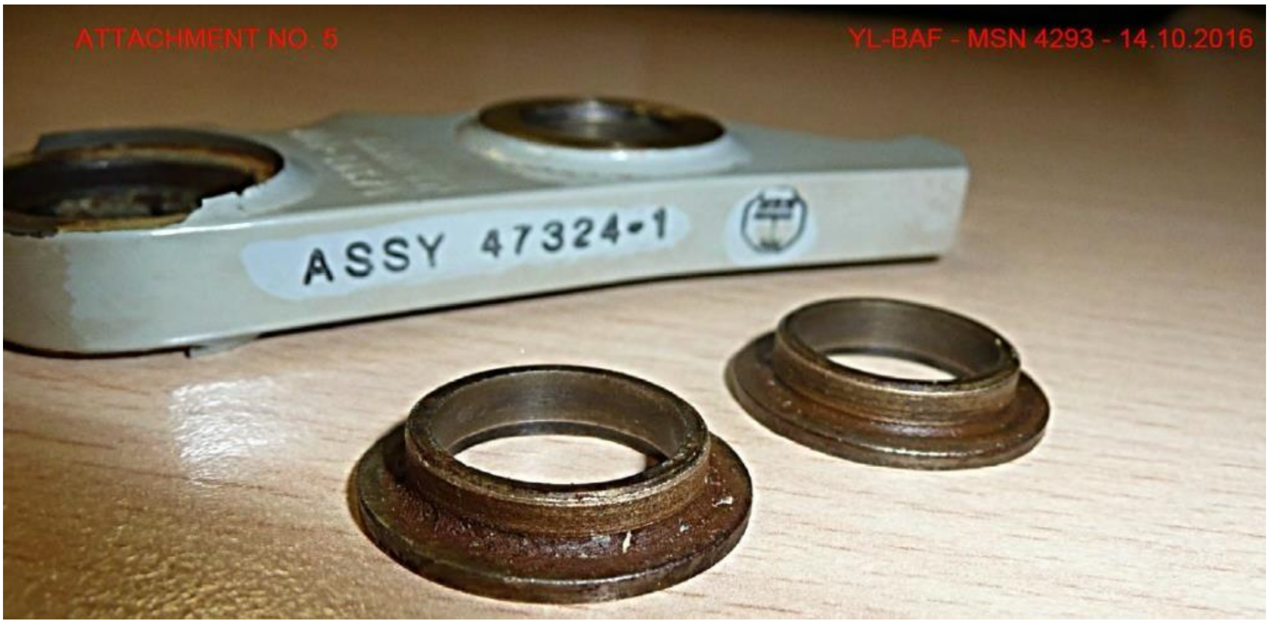

ATTACHMENT NO. 4
YL-BAJ - MSN 4309 - 12.10.2016
ASSY 47324-1

Picture 52


ATTACHMENT NO. 4
YL-BAJ - MSN 4309 - 12.10.2016

Picture 53

Picture 54



Picture 55


ATTACHMENT NO. 5
YL-BAF - MSN 4293 - 14.10.2016

Picture 56


ATTACHMENT NO. 5
YL-BAF - MSN 4293 - 14.10.2016

Picture 57

Picture 58

Picture 59

Picture 60

Picture 61

Picture 62

Picture 63

Picture 64

Picture 65

Picture 66

Picture 67

Picture 68

Picture 69

Picture 70

Picture 71


ATTACHMENT NO. 7
YL-BAE - MSN 4289 - 21.10.2016

Picture 72


ATTACHMENT NO 8.
YL-BBT - MSN 4438 - 16.01.2017
ASSY 47324-8

Picture 73

Picture 74

Picture 75

As interim solution airBaltic has reduced lubrication interval to 270 FH for Lock Link. Reason of such figure so that next lubrication would match with general NLG lubrication task of 500 FH. Additionally currently they are switching to Aeroshell Grease 33, before they used Aeroshell Grease 7 for landing gear lubrication. It is no possible to approve that grease 33 is better than grease 7 as both are approved as per AMM & CPM but Aeroshell data sheet for grease 33 reflects improved wear and corrosion resistance, so airline will check if situation can be improved.

Company introduced new Maintenance Programme task 322100-BT-01 (Inspection of the NLG) with interval 1C. Already completed on 2 aircrafts (YL-BAH and YL-BAE), remaining aircrafts are to be inspected during current C-Check visits.
Company introduced new Maintenance Programme task 320001-BT-01 (Lubrication of Nose Landing Gear Drag Strut Lock Link P/N 47324-1) with interval 275 FH.
Transition from Aeroshell Grease 7 to Aeroshell Grease 33 for Landing Gear Lubrication is in progress. Completed on 11 aircrafts. Remaining 1 aircraft (YL-BAQ) is scheduled for completion during the Week 4, 2017.

According to UTC Aerospace Systems Q400 NLG LLL observations Report Rev NC, 2017/01/10 of two LLL (P/N) 47324-1 that were sent by AirBaltic to UTCA**S -** A/C MSN 4331 and A/C MSN 43314293 in both lock link assemblies;

- there was observable radial clearance between the two bushings and the lug bore;
- the two 47330-5 bushings at lower drag strut attachment joint were loose;
- the bore and bushing support face of the lower drag strut attachment lug were missing primer from most areas. At these areas, corrosion was observed;
- there was a visible step between the surface where the OD of the bushing rests and the greaser gap, indicating wear of the bore surface where the bushing engages;
- there was observable radial free-play between the two bushings and the lug bore.

Observations made on 2x 47330-5 bushings at lower drag strut attachment joint:

Wear was observed on the outer surface of both bushings. Nature of wear was similar to wear observed on lock links from A/C 4302 involved in the serious incident, but the radial free play has not progressed to the extent that A/C 4302 had experienced.

Dimensional measurements for A/C MSN 4331:

- 47324 lower drag strut attachment lug worn ID = .693” max;
- 47330-5 bushing worn OD = .672” min;
- Calculated radial free-play = (.693” – .672”) / 2 = .011”

Dimensional measurements for A/C MSN 4293:

- 47324 lower drag strut attachment lug worn ID = .693” max;
- 47330-5 bushing worn OD = .682” min;

- Calculated radial free-play = (.693” – .682”) / 2 = .006”

According to opinion of UTC Aerospace Systems;

- Loosening of bushings – Contributing factors are bushing geometry and operational loads;

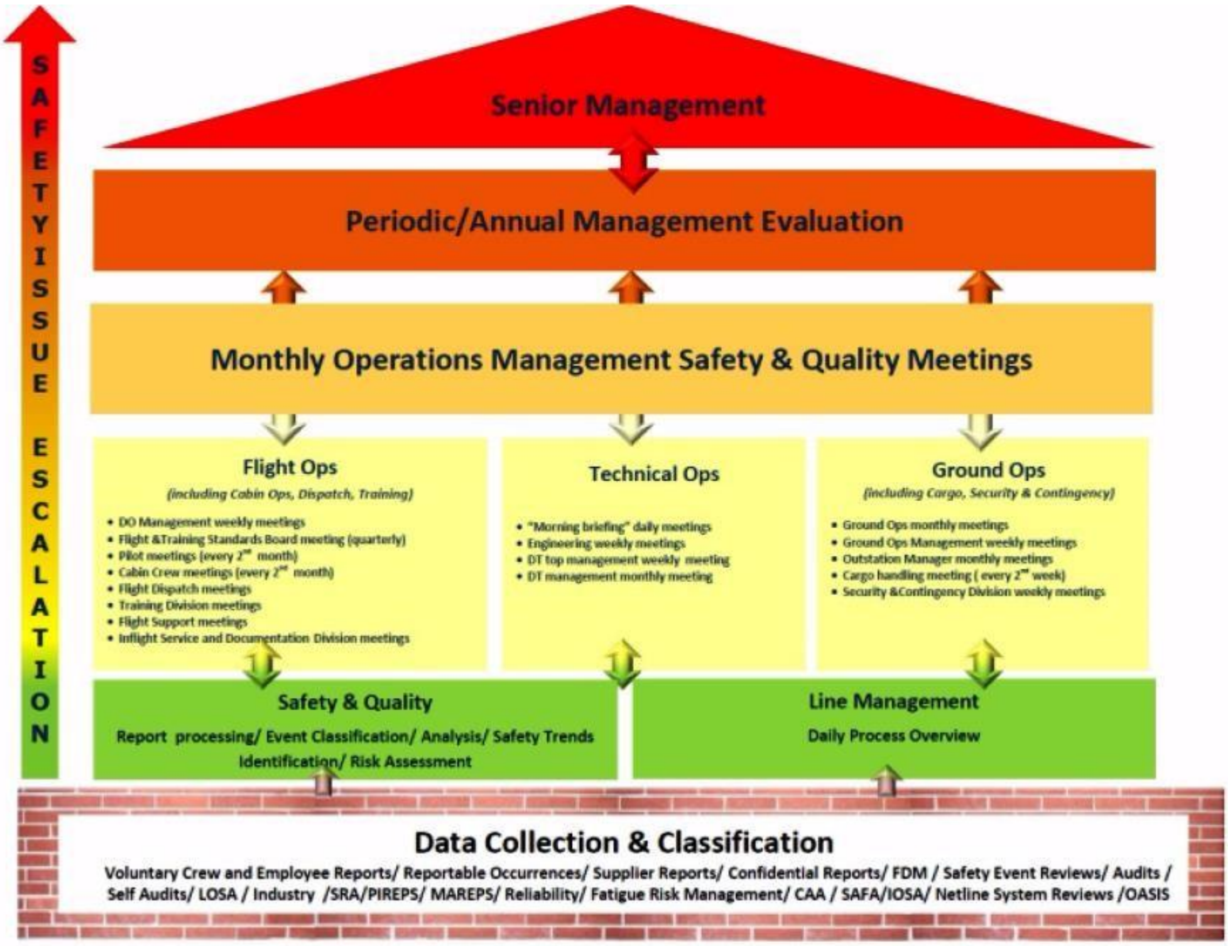
- Accelerated corrosion in the lower drag strut attachment joint – The severity of corrosion on the Air Baltic lock links has not been seen on drag struts from other operators received by UTAS MRO facilities for overhaul from 2010-2016 (49 in total). The effect of formate and acetate based runway de-icing fluids cannot be discounted as a contributing factor.

1.17.1. Safety Management System

The safety policy is defined in accordance with international and national requirements, SMS is organized according to requirements of the ICAO Annex 19 “Safety Management”, ICAO Safety Management Manual Doc.9859 (edition 2013), and “Management system”, point (a)(1) [complex operators] ORO.GEN.200(a)(1).

The SMS consists main ICAO Components - Safety Policy and objectives, Safety Risk Management, Safety Assurance and Safety Promotion

The SMS is based on reporting, event risk classification, hazard identification, collecting and analysing data and continuously assessing safety risks, which facilitates determination of suitable countermeasures and follow-up activities in a systematic order, to eliminate or reduce such risks to an acceptable level.



Building blocks of SMS integration within company operation.

In company established integrated safety and compliance monitoring system throughout the organization. Both Quality and Safety teams are responsible for implementation and maintenance of integrated compliance monitoring and SMS.

Appointed Accountable Manager (according to the Board decision EB140 of 16 May, 2012) has an ultimate responsibility and accountability on behalf of the Organization for the implementation and maintenance of the SMS throughout the organization and allocation of resources to support and maintain an effective SMS.

According to the Board Resolution No EB 142-23/2012 the person nominated as Accountable Manager **is entitled to exercise the allocation of necessary funding** required to ensure safe and compliant operation. Safety accountabilities and responsibilities of Accountable manager are clearly defined.

2. Analysis

2.1. Flight crew

The flight crew was properly licensed.

2.2. Aircraft

The aircraft had a valid certificate of airworthiness and the centre of gravity was within the envelope. The aircraft maintenance records were in compliance with the established maintenance program.

2.3. Weather

The weather at the time was VMC and did not influence sequence of events.

2.4. Passenger briefings

The crew briefed the passengers several times. All the briefings were useful and honest. The cabin crew (CA1) briefed the passengers using the PA system. The cabin attendants then addressed the passengers individually. The passengers responded as instructed before the landing.

2.5. Information to ATC

The cockpit crew chose to inform Riga International airport Tower about the Nose Landing Gear problem in due time. The crew didn't declare emergency, they informed Riga Tower controller that they will like to make low pass initially to check the NLG position. The "ground crew" was ready and in position before the landing. The information to the tower was useful and timely.

2.6. Airplane Flight Manual - airBaltic Operations Manual Part B Q400

If the landing gear fails to extend or retract, assuming that the Normal Extension/Retraction procedures have been actioned correctly, the OM contains following list known conditions that have presented the Flight Crew with an abnormal landing gear configuration:

- A burnt out landing gear advisory light bulb can give a false indication that the gear is not down. If "3 green" gear down and locked advisory lights are not observed, ensure that the light bulbs in the gear indicator panel have been checked utilizing the Advisory/Test switch;

- Failing to use the Alternate Indication system for a landing gear down and locked confirmation;

- The Alternate Release and Extension doors not in the fully closed position prior to a normal landing gear selection;

- The Landing Gear Inhibit switch is not in the Normal position.

Once it is determined that the normal system has failed to extend/retract the landing gear, and the aircraft was appropriately configured giving due regard to the above mentioned possible errors, the QRH directs the use of the Alternate Extension system.

When it is known that a landing must be performed which could be identified as an emergency landing due to the presence of factors which introduce a hazard to the airplane and its occupants, **QRH "EMERGENCY LANDING"** checklist outlines the main points to be addressed as applicable.

With different potential landing gear failure scenarios, the following considerations may also be applicable:

If the Alternate Gear extension procedure has been completed, and it cannot be verified that the nose gear is down and locked by the normal and alternate systems, the Flight Crew must make a decision to either perform a landing with the nose gear not locked, or reset the Alternate Extension system and cycle the landing gear in an attempt to achieve all gear down and locked. It is possible to safely land the Dash 8 Q400 airplane with the nose landing gear retracted. The geometry of the Q400 airplane is such that the propellers will not come in contact with the runway with the main gear down and the nose gear retracted. In addition to the direction given in the QRH
"EMERGENCY LANDING" checklist, the following is offered for consideration:

- Reduce landing weight through fuel burn;
- Attempt to achieve an aft C of G through passenger re-seating;
- Select a runway with minimal crosswind;
- Land with flap 35 degrees;
- Fly the appropriate VREF for the landing weight;
- Touchdown offset from the runway centerline if runway equipped with a centerline lighting system;
- On touchdown, hold the nose just off the runway with the elevator. Prior to losing elevator control gently lower the nose to the runway;
- Should the nose wheel not be extended or collapse, maintain directional control with rudder until no longer effective at which point asymmetric braking can be used as required;
- Apply brakes or reverse thrust only after the nose wheel is on the ground and appears to be locked. If nose gear is not extended or collapses apply brakes only.

Opting to cycle the landing gear in an effort to extend the nose gear from this abnormal situation would require a reset of Alternate Extension procedure. This may be accomplished by utilizing the following procedure:

1. Ensure No. 2 hydraulic system pressure and quantity are normal and the following landing gear advisory lights are illuminated: selector lever amber, gear green locked down (main gear only), red gear unlocked (nose gear) and all amber doors open;
2. NOSE L/G RELEASE handle – Return to stowed position;
3. LANDING GEAR ALTERNATE EXTENSION door – Close fully;
4. MAIN L/G RELEASE handle – Return to the stowed position;
5. LANDING GEAR ALTERNATE RELEASE door – Close fully;
6. LANDING GEAR lever – DN;
7. L/G DOWN SELECT INHIBIT SW – Normal and guarded. Check amber donors open advisory lights out (main gear only) and LDG GEAR INOP caution light out; **NOTE:** It may take up to 17 seconds for the doors to close.
8. LANDING GEAR lever – UP. Check all gear, door and LANDING GEAR lever advisory lights out. If the Flight Crew decides to cycle the landing gear in an effort to achieve all gear down:
9. LANDING GEAR lever – DN. Check 3 green gear locked down advisory lights illuminate, all amber doors open, red gear unlocked and selector lever amber advisory lights out;
10. Items 8 and 9 may be repeated in an effort to achieve 3 gear down and locked.

CAUTION: Should the LDG GEAR INOP caution light illuminate, or loss of NO. 2 hydraulic system pressure or quantity, or any abnormality in landing gear system indication other than those associated with the affected main landing gear be experienced, see **QRH "ALTERNATE LANDING GEAR EXTENSION" checklist.**

2.7. FDR review

A review of the relevant portions of the FDR's data confirmed that the NLG did not reach 'up-lock' after the initial up selection, the MLG did. In addition, it was confirmed that the right MLG did not retract when the crew selected the landing gear up.

2.8. CVR review

The CVR data were reviewed in order to confirm the flight crew statements with the initial NLG faults and communication with ATC and ground services.

2.9. Incident scenario and failure sequence

On 17 September 2016 the nose landing gear of a de Havilland Canada Q400-8 from airBaltic did not fully retract after take-off for flight BT641 from Riga (RIX) to Zürich (ZRH). The crew tried to deploy and retract the NLG without success. They emergency-landed safely at Riga International airport with the NLG partially deployed at approximately the positions at which the landing gear got stuck. The NLG bay doors were damaged during the landing.

After carefully removing components of the NLG, damage to the Drag Strut ASSY was observed. The Transport Accident and Incident Investigation Bureau sent the drag strut assembly and NLG actuators to the NLR to investigate the causes of the failure.

(Laboratory Report "Failure analysis of a landing gear drag strut assembly" enclosed to Draft final Report in the Appendix A).

2.10. Failure analysis of a landing gear drag strut assembly

After cleaning and detailed inspection in the NLR of drag strut assembly it was stated:

- The damage to the components is largely confined to the locking mechanism;
- The upper and lower drag strut are undamaged, except for the connections to the locking mechanism and some surface damage;
- The LLL, LLL pin and upper lock link pin are the parts that completely failed;
- The LLL apex pin, upper lock link pin and the stop bolt were unable to rotate. For the LLL apex pin this is because the pin is heavily deformed;
- The failed pins are highly deformed and the fracture surfaces indicate that failure occurred by shear overload;
- All fracture surfaces of the LLL are largely covered with dimples indicative for overload;
- All damage observed in the drag strut assembly agrees with overloading of the locking mechanism when it locked at the minimum drag strut angle. When the aircraft lands and puts

load on the NLG with NLG in this condition, this will transfer all load through the locking mechanism, which is not designed for carrying this load.

- Locking of the mechanism at this position is only possible if the total distance between the turning points is decreased;

- It is likely that the corrosion of the LLL hole for the LLL pin and wear of the bushings OD has decreased the total distance between the turning points of the locking mechanism. Over time this would inevitably result in locking of the mechanism at the minimum drag strut angle;

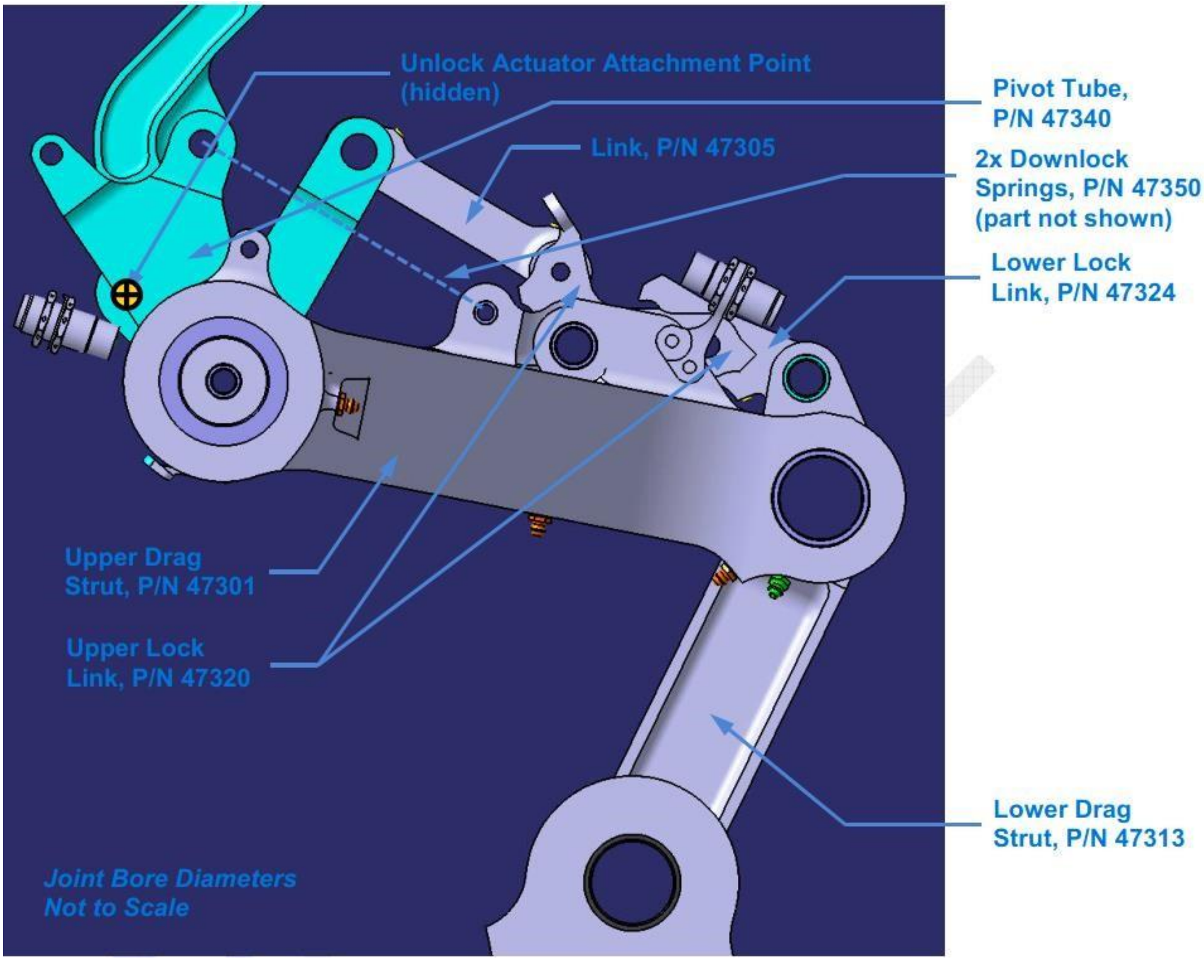
- Insufficient retention of the LLL bushings will result in bushing movement and subsequent sealant loss. This sealant loss allows moisture ingress, accelerates corrosion and LLL wear. The resultant wear will elongation the LLL bushing holes and this resulted in the premature engagement of the LLL in the drag strut assembly;

- The top fracture surfaces of the LLL shows two optical transitions. The first transition occurs at 50-100 μm crack depth and corresponds to the transition from fatigue to overload The fatigue crack growth rate at the transition is very slow based on the striation spacing (in the order of 100 nm per cycle). The second transition occurs at 250-400 μm crack depth, but dimples are present before and after the transition. It is therefore concluded that the second transition is not related to a fatigue beach mark. It is expected that the lug of the LLL failed by overload, because the fatigue crack length and crack growth rate at the transition are both small and all fracture surfaces are largely covered with dimples.

- The stop bolt shows a clear deformation on the side that comes into contact with the LLL;

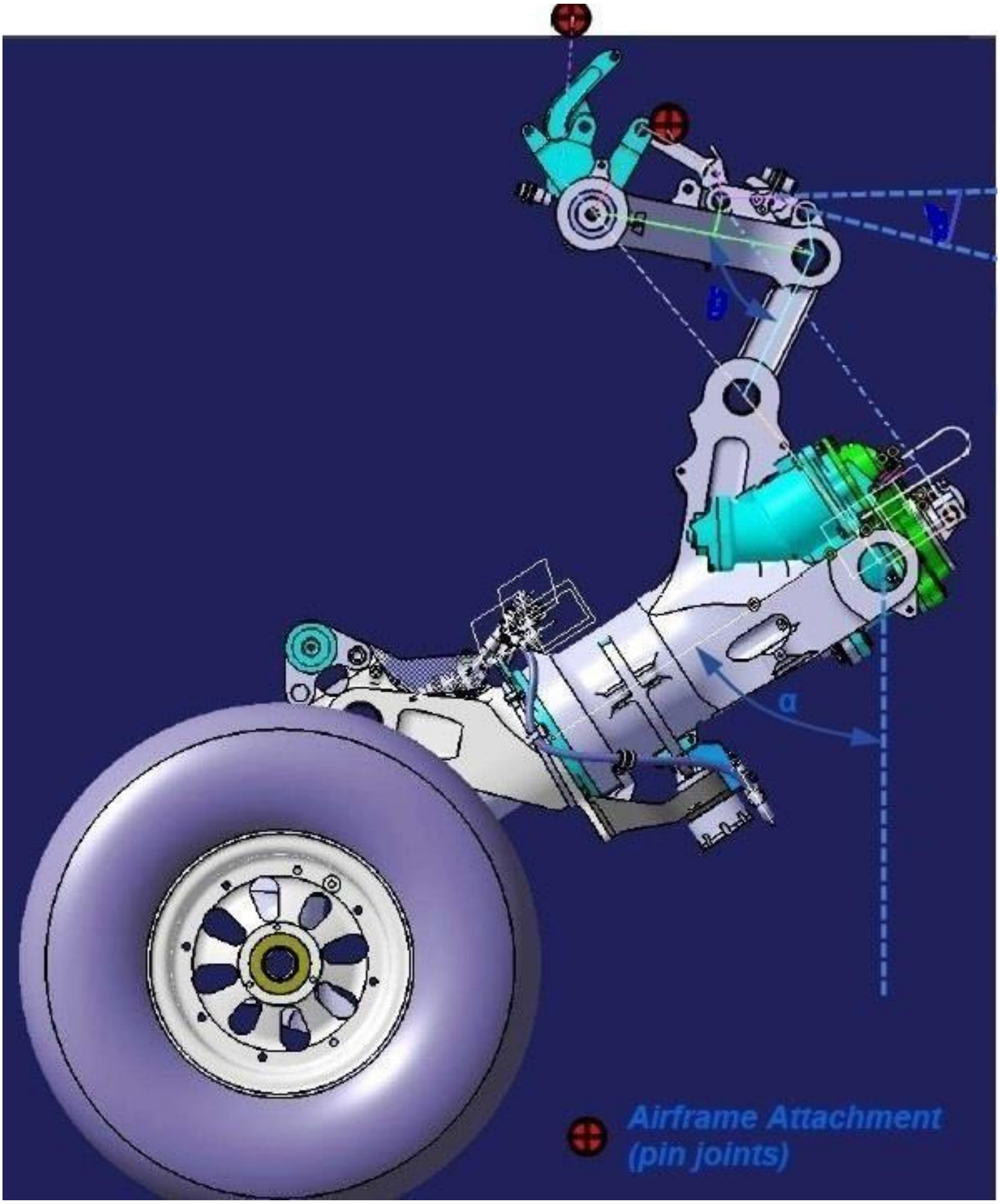
- The other side is rough, but not deformed;

- The stop bolt is unable to rotate after failure of the drag strut assembly. This indicates that a high load was transferred from the LLL to the stop bolt and that it was in contact with each other when a high load was introduced to the LLL. This means that the locking mechanism was locked when a high load was introduced;

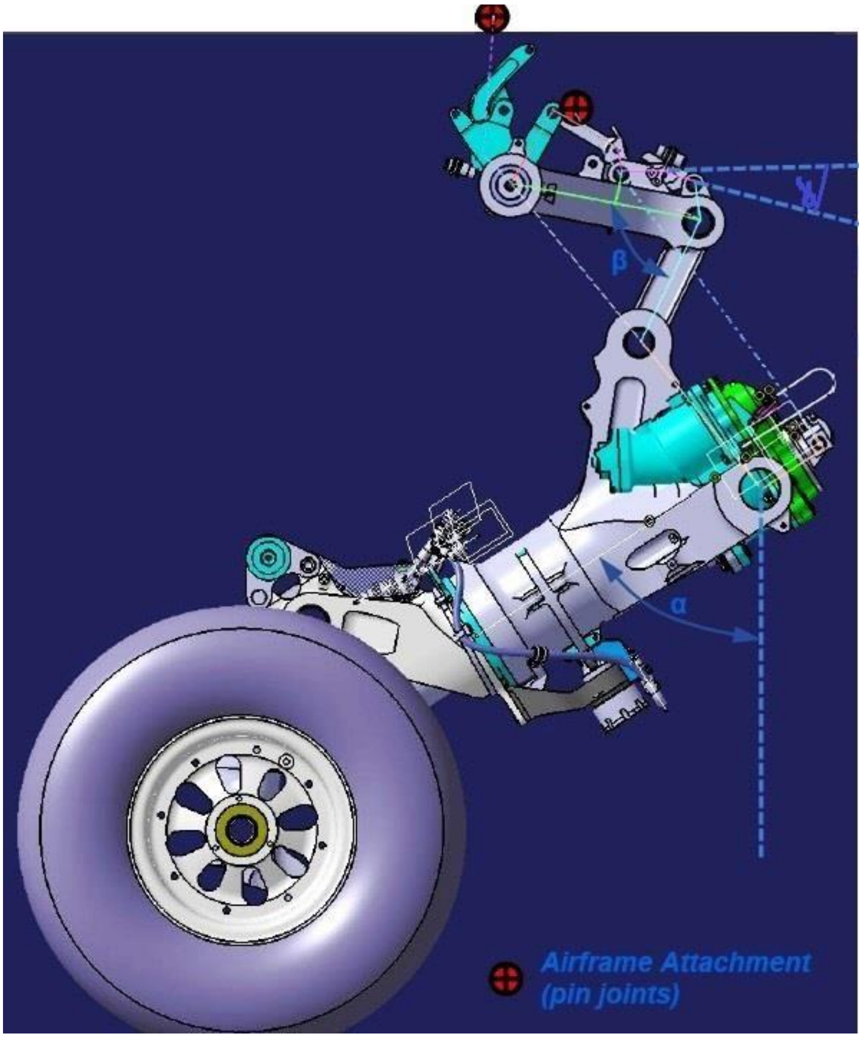


Picture 76 Q400 Nose Landing Gear Drag Strut Assembly

- The locking mechanism locks when the lock link angle **γ**, is more than 180°, which is possible at nose landing gear angles, α, of 0° (NLG fully extended/down) and 120° (NLG fully retracted/up). For a gear angle approaching 56° the angle between the upper and lower drag strut approaches a minimum value and the lock link angle approaches a local maximum of 162°;



γ
β
α
Airframe Attachment
(pin joints)

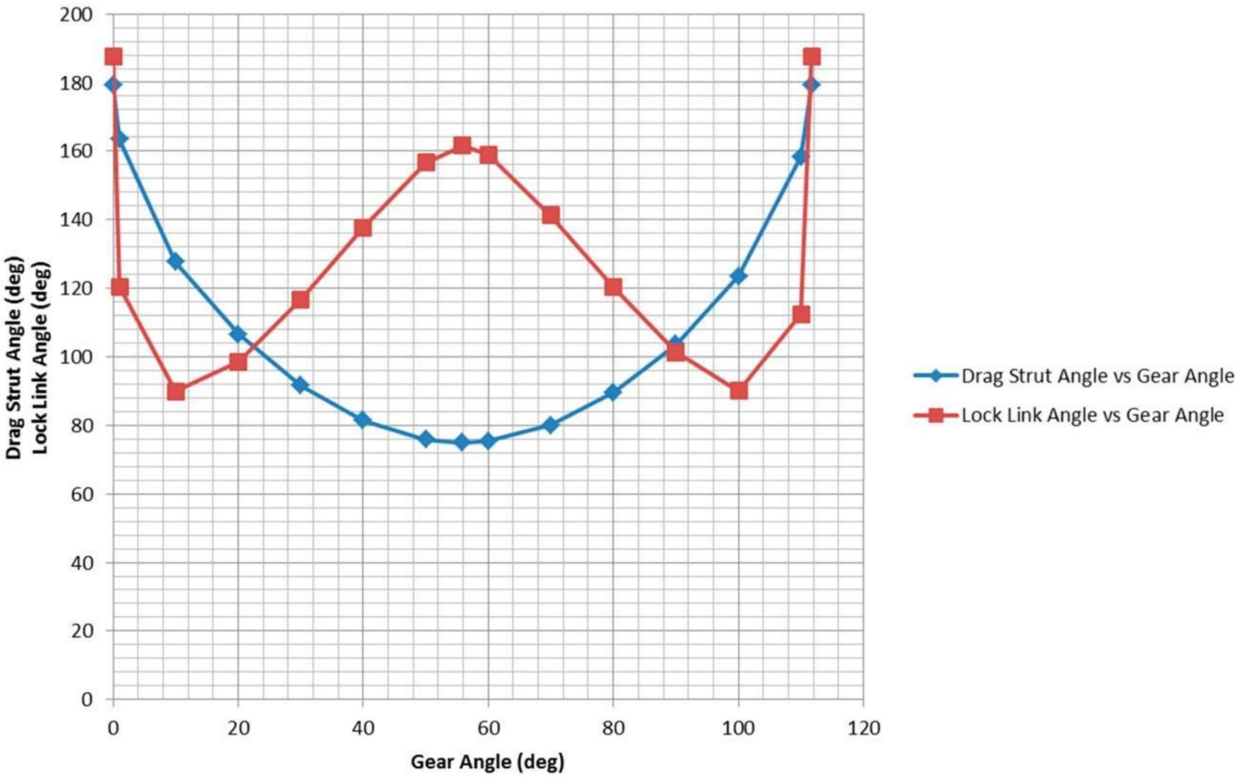


Picture 77 Relevant Angular Dimensions for Table 2 and Figure 5

α = Gear angle β = Drag strut angle
γ = Lock link angle

α (deg)	β (deg)	γ (deg)	Comments
0.00	179.15	187.5	NLG fully extended (down-and-locked)
1.00	163.47	120.42	
10.00	127.72	89.93	
20.00	106.52	98.56	
30.00	91.59	116.74	
40.00	81.34	137.63	
50.00	75.83	156.69	
55.85	74.95	161.56	Reversal point (likely point of jamming during incident)
60.00	75.39	158.97	
70.00	80.06	141.20	
80.00	89.51	120.22	
90.00	103.60	101.28	
100.00	123.45	90.09	
110.00	158.39	112.33	
111.71	179.15	187.50	NLG fully retracted (up-and-locked)

Table 5: Drag Strut Angles and Lock Link Angles for Various Gear Angles



Picture 77 Drag Strut Angle and Lock Link Angle vs Gear Angle

- The exact lock link angle at the minimum drag strut angle depends on the clearances that are present in the turning points of the locking mechanism. From images just before touchdown of the aircraft it is concluded that the gear angle was approximately 60°. A possible scenario is that the locking mechanism locked when the drag strut angle was at the minimum value;
- When the locking mechanism is locked at the minimum value of the drag strut angle and it is unable to unlock, then a high compressive load is introduced to the locking mechanism when the aircraft is landing and puts load on the NLG;
- This is because the weight of the aircraft results in a load that will pushes towards higher gear and drag strut angles. As a result, the lugs of the lower drag strut introduce a compressive stress in the LLL (in the direction of the long axis of the LLL) through the LLL pin. Since the pin is not designed for carrying the load that is introduced by the weight of the aircraft with the drag strut in this abnormal geometry, this would result in failure of the pin. The load carrying capacity of the upper lock link pin is equal to the LLL pin and the load path also runs from the upper lock link to the upper drag strut through this pin. Therefore, the upper lock link pin is likely to fail when the LLL pins fails;

- All damage observed on the drag strut assembly agrees with this failure scenario, because both the LLL pin and the upper lock link pin were severely deformed and failure occurred by shear overload. The LLL apex pin did not fail, but was unable to rotate due to heavy deformation;

- The bushings of the two lugs on the lower drag strut are heavily deformed and the two lugs are slightly deformed This also indicates that a high compressive load was introduced in the LLL;

- The link and the pivot tube only have some scratchings or top coating damage, this is as expected because in the locked state the load is transferred from the lower drag strut through the LLL and the upper lock link into the upper drag strut. This did not only lead to failure of the pins, but also the skewing of the entire upper lock link on the upper drag strut;

- It is expected that the surface damage on the upper drag strut, are caused by impact of foreign objects and are not directly related to the failure of the drag strut assembly. It is expected that the surface damage to the upper drag strut is introduced after failure of the drag strut assembly by the nut of the LLL pin. The failed LLL pin was still present after disassembly of the NLG and it is expected that the damaged pin with the nut came out of the bushing and scraped along the upper drag strut when the lower drag strut was rotating during disassembly of the NLG.

- The surface damage to the upper drag strut is located at the position of the LLL apex pin. It is expected that the surface damage between the lugs of the lower drag strut is caused by the LLL after failure of the LLL pin, the lost connection makes it possible for the LLL to come into contact with the lower drag strut. The same applies for the surface damage on the upper drag strut and the bottom of the upper-and lower lock link. The lost connection makes it possible for these parts to come into contact with each other. The same is expected for the surface damage on the upper lock link which could have come into contact with the proximity sensors after failure of the LLL pin.

- It is likely that the lugs of the lower drag strut came into contact with the upper lock link after failure of the LLL pin. The surface damage and deformation on these parts are similar and these surfaces are in line with each other when the locking mechanism is locked at the minimum drag strut angle. The contact between these parts would prevent full retraction of the NLG immediately after failure of the LLL pin. After landing and stopping of the aircraft, the gear angle was still at approximately 60°. It is possible that the upper lock link pin failed simultaneously with the LLL pin or when the lugs of the lower drag strut came into contact with the upper lock link. However, for the root cause analysis this is of less importance.

- Failure of the LLL lug for the LLL pin occurred by overload. It is expected that overloading of the LLL pin resulted in ovalization of the bushings and the lug, which resulted in high tensile stress in the lug. The high tensile stress resulted in failure by overload at the top and bottom fracture surface and the second crack in the LLL. In addition, the stress in the lug was raised by the decrease in thickness from the corrosion and the presence of stress concentrators such as the corrosion pits and small fatigue cracks. The fatigue cracks were very small and the striation spacing shows that the crack growth rate was low. Together with the large area of dimples on the fracture surface this indicates that the fatigue cracks did not reach critical size and did not play a contributing role in the failure scenario. UTAS did not find fatigue cracks in these lugs during overhaul of other drag strut assemblies. All load cases pertinent to the drag strut assembly were tested by UTAS during certification fatigue testing and pressure impulse testing. There was no fatigue cracking observed after these tests. It is likely that the corrosion accelerated fatigue initiation by decreasing the lug thickness, creating surface defects and/or embrittlement by hydrogen from the corrosion process.

- The described failure scenario is only possible if the locking mechanism is able to lock at the minimum drag strut angle. During retraction of the NLG, the unlock actuator is constantly pushing the pivot tube clockwise (observed from the LH side), which means that it is constantly trying to lock the mechanism during retraction. This will result in a compressive load in the LLL between the holes for the LLL pin and the LLL apex pin.
  Whenever the LLL pin lug would be missing, this would not lead to locking of the mechanism;
- The locking is only possible if the distance between the turning points of the mechanism decreases, which allows the lock link angle to increase at the minimum drag strut angle. Since both the LLL pin hole in the LLL and the bushings were affected by corrosion on the LLL, it is possible that the corrosion decreased the distance between the turning points. The total free-play in the compressive direction (distributed across all joints of the lock link) that is necessary for the lock link angle to reach 180° at the minimum drag strut angle is 1220 μm (0.048”);

- The coating is not present in and around the LLL hole for the LLL pin and the metal is affected by corrosion. A stacked digital optical microscopy image of the surface of the hole and for a random location the difference in height is 573 µm, while the surface should be straight. Not only the coating, but also the cadmium plating is not present anymore. The surface of the bushing also shows uniform pitting and the pitting depth is in the order of 20 µm. It is likely that the thickness of the bushing has decreased due to the corrosion pitting. However, due to the deformation of the bushings from the landing, it is possible to determine the thickness reduction prior to the incident. When all clearances in the other turning points and the thickness reductions are added, it is expected that it results in sufficient free-play necessary for the lock link angle to reach 180° at the minimum drag strut angle.

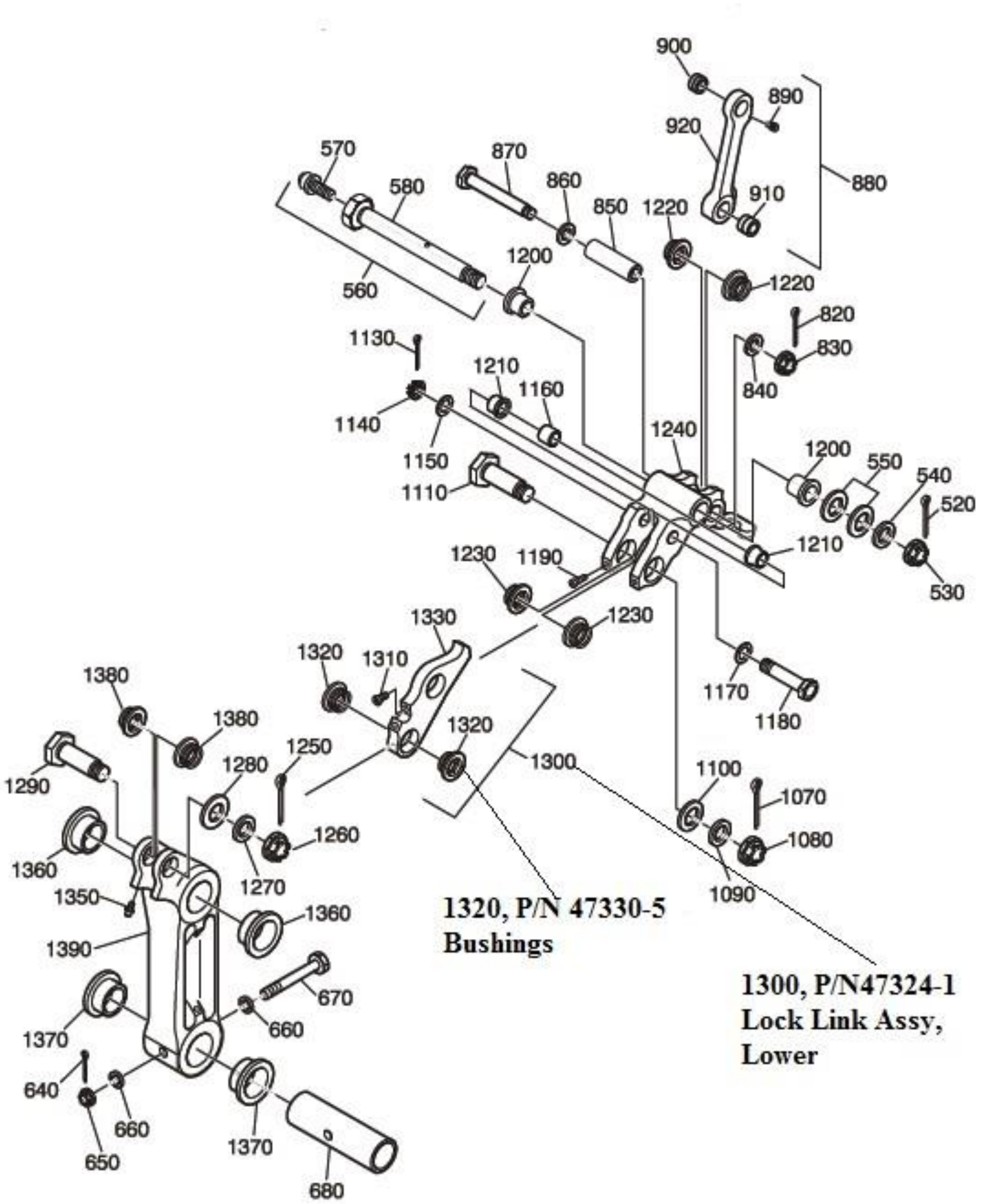
- The severity of the corrosion at the LLL hole for the LLL pin is higher than normally observed for other airlines. The corrosion at the LLL hole for the apex pin is much less for this particular LLL and other LLL of aircrafts operated by airBaltic. Similar corrosion has been observed at the LLL hole for the LLL pin for other aircrafts operated by airBaltic. For all lower lock links that were inspected by airBaltic, the top coat and the sealant around the bushings of the LLL hole for the LLL pin was damaged. The bore of several LLL pin holes showed corrosion. However, one LLL did not show corrosion, but the top coat and the sealant was damaged. Damage to the top coat and sealant allows for ingress of corrosive fluids, such as salt water or de-icing fluids. It is therefore concluded that the corrosion is a result of damage to the corrosion protection (top coat and sealant).

- It is possible that the close proximity to the Gulf of Riga and/or the use of particular deicing fluids resulted in a higher corrosion rate compared to other airliners. The presence of damage to the top coat and sealant of the LLL pin holes for all lower lock links that were inspected by airBaltic indicates that there could be a problem **with the retention of the bushings.** Rotation of the bushing not only results in damage to the top coat and sealant, but also to the primer and cadmium plating in the bore of the hole. This would expose the bare steel to corrosive fluids.

- It is likely that corrosion of the LLL hole for the LLL pin has decreased the total distance between the turning points of the locking mechanism. Over time this would inevitably result in locking of the mechanism at the minimum drag strut angle. When the aircraft lands and puts load on the NLG, this will direct all load through the locking mechanism is, which is not designed to carry this load. All damage observed in the drag strut assembly agrees with overloading of the locking mechanism when it is locked at the minimum drag strut angle. Locking of the mechanism at this position is only possible if the total distance between the turning points is decreased. Therefore, it is concluded that corrosion of the LLL hole for the LLL pin is the cause of the locking and failure of the drag strut assembly. The corrosion is most likely a result of damage to the top coat and sealant, which allowed for ingress of corrosive fluids.

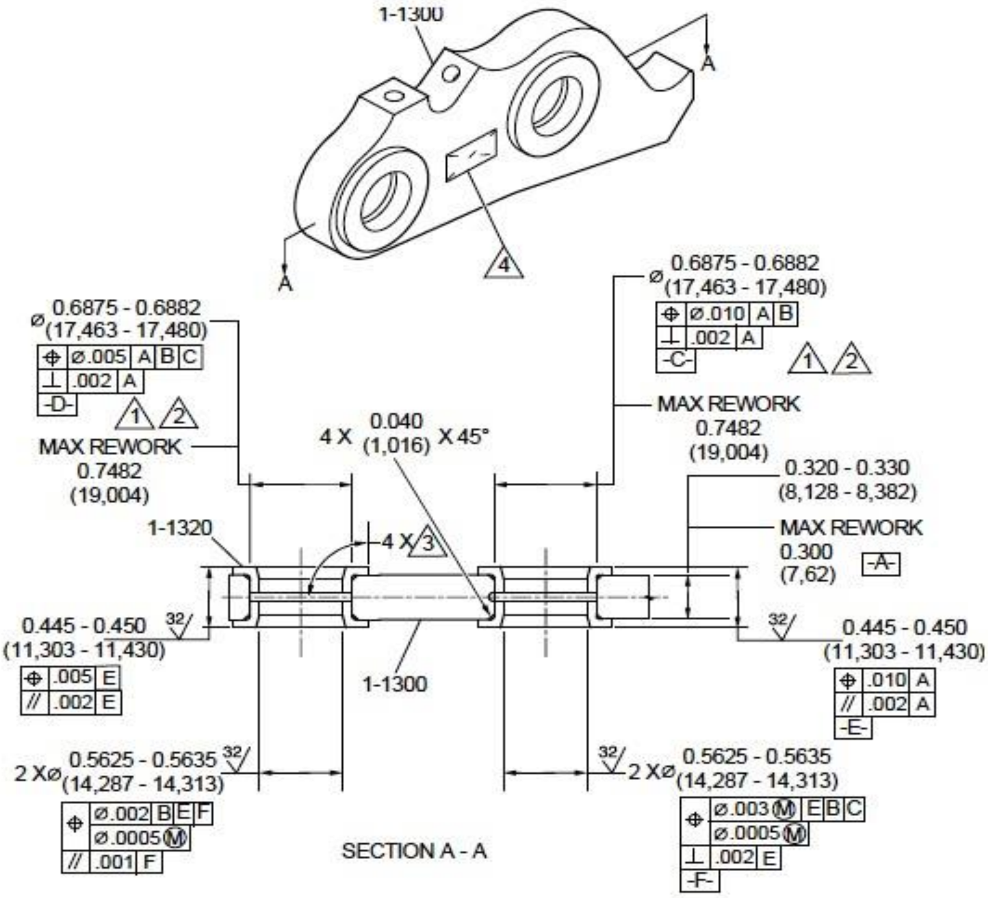
2.11. Lower lock link bushings

According to aircraft manufacturer information UTAS review of bushings spares sales indicates that about 1/3 of NLG assemblies overhauled had a set of bushings replaced. UTAS MROs had received 49 drag struts for overhaul in the 2010-2016 timeframe, with no recorded incident of such severe corrosion on the lower lock link lug.



Picture 78 Drag Strut Assembly

This is evidence that rather bushings retention is a main problem and it is widespread while the corrosion damage might be endemic to certain geographical areas only.



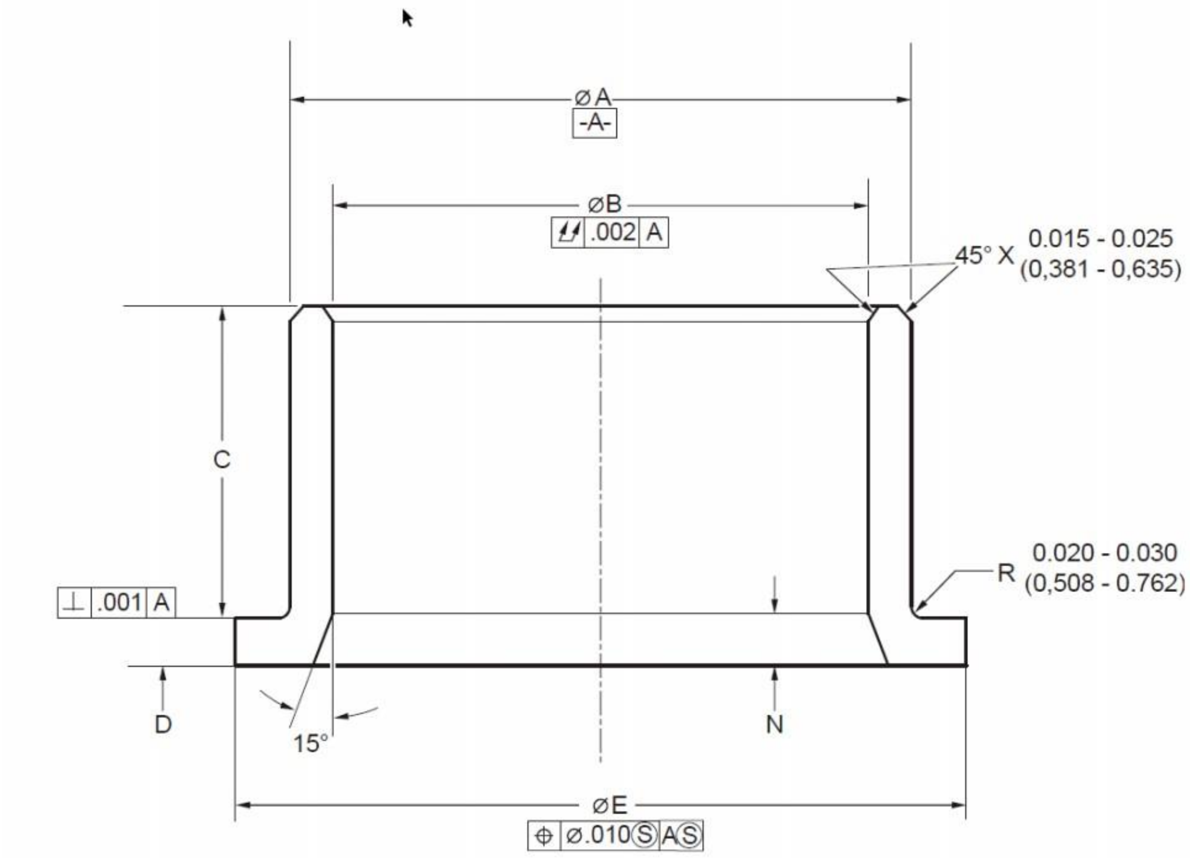
Picture 79 Drag Strut Assembly bushing (1320)

Per design the interference fit should be 0.0001” to 0.003”. A brief analysis indicates that if parts are made to provide minimal interference fit of 0.0001” at 20 C, the interference is eliminated completely at about -10C. Minimal interference of at least 0.0004” is required to ensure some marginal retention at -54C. Even single event when the bushing retention is compromised leads to breaking the sealant and subsequent moisture intrusion. A lock link with broken sealant is at risk of failure. Locklinks with this condition should be eventually repaired/replaced.

As per Landing Systems-Landing Gear, P/N47300 CMM, Revision 5 the bore in the LL can be opened up to 0.060” and oversized bushings are approved. Rework (as per CMM, Chapter Repair) of the lock link includes machining 300M part, NDT, plating, baking and freeze fit of new bushings. This is complex and time consuming process. Aircraft manufacturer has been requested NLG manufacturer UTAS to consider the possibility of a temporary repair that would include bushing removal, cleaning of the corrosion, brush Cad plating and reinstallation of bushings with an adhesive. Consequently this should be accompanied with some inspection schedule until the locklink is replaced or permanently repaired. Adhesive should also be investigated as an additional mean of bushing retention improvement for repairs/production. Locktite sealant was proven effective in improving grease fitting retention.

Once a repair scheme is developed and approved consequently repeated inspection should be introduced. Eventually, the lock link assembly needs to be redesigned to ensure proper retention of the bushings.

The Laboratory Report indicates corrosion pits on the OD of the AL-Ni bronze bushings. Although pitting is evident, but there are no signs of any corrosion products (typically copper alloy corrosion products are copper carbonate and its derivatives). These are relatively poorly soluble in water and green in color, making it easy to see. Copper formate and copper acetate are soluble in water but are intense blue in color, so these should have left some discoloration on the LLL. None of this was found. The nature of pits on the OD of the bushings remains unknown.



Picture 80

FIG/ ITEM No.	BASIC BUSHING DIMENSION					GROOVE INFORMATION				CORNER RELIEF
	A	B	C	D	E	F	G	H	J	N
1320	0.6883 (17,482)	0.5550 (14,097)	0.120 (3,05)	0.083 (2,11)	0.890 (22,61)	NA	NA	NA	NA	0.090 (2,29)
	0.6887 (17,493)	0.5590 (14,199)	0.130 (3,30)	0.093 (2,36)	0.910 (23,11)					

Bushings interference fit was marginal. An **interference fit**, also known as a **press fit** or **friction fit** is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening. The **tightness** of fit is controlled by amount of interference. In engineering and machining, an **allowance** is a planned deviation between an exact dimension and a nominal or theoretical dimension, or between an intermediate-stage dimension and an intended final dimension. The value of the allowance depends on which material is being used, how big the parts are, and what degree of **tightness** is desired. **What degree of tightness is desired or applied in fastening bushings with LLL hole (bore) not indicated it the specifications of Landing Systems-Landing Gear, P/N47300 CMM.**

This was validated by 47324 drawing review (Picture 79). Minimal interference fit can be as low as 0.0001 inch. Friction torque between the pin and the bushing exceeded retention capability of the interference fit between the bushing and the LLL body. Analysis shows that at minimal interference fit of 0.0001 inch, the temperature drop by 30□C eliminates the interference completely. It means that at about -10 C the bushings would free spin if not hold in place by filled bead of sealant. Bushings are spun and sealant bead is damaged. Repeated spinning removed layer of primer. As a result moisture and runway deicers penetrated the joint, salt based (potassium formate and sodium acetate) dissolved cadmium plating and base metal corrosion progressed. Repeated spinning removed corrosion products exposing the base metal. Bushing OD wears out and copper alloy form galvanic cell with exposed 300M steel further accelerating the corrosion. Mating surface of the bushing with the inside of the LLL pin hole is very rough. Material loss from OD is evident. On copper alloy corrosion products are in the middle of this surface and a channel is present that runs in the circumferential direction.

The small engaged length of this particular bushing was also a factor in addition to the low radial interference. The radial interference sets the interference pressure, and the relationship between this interference pressure and the load reaction capability of the interface is determined, in part, by the engaged length of the bushing.

Picture 81 Optical microscopy image of the mating surface of the bushing with the inside of the LLL pin hole

Corrosion of LLL hole and wear of bushing OD led to excessive clearance in the mechanism and allow for jamming of the NLG. Landing loads damaged the locking mechanism.

2.12. Management of Fire-fighting and Rescue Operations

According to Section 14 of Fire Safety and Fire-fighting Law:

- Fire-fighting and rescue operations shall be managed by the official with a special service rank. Until the arrival of the unit of the State Fire-fighting and Rescue Service, fire-fighting and rescue operations shall be carried out by the the fire safety, **fire-fighting and rescue services of the institutions**, organisations, commercial companies and local governments;
- All fire safety, **fire-fighting and rescue services**, any other services, units, as well as natural persons present at the place of fire or accident **are subject to the manager of firefighting and rescue** operations.

In the given case, until the arrival of the staff of the State Fire-fighting and Rescue Service (VUGD), rescue operations shall be managed by the Fire Fighting team "UK" manager Riga international airport.

The investigation, neither in the Fire Safety and Fire-fighting Law, neither in the Cabinet Regulation No. 331, May 31, 2016 "Regulations on measures relating to civil aviation accidents", neither in the Emergency Action Plan KV 1135 P did not establish any evidence of how the management of fire and rescue works was taken by State Fire-fighting and Rescue Service (VUGD) from the Riga International airport Fire Fighting team manager. **There was not in place formalized process of taking over responsibility.**

Taking into account that State Fire-fighting and Rescue Service VUGD did not participate with all the manpower arriving at the place, therefore **there was not provided the necessary help to all passengers and part of passengers evacuated unaided through the rear door**.

During the evacuation responsible officer for the rescue work did not monitor **the overall situation**.

3. Conclusions

3.1. Findings

1. The flight crew was properly licensed.

2. The aircraft had a valid airworthiness certificate.

3. The mass and centre of gravity was within the limitations.

4. The weather at the time of the accident was VMC.

5. The aircraft maintenance records were verified to be in compliance with the established maintenance program.

6. Since Year 2011 in FDM have been recorded 4 hard landings with Vertical G value equal to or exceeding 2.2G – threshold to carry out hard landing maintenance actions. **No Overweight landings on YL-BAI in FDM recorded.**

7. After landing the NLG collapsed not abruptly but progressively.

8. Aircraft fuselage damage was limited to the NLG front door.

9. The damage to the components was largely confined to the locking mechanism.

10. In the locked state the load was transferred from the lower drag strut through the LLL and the upper lock link into the upper drag strut. This lead to failure of the pins, as well as the skewing of the entire upper lock link on the upper drag strut;

11. When the locking mechanism was locked at the minimum value of the drag strut angle and it is unable to unlock, then a high compressive load was introduced to the locking mechanism when the aircraft was landing and puts load on the NLG;

12. All damage observed in the drag strut assembly confirms overloading of the locking mechanism when it locked at the minimum drag strut angle.

12. The fatigue cracks originated at corrosion pits did not reach critical size and did not play a contributing role in the failure scenario.

13. On the OD of the AL-Ni bronze bushings corrosion pitting was likely evident, but there was not found signs of any corrosion products, which left signs of discoloration on the LLL. The nature of pits on the OD of the bushings remains unknown.

14. For all lower lock links that were inspected by airBaltic, the top coat and the sealant around the bushings of the LLL hole for the LLL pin was damaged. The bore of several LLL pin holes

showed corrosion. However, one LLL did not show corrosion, but the top coat and the sealant was damaged.

15. The severity of the corrosion at the LLL hole for the LLL pin is higher than normally observed for other airlines.

16. Damage to the top coat and sealant allows for ingress of corrosive fluids, such as salt water or de-icing fluids. The corrosion is a result of damage to the corrosion protection (top coat and sealant).

17. Even single event when the bushing retention is compromised leads to breaking the sealant and subsequent moisture intrusion. A lock link with broken sealant is at risk of failure.

18. Corrosion of LLL hole and wear of bushing OD led to excessive clearance in the mechanism and allows for jamming of the NLG.

19. The total free-play in the compressive direction (distributed across all joints of the lock link) that is necessary for the lock link angle to reach 180° at the minimum drag strut angle is 1220 μm (0.048”);

20. When all clearances in the other turning points and the thickness reductions are added, it is expected that it results in sufficient free-play necessary for the lock link angle to reach 180° at the minimum drag strut angle.

21. . Locking of the mechanism at the minimum drag strut angle position is only possible if the total distance between the turning points of the locking mechanism is decreased.

22. Bushings minimal interference fit can be as low as 0.0001 inch, bushings interference fit is marginal.

23. When bushings would free spin if not hold in place by filled bead of sealant and sealant bead is damaged then repeated spinning removed layer of primer. As a result moisture and runway de-icers penetrated the joint, salt based (potassium formate and sodium acetate) dissolved cadmium plating and base metal corrosion progressed. Repeated spinning removed corrosion products exposing the base metal, bushing OD wears out and copper alloy form galvanic cell with exposed 300M steel further accelerating the corrosion.

24. In accordance with CMM the bore in the LL can be opened up to 0.060” and oversized bushings are approved. Rework (as per CMM) of the locklink is complex and time consuming process. Temporary repair would include bushing removal, cleaning of the corrosion, brush Cad plating and reinstallation of bushings with an adhesive. This **should be accompanied with some inspection schedule** until the locklink is replaced or permanently repaired.

25. What degree of tightness is desired or applied in fastening bushings with LLL hole (bore) not indicated in the specifications of Landing Systems-Landing Gear, P/N47300 CMM.

26. Removal aircraft from Runway takes time 4 hours and 42 minutes.

27. During the evacuation responsible VUGD officer for the rescue work did not monitor the overall situation.

28. There was not in place formalized process of taking over responsibility of the management of fire and rescue works by State Fire-fighting and Rescue Service (VUGD) from the Riga International airport Fire Fighting team manager.

29. Regulations of State Fire-fighting and Rescue Services as well as Riga International airport **have not consist in formalized process** of taking over responsibility of the management of fire and rescue works in the airport by State Fire-fighting and Rescue Service (VUGD) from the Riga International airport Fire Fighting team manager.

30. Aircraft Operator airBaltic doesn't have any special aircraft recovery equipment.

31. Riga International airport doesn't have facilities for recovering aircraft that is unable to move under its own power or through the normal use of an appropriate tow tractor and tow bar.

3.2. Causes

3.2.1. Root cause

Root cause is insufficient retention of the bushings in the LLL body.

3.2.2. Direct cause

Excessive clearance in the mechanism by virtue of corrosion of LLL hole and wear of bushing OD.

3.2.3. Possible contributing causes

1. Moisture and runway de-icers penetration in the joint, salt based (potassium formate and sodium acetate) cadmium plating dissolving and base metal corrosion progression.
2. Insufficient tightness applied in fastening bushings with LLL hole.
3. Possibility that the upper lock link pin failed simultaneously with the LLL pin or when the lugs of the lower drag strut came into contact with the upper lock link.

4. Safety Recommendations

4.1. Safety initiatives during the investigation

During the course of the investigation the following safety actions were issued:

4.1.1. Transport Canada issued Airworthiness Directive (AD) CF-2018-01, which introduced a repetitive inspection and repair requirement. The manufacturer has indicated that it intends to redesign the affected part.

4.1.2. airBaltic has reduced lubrication interval to 270 FH for Lock Link. Reason of such figure so that next lubrication would match with general NLG lubrication task of 500 FH.

4.1.3. airBaltic for landing gear lubrication was switching to use Aeroshell Grease 33, instead Aeroshell Grease 7 used before.

4.2. The Transport Accident Incident Investigation Bureau, Latvia makes the following recommendations:

Recommendation - LV2017-002

The investigation revealed that the NLG was locked because the bushings on the lock link of the NLG locking mechanism becoming loose, due to insufficient interference fit which resulted in some bushing outer diameter wear and fretting. A dislodged bushing will also cause the bushing sealant to break and allowed to ingress moisture and corrosion. Excessive free play at the lock link can result in the inability to fully retract or deploy the NLG, resulting in a risk of NLG collapse on landing.

Consequently, the Transport Accident Incident Investigation Bureau makes the following recommendation to the Authority Transport Canada responsible for transportation system:

In coordination with other involved parties of industry urgently develop and implement an Airworthiness Directive that will allow the locklink assembly to be redesigned to ensure proper retention of the bushings of aircraft equipped with Lower Drag Strut Assembly part number 47300.

Recommendation - LV2017-003

The investigation showed that the bushing retention leads to breaking the sealant and subsequent moisture intrusion. The bushings are spun as a result sealant bead is damaged. Repeated spinning removes layer of primer. Penetrated moisture and runway deicers in the joint leads to corrosion of LLL hole that together with wear of bushing OD leads to excessive clearance in the mechanism and allow for jamming of the NLG. A locklink with broken sealant is at risk of failure. The locklink assembly needs to be redesigned to ensure proper retention of the bushings.

Consequently, the Transport Accident Incident Investigation Bureau makes the following recommendation to the aircraft manufacturer Bombardier Inc. :

It is recommended to review the design, the certification and the maintenance program of the aircraft Bombardier DHC-8-402 NLG Lower Drag Strut Assembly part number 47300.

Recommendation - LV2017-004

The aircraft must be removed in a timely and efficient manner. If the aircraft operator fails to take Responsibility for the removal operation, the aerodrome operator may take over the responsibility of removal disabled aircraft or contract the removal to a third party. It is suggested that the aerodrome operator, in conjunction with the aircraft operators, hold regular tabletop exercises in order to anticipate various aircraft removal scenarios and their projected outcomes.

Responsibilities for the removal of a disabled aircraft ***lie not only with the aircraft operator, but also with the State and the aerodrome operator.*** *For an aircraft removal operation to begin and be completed as quickly as possible, all parties must be expeditiously facilitated and already have the proper procedures in place. An efficient removal operation requires sufficient planning and* ***readily accessible recovery equipment****.*

Riga International aircraft has not facilities for removing aircraft that is unable to move under its own power or through the normal use of an appropriate tow tractor and tow bar.

Consequently the Transport Accident Incident Investigation Bureau, Latvia makes the following recommendation to the Riga International airport:

It is recommended that the Riga International airport consider opportunity to complement facilities and equipment list of Removing Disabled aircraft Plan with equipment to provide for removing aircraft that is unable to move under its own power or through the normal use of an appropriate tow tractor and tow bar.

Recommendation - LV2017-005

Consequently the Transport Accident Incident Investigation Bureau, Latvia makes the following recommendation to Operator airBaltic:

It is recommended that the **airBaltic** consider opportunity to complement facilities and special aircraft recovery equipment.

Recommendation - LV2017-006

Upon ***State Fire-fighting and Rescue Service (VUGD)*** *arrival at the airport and, accordingly, takeover of the management, VUGD was responsible of the evacuation of passengers from the aircraft. As VUGD did not participate with all of the resources at incident on-site, passengers were not given assistance by evacuation through the aircraft rear doors.*

Consequently the Transport Accident Incident Investigation Bureau, Latvia makes the following recommendation to State Fire-fighting and Rescue Service (VUGD):

It is recommended that the *State Fire-fighting and Rescue Service (VUGD) shall organize VUGD responsible staff "****TABLE top****" training in cooperation with Riga International airport* **Fire fighter team (UK).**

Recommendation - LV2017-007

Consequently the Transport Accident Incident Investigation Bureau, Latvia makes the following recommendation to State Fire-fighting and Rescue Service (VUGD):

It is recommended that the *State Fire-fighting and Rescue Service (VUGD) shall formalize management takeover process to record the taking over responsibility for the event site.*

May 17. 2018 Riga

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