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In this issue

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Editorial

As we approach winter, we are reminded of the snowing conditions, slippery runways, and other aspects associated with winter operations. It is our duty to remind the flight deck crew of the dangers associated with winter operations, be it snow or precipitation.

In this issue, we look into the fatal crash of a Bombardier Challenger 604 at Birmingham in 2003 which was due to the failure to de-ice the frost on the wings before takeoff.

We discuss the intake icing, fan-blade icing, ground de-icing/anti-icing, and the effect of runway de-icing fluids on braking, particularly carbon brakes.

Finally, we have a brief on the hydraulic system failure incident on a B747 due to a tire burst during takeoff.

As always, we look forward to your feedback, suggestions and contributions which can be sent to our office address given in this page. Happy reading and many more safe landings.

Uncontrolled roll on takeoff

On January 4, 2002, at 1207hrs (UTC), a Bombardier Challenger 604 (N90AG) began to roll left immediately after liftoff on runway 15 at Birmingham International airport, UK. In spite of the crew applying correct aileron and rudder inputs, the roll continued. The left winglet struck the runway shoulder, and the airplane struck the ground inverted and burned. The two pilots, an observer and two passengers were killed.

The UK Air Accident Investigation Board (AAIB) investigated the accident and identified the following causal factors:

- The crew did not ensure that N90AG's wings were clear of frost prior to takeoff.
- Reduction of the wing stall angle of attack, due to the surface roughness associated with frost contamination, to below that at which the stall protection system was effective.

© D.Pedley/UK AAI report 5/2004

- Possible impairment of crew performance by the combined effects of a non-prescription drug, jet-lag (circadian desynchronosis) and fatigue.

N90AG was operated by Epps Air Services in Atlanta, Georgia, USA.

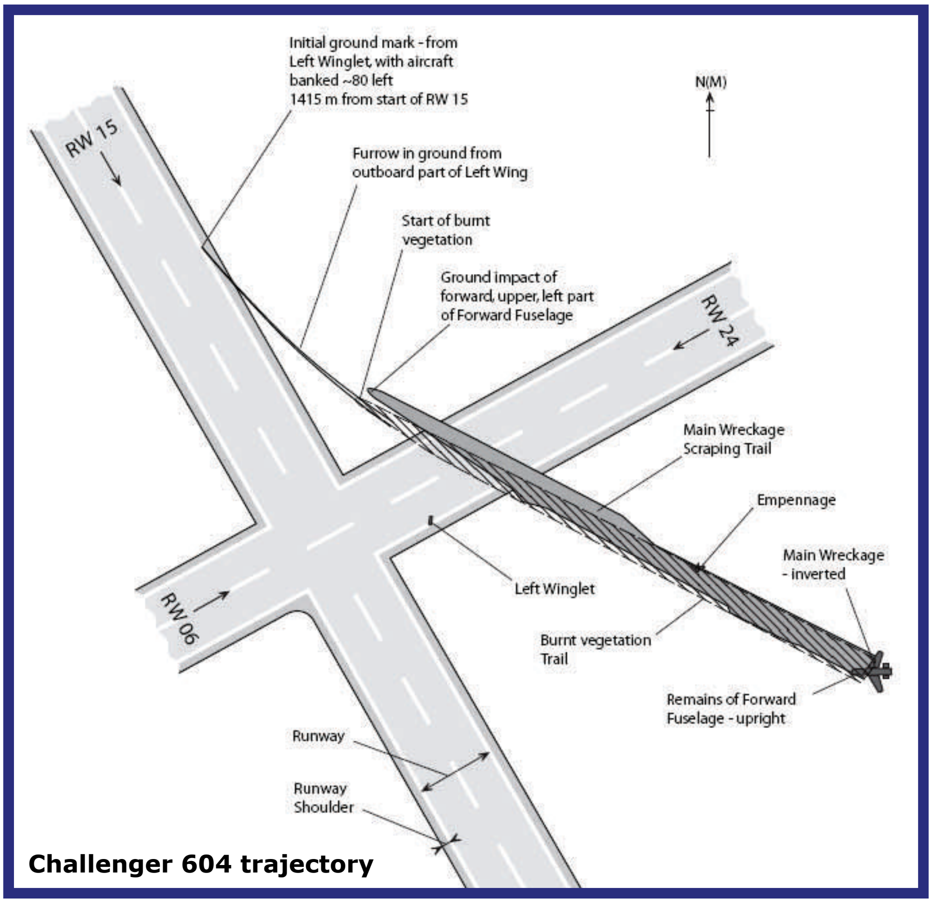
The commander (PIC), 51, had an ATP and about 10,000 flight hours, including about 800hrs on the type. He was the director of operations for Epps Air Services.

The second-in-command (SIC), 58, had an ATP and about 20,000 flight hours, including about 800hrs on the type.

On January 3,2002, the crew came on duty at 0900hrs (0400hrs local time) at PDK in preparation for a planned flight to the UK. An additional company pilot, not qualified on the Challenger 604 and not part of the flight crew, was on board as an observer for transatlantic experience.

The aircraft and crew departed PDK at 1015hrs for a flight to Fort Myers Airport (FMY) in Florida to pick up a passenger. After landing at FMY at 1135hrs, N90AG departed at 1200hrs for a flight to West Palm Beach Airport (PBI) to pick up a second passenger. The aircraft landed at PBI at 1230hrs and departed at 1259hrs.

After an uneventful flight, N90AG arrived at Birmingham Airport at 2039hrs. The aircraft was parked outside overnight. Ground de-icing personnel categorized frost conditions as severe with 12.7mm accumulation on wing surfaces.



Challenger 604 trajectory

The aircraft was parked on the Western Apron. Over the night the air temperature remained below zero, with a minimum of -9°C at 0550hrs. Initially the sky was clear, with increasing, but variable cloud cover after midnight. The surface wind overnight was south-easterly at about 3 kt.

The two pilots and the observer spent the night in a local hotel. Records indicated that they checked in at approximately 2115hrs and had a meal and some alcohol between 2144hrs and 2315hrs, before retiring to bed. The handling pilot for the return to the USA made a phone call home at 0200hrs.

The next morning, the handling pilot and the observer arrived at the aircraft together at approximately 1040hrs. Evidence from the dispatchers indicated that the APU was started at about 1050hrs. The commander arrived at approximately 1100hrs.

At different times, each of the two crew members was seen to carry out an independent external inspection of the aircraft. Aircraft refueling commenced at about 1105hrs and the aircraft fuel tanks were reported full at about 1140hrs. Then, following the arrival of the two passengers, the aircraft doors were closed. The occupants were the same as on the arrival flight. During the morning, various witnesses had seen frost/ice on the wing surfaces of N90AG.

Other aircraft had been deiced during the morning, with associated reports of severe to moderate ice accumulation. Evidence from the CVR indicated that the operating pilots discussed the presence of frost on the leading edge prior to engine start. However, neither requested deicing and N90AG was not deiced. The Birmingham METAR at 1150hrs was as follows: surface wind 150°/6kt; visibility 8,000m; cloud scattered at 700 ft & broken at 800ft AGL; temperature -2°C with dew point - 3°C; QNH 1027mb.

Following ATC clearance, engine start was at 1156hrs and N90AG was cleared to taxi at 1201hrs. All radio calls during the accident flight were made by the commander, seated in the right cockpit seat. During taxi, the crew completed their normal Before Takeoff Checks; these included confirmation that the control checks had been completed and that anti-ice might be required immediately after takeoff. Flap 20 had been selected for takeoff and the following speeds had been calculated and briefed by the pilots: V1 137kt; VR 140kt; V2 147kt. By 1206hrs, the aircraft was cleared to line up on Runway 15. At 1207hrs, N90AG was cleared for takeoff with a surface wind of 140°/8kt. The pilot in the left seat was handling the controls.

Takeoff appeared normal up to lift-off. Rotation was started at about 146kt with the elevator position being increased to 8°, in the aircraft nose up sense, resulting in an initial pitch rate of around 4°/sec. Lift-off occurred 2 seconds later, at about 153kt and with a pitch attitude of about 8° nose-up. Once airborne, the elevator position was reduced to 3° aircraft nose-up whilst the pitch rate increased to about 5°/sec.

Immediately after lift-off, the aircraft started to bank to the left. The rate of bank increased rapidly and 2 seconds after lift-off the bank angle had reached 50°. At that point, the aircraft heading had diverged about 10° to the left.

Opposite aileron, followed closely by right rudder, was applied as the aircraft started banking; full right aileron and full right rudder had been applied within a second and were maintained until the end of the recording. As the bank angle continued to increase, progressively more aircraft nose-up elevator was applied.

Stick-shaker operation initiated 3.5 seconds after lift-off and the recorders ceased 2 seconds later. The aircraft struck the ground, inverted, adjacent to the runway. The last recorded aircraft attitude was approximately 111° left bank and 13° nose-down pitch; the final recorded heading was about 114°(M).

The aircraft was largely destroyed by impact and fire damage (see photo above). All the five onboard died.

The Aircraft Accident Investigation

Board (AAIB), UK investigated the accident and found the following.

- The flight crew were properly licensed to conduct the flight. The pilot in the right seat was the designated commander and the pilot in the left seat was the handling pilot and SIC.
- Frost deposits had formed on the aircraft while parked overnight in subzero temperatures.
- The pilots did not request aircraft de-icing and the aircraft was not deiced before takeoff.
- Frost contamination of aircraft lifting surfaces was present when the aircraft took-off.
- As the aircraft lifted off, the left wing stalled at an abnormally low angle of attack, causing the aircraft to roll rapidly to the left.
- The roll could not be stopped despite immediate and full application of corrective aileron and rudder controls.
- The left wing tip contacted the ground and the aircraft crashed inverted.
- The aircraft weight was within normal limits. The position of the longitudinal centre of gravity could not be determined accurately but did not contribute to the accident.
- The pitch trim was not set in accordance with the schedule but this did not contribute to the accident.
- Wake turbulence from preceding aircraft did not contribute to the accident.
- There was a fault with the aircraft stall protection system but this did not contribute to the accident.
- A small degree of wing surface roughness can cause a major reduction in the wing stall angle of attack.
- Wing surface roughness associated with frost contamination caused sufficient flow disturbance to result in a wing stall at an abnormally low angle of attack. The stall protection system was ineffective in this situation.
- The Challenger 604 aircraft typically does not stall symmetrically and any tendency to roll could be accentuated by asymmetric ice contamination.
- APU exhaust gas flow during pre-flight preparations probably caused some asymmetry in the frost contamination.
- Long standing FAA guidance material suggesting that polished wing frost was acceptable is inappropriate.

The accident flight was conducted under FAR part 91 [*General operating and flight rules.*] Part 91.527 states that takeoff is prohibited with "any frost adhering to the wings or stabilizing or control surface, unless that frost has been polished to make it smooth." Part 135 [*Commuter and on-demand operations*] has a similar provision (Part 135.227).

Attempts were made to determine the definition of 'polished frost' and, indeed, how to polish frost, but nothing was found.

- The means intended to ensure that the aircraft's aerodynamic surfaces were clear of ice contamination were procedural. The challenger 604 flight manual states " *take off must not be attempted if snow, ice or frost are present in any amount on the wings and tail surfaces of the airplane."*
- The airframe ice detection system was not designed to provide an effective crew warning of pre-take-off frost contamination of the wings.
- Crew rest periods were in accordance with FAA regulations but the performance of both crew members may have been affected by jet-lag and fatigue.
- Traces of a non-prescription drug containing diphenhydramine, typically used to aid sleep, were found in both pilots. *Specialist medical opinion was that it was possible that the judgment and reasoning of both crew members had been adversely affected by a combination of jet-lag, tiredness and the effects of diphenhydramine.*
- Typically there were no warnings about drowsiness or avoiding operating machinery on the packaging of sleep aid drugs sold in the USA containing diphenhydramine.

AAIB determined the following as the causes of the accident

1. Crew did not ensure that the wings were clear of frost prior to takeoff.

2. Reduction of the wing stall angle of attack, due to the surface roughness associated with frost contamination, to below that at which the stall protection system was effective.

3.Possible impairment of crew performance by the combined effects of a non-prescription drug, jet-lag & fatigue.

AAIB, UK made the following safety recommendations:

1. US FAA, and all Authorities who follow FAA practice, *delete all reference to 'Polished Frost' within their regulations and ensure that the term is expunged from Operations Manuals.*

2. Bombardier Aerospace include the following specific limitation within appropriate aircraft manuals: *'Wings and tail surfaces must be completely clear of snow, ice and frost prior to takeoff.'*

3. The CAA require the following specific statement within the limitations section of the flight manuals of aircraft with a significant susceptibility to ice contamination, *'Wings and tail surfaces must be completely clear of snow, ice and frost prior to takeoff',* and communicate this recommendation to other civil airworthiness authorities responsible for the primary type certification of new aircraft types.

4. FAA act upon the NTSB recommendations A-00-4, A-00-5 and A-00-6 and, in particular *review the guidance given to flight crew about the dangers of using non-prescription medication.*

5. FAA take measures to encourage action by the US Food and Drug Administration to ensure that over-the-counter medication contains appropriate warnings on any associated potential dangers in operating aircraft.

6. Bombardier Aerospace reassess the fault tolerance of the stall protection system for the Challenger 604 and other aircraft models with a similar system and the measures aimed at verifying its integrity in service.

7. FAA and JAA review the current procedural approach to the pre takeoff detection and elimination of airframe ice contamination and consider requiring a system that would directly monitor aircraft aerodynamic surfaces for ice contamination and warn the crew of a potentially hazardous condition.

Reference:

1. Report on the accident to Bombardier CL600-2B16 Series604, N90AG at Birmingham International Airport, 4 January 2002, Aircraft Accident report 5/2004, AAIB UK.

GROUND DE/ANTI-ICING

Dr.M.S.Rajamurthy

As even a very light coating of frost, snow or ice that is hardly visible could have adverse effect on the airplane performance, awareness of icing effects and the procedures to ensure clean wing and other surfaces is very important for safety. The Challenger 604 accident exemplifies the tragic outcome of not ensuring this.

As icing effects can be catastrophic, the airworthiness and civil regulatory agencies keep reminding the operators of the hazards associated with it.

Any deposit of frost, ice, snow or slush on the external surfaces of an aircraft may drastically affect its flying qualities because of reduced aerodynamic lift, increased drag, modified stability and control characteristics. Furthermore, freezing deposits may cause moving parts, such as elevators, ailerons, flap actuating mechanism etc., to jam and create a potentially hazardous condition. Engine/APU systems performance may deteriorate due to the presence of frozen contaminants to intakes, fan blades and components.

Also, engine operation may be seriously affected by the ingestion of snow or ice, thereby causing engine stall or compressor damage. In addition, ice/ frost may form on certain external surfaces (e.g. wing upper and lower surfaces, etc.) due to the effects of cold fuel / structures, even in ambient temperatures well above 0° C.

In our previous winter issues (Dec.05, Dec.06 and Dec.07) we have discussed in quite some detail the criticality of ice formation on aircraft and the need for ground and inflight de/anti-icing. The flight deck crew, particularly those flying the Europe and US sectors are strongly advised to review our previous winter issues and revisit the NASA Glenn Research center site (see links in the web watch) and go through the pilot's guide on ground icing and inflight icing.

This year, European Aviation Safety Agency (EASA) issued two safety information notices related to ground–icing and runway de-icing. These specifically address intake/fan-blade icing, effect of fluid residues on flight controls and the effect of runway deicing fluids on aircraft carbon brakes. This is summarized in the following.

Intake and Fan blade Icing

During extended ground operations/ taxiing prior to flight in conditions of moderate to heavy freezing precipitation, it is possible for snow and slush to accumulate within the engine intake ducting and/or on the rear surfaces of engine compressor/ fan blades.

Such accumulation may not be visible to the crew, nor prevented by the use of engine anti-icing, especially when engines are operated at or close to ground idle rpm. Intake duct deposits and engine blade deposits may detach and be ingested by the engines) during the subsequent application of high power settings for takeoff, with consequential adverse effects on engine operation, and possible flameout. Ice accumulation on the surfaces of engine compressor/ fan blades may severely affect the aerodynamic characteristics of the blades and cause compressor stall, leading to surging and engine malfunctioning and/ or reduced thrust.

Several accidents have already occurred due to these phenomena.

Intake icing

This is, in part, caused by the design of engine intake/ducting on certain aircraft, whereby accumulations of snow and/or slush can occur in the engine air intakes during low power engine operations, such as taxiing after landing and also prior to takeoff, in certain meteorological conditions. Relatively long/curved intake ducts/tracts are particularly prone to this phenomenon.

This phenomenon is most likely to occur in susceptible aircraft during precipitation of heavy snow or rain at temperatures close to 0°c before and after engine start. In such cases, the use of engine anti ice system may be ineffective in preventing accumulations forming in engine intakes.

It is also likely that such deposits may not be visible or apparent to pilots and ground staff, particularly so in the case of high-mounted engines. Also, in some cases, accumulation will not take place until after engine start. This situation may be masked by the fact that the de/anti-icing treatment of the rest of the airframe is still effective, with frozen deposits not yet forming on the treated areas.

The consequences of unrecognized intake icing will only become evident during high power engine running (i.e. during takeoff), when it can be too late to take precautionary actions.

Ice accumulation on the rear face of engine compressor/fan blades

This phenomenon is most likely to occur in susceptible engines during precipitation of heavy snow or rain precipitation at temperatures close to 0° c before and after engine start. In such cases, the use of engine anti-ice system may be ineffective in preventing accumulations forming on the rear faces of blades.

It is also likely that such deposits may not be visible or apparent to pilots and ground staff, particularly so in the case of high-mounted engines. Also, in some cases, accumulation will not take place until after engine start (rotating parts striking supercooled droplets).

[It should be noted that compressor/ fan blade icing may have occurred during the previous approach/taxi in. In this case, such accumulations may be detected during a subsequent pre-flight inspection (PFI). The potential for re-occurrence during any subsequent operation of engines) must be recognized and precautionary measures taken.]

Alternatively, accumulations may occur after engine-start on previously inspected and "clean" blades. Such occurrences will therefore not be detected during PFI, nor during normal idle/low power running of engines during ground maneuvering.

In such cases, it is vital that the potential for blade icing is fully understood by responsible staff and appropriate countermeasures are employed, as recommended by the aircraft manufacturer.

The consequences of unrecognized blade icing will only become evident during high power engine running (i.e.

during takeoff), when it can be too late to take precautionary actions.

Recommendations:

In the first instance, manufacturers' recommendations, where given, should be followed. In cases where guidance is not provided, operators should liaise with manufacturers and other qualified entities to obtain advice in order to develop suitable procedures.

It is recommended that operators take appropriate action to recognize and address these phenomena in their Operations Manuals and to give suitable advice, guidance and training to pilots and ground staff. Good coordination between Operations and Maintenance is essential, in particular with regard to maintenance inspections (in conjunction with the maintenance programme and manufacturer's recommendations).

Ground De-/Anti-Icing of Aircraft

Ground de-icing/anti-icing are intended to ensure that the aircraft is clear of contamination so that degradation of aerodynamic characteristics or mechanical interference will not occur and, following anti-icing, to maintain the airframe in that condition during the appropriate holdover time.

The de-icing and/or anti-icing procedures should therefore include requirements, including type-specific, taking into account manufacturer's recommendations and cover:

(i) Contamination checks, including detection of clear ice and under-wing frost. [Note: limits on the thickness/ area of contamination published in the AFM or other manufacturers' documentation should be followed];

(ii) De-icing and/or anti-icing procedures including procedures to be followed if deicing and/or anti-icing procedures are interrupted or unsuccessful;

(iii) Post treatment checks;

(iv) Pre take-off checks;

(v) Pre take-off contamination checks;

(vi) The recording of any incidents relating to de-icing and/or anti-icing; and

(vii) The responsibilities of all personnel involved in de-icing and/or anti-icing.

Under certain meteorological conditions de-icing and/or anti-icing procedures may be ineffective in providing sufficient protection for continued operations. Examples of these conditions are freezing rain, ice pellets and hail, heavy snow, high wind velocity, fast dropping OAT or any time when freezing precipitation with high water content is present. No Holdover Time Guidelines exist for these conditions.

The ground de-icing/anti-icing procedures established in the KAC OPM - section 4.5 should be followed in conjunction with the aircraft-specific operations manuals.

Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-Icing (RDI) Fluids

The use of low-weight carbon brakes in modern aircraft and the concurrent switch to more environmental friendly organic salts runway de-icing fluids have led to a concern related to safety and an additional cost to airlines.

Aircraft manufacturers have informed EASA, that the organic salts (mainly potassium formate and acetate, but other alkalis as well) are sprayed by the wheels mainly during aircraft take-off and landing runs. They remain on the underside of the aircraft and can be collected as ice and slush on the bogies.

The worst condition is the spray between wheels which drives the RDI directly into the brakes and, particularly, coats the Carbon Heat Sink plates which are also used as the pressure plates to provide braking. At landing gear retraction the ice and slush on the bogies (now in a horizontal position) melt into the brake units where they further invade the carbon discs.

The presence of the alkalis creates a catalytic condition which lowers the temperature at which oxidation occurs. This softens the carbon causing it to flake and crumble undetected and unpredictably over time reducing the life and long-term efficiency of the brakes themselves.

Thermal oxidation is a normal condition of brakes, which occurs at high temperatures around 400 - 500°C and above. This is a known phenomenon and does not impinge on brake life. Catalytic oxidation is a condition where the alkalis lower the temperature of oxidation significantly (down to 100-200°C)and lower brake life by crumbling etc. This significantly increases the cost through replacement and refurbishing etc.

There is the danger of possible brake failure during high-speed aborted take-off or dragged brake during normal take off (and subsequent overheat, once airborne) or excessive vibration during any ground phase. It should be noted here that the centre of the brake unit cannot be easily inspected and this is where its stator couplings are indexed to the torque tube, mechanically linked to the axle, thus transmitting the braking torque to the wheels. Where these fail, the effectiveness will be diminished.

Many aircraft have the additional issues of Cadmium and Aluminum corrosion, corrosion in landing gear joints, and electrical wire bundle degradation, also caused or accelerated by the same deicing fluids, which, again, is a further unaccounted for expense. The electrical wire bundle problem is a particular concern for older aircraft, particularly those using Kapton insulation. The cable bundles tend to trap residue from RDI fluids. When this happens, the residue can absorb up to 6 times its original volume. This mixture, remaining in the cable bundles may cause more safety concern than any of the other conditions.

EASA has determined that the aforementioned information may raise airworthiness concerns on aircraft-loss of one brake during a rejected take off operation is potentially catastrophic, even if no accident of this kind occurred since the introduction of environmental friendly de-icing fluids.

Furthermore, this issue could also be seen in the context of airport equipment as de-icing fluids are equipment/ materials used by de-icing vehicles.

EASA makes the following recommendation to all aviation stakeholders operating large aircrafts equipped with carbon brakes and operated to/from airports where runway icing conditions are possible through a Safety Information Notice to raise awareness and to carry out a detailed visual inspection of the wheel carbon heat pack for obvious damage, distortion, missing elements or corrosion upon performance of scheduled maintenance of the landing gear wheels.

References:

1. EASA Safety Information Bulletin no.2008-19, Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icing (RDI) fluids, 13 March 2008.
2. EASA Safety Information Bulletin no.2008-29, Ground De-/Anti-Icing of Aeroplanes; intake/Fan-blade icing and effects of fluid residues on flight Controls– 04 April 2008.

Blown tire disables Hydraulic system

On October 20, 2007, a B747 departed before dawn from Los Angeles International Airport for a flight to Brisbane, Australia.

Soon after takeoff, there was a warning of the hydraulic system failure on the EICAS (Engine indicating and crew alert system) and the cabin crew reported that a bang was heard just before the aircraft got airborne.

The crew completed the appropriate checks and were advised by the ATC that tire debris and no other material had been recovered from the runway.

The crew confirmed that all other aircraft systems were functioning normally. After considering the status of the aircraft and the option of dumping fuel and returning for a night landing at Los Angeles, the crew decided to proceed towards the planned destination while closely monitoring the aircraft systems and fuel usage. This decision of the crew was concurred by the maintenance personnel.

The 747 landed at Brisbane without further incident, but had to be towed from the runway as the hydraulic system failure had disabled the nose-wheel steering system.

Australian Transport Safety Bureau (ATSB) conducted the investigation of the incident. It reported that as the aircraft became airborne, a tire on the left body landing gear disintegrated and a section of the tire debris impacted a line of the no.1 hydraulic system in the left body landing gear well which caused fluid and pressure loss from that system.

During the investigation ATSB found information in the FCOM conflicting that in FCTM. FCOM recommended landing at the nearest available airport if more than one of the 747's four hydraulic systems failed; however, "for a single hydraulic system failure, the checklist listed the aircraft services that the relevant system operated". It did not suggest a course of action.

The FCTM recommended that following a tire failure on takeoff, the flight crew should not consider continuing the flight to the destination if other damage, such as a hydraulic system failure, also occurred.

ATSB observed that pilots primarily use the FCOM for guidance in flight, and the conflicting information between the FCOM and FCTM "create the potential for confusion and less-than-optimal response by the crew." The airline recommended that Boeing review "operational policy statements in the FCTM. The manufacturer accepted the suggestion and indicated that examination would be undertaken.

Reference:

AeroSafety world, Sept.2008.

Web watch

http://aircrafticing.grc.nasa.gov/courses_ground.html — ***a pilot's guide to ground icing*** *- all about ground icing problems, de/anti-icing fluids, de-icing and anti-icing aircraft*

http://aircrafticing.grc.nasa.gov/courses_inflight.html — ***a pilot's guide to in-flight icing*** *- all about inflight icing problems*

PHOTO OF THE MONTH

Emergency landing

February 23, 2008, Manchester - Inter national (MAN/EGCC) UK, an American Airlines Boeing 767-323/ER made an emergency landing due to hydraulic failure. The gear doors were stuck down and the fast landing coupled with no nosewheel steering meant the runway was blocked for some time. The aircraft stopped safely but had very hot brakes and a couple of burst tyres.

The Confidential Aviation Hazard Reporting System (CAHRS) provides a means of reporting hazards and risks in the aviation system before there is loss of life, injury or damage. It is open to anyone who wishes to submit a hazard report or safety deficiencies confidentially and non-punitively. Reports help to identify deficiencies and provide safety enhancement in areas of aviation. CAHRS forms can be collected at different location of KAC (i.e. Flight Dispatch) Premises. Completed forms can be dropped in FS&QA allocated box at Flight Dispatch or e-mailed to kwioeku@kuwaitairways.com or faxed to 00965-4749823 or mail to Flight Safety and Quality Assurance office, Operations Department, P.O. Box 394, Safat 13004, Kuwait Airways –Kuwait.