Remarks For

Mr James Donnelly
Manager, Product Safety
Bombardier Aerospace, Regional Aircraft

2001 Australasian Air Safety Seminar
June 2 - 3, 2001

(Check against delivery)

Today I'd like to describe—very briefly—four seemingly unrelated aircraft accidents and to discuss with you some of the common features and the lessons they offer us.

I should also preface these remarks by noting that the opinions to follow are my own, and are based on my 16 years of accident investigation experience. These opinions may not necessarily reflect the position of Bombardier Aerospace.

The first event occurred early this year, and involved a Dash 8 Q Series 300 aircraft landing at Kenman Island, Taiwan.

This event is different from many we investigate, in that the final few seconds were captured on videotape. See for yourselves…

[Video…]

As you can see, the landing resulted in extensive aircraft damage, including the collapse of both main landing gear assemblies and damage to the propellers, engines and fuselage. Fortunately, there were no serious injuries aboard the aircraft or on the ground.

Our investigation—including analysis of the digital flight data recorder—showed that the aircraft completed a 119-degree descending turn to the right and rolled wings level about 15 seconds before touchdown, at an altitude of approximately 200 feet AGL.

During the approach the acceleration record also shows excursions in Nz as high as 1.4g and as low as 0.6g. These readings suggest that the aircraft experienced a significant degree of turbulence on approach.

The rate of descent increased to more than 20 feet per second during the last seven seconds of the approach, and may have been as much as 30 feet per second at touchdown. At the same time, indicated air speed decreased by about 10 knots, while the aircraft maintained a nose-down attitude.

Damage to the elevator travel limit stops and the accelerometer provide further support for the finding of excessive vertical velocity at touchdown.

Since the DFDR recorded no significant pilot inputs to cause the increased rate of descent just prior to touchdown, we have inferred that the aircraft encountered windshear.

With these findings in mind, we must suggest that a prime contributor to this accident was the pilot's decision to land following an unstable approach. Fortunately, as I said, there were no serious injuries.

Could this accident have been prevented? Absolutely! Consider these three factors:

First, this airport is known to be susceptible to windshear.

Second, this was a very experienced crew. The pilot had more than 4,500 hours total time, including more than 2,500 hours as pilot in command on Dash 8s.

Third, the pilot made no attempt to counter the excessive sink rate. The pilot should have elected to initiate a go-around.

His failure to do so at the appropriate time constituted a failure in basic airmanship and therefore a major breach in the aviation safety system.

The second event I'd like to present dates all the way back to November 1987, and it involved a de Havilland Canada DHC-4 Caribou STOL transport aircraft.

Like many aviation accidents, this story has a number of contributing elements that combined to form a dangerous situation from which there was no escape that day.

The story really begins with the operator's maintenance department removing the aircraft's reversing propellers and installing non-reversing props in their place.

The approved procedure calls for the installation of a number of additional components, including a propeller governor. Somewhere in the process, the maintenance personnel found they did not have the specified propeller governor gasket. In its place they manufactured and installed a temporary substitute, which was intended to be used only for engine ground runs.

Instead, however, the aircraft was mistakenly dispatched for a routine flight to haul mining equipment from Calgary, Alberta to Ross River, in the Yukon Territory, with an intermediate fuel stop at Fort Nelson.

Following refueling at Fort Nelson, the flight departed and proceeded normally, by way of Faro, where the letdown began for the final 30-mile leg down the valley to Ross River. Since Ross River had no published letdown procedure, the Faro letdown was used to break cloud cover for a final visual approach to Ross River.

I should note that both Faro and Ross River are located in steep-sided valleys, more than 2,000 feet above sea level.

The crew flew two approaches to the Faro NDB and successfully carried out missed approaches, as they were not clear of the clouds, at the prescribed altitude. The crew then decided to divert to Watson Lake, and the aircraft climbed above the 9,400-foot Minimum Enroute Altitude for the 180-mile trip.

Shortly thereafter the crew were alerted by the number 2 engine low oil quantity light and the low oil pressure light. Oil was seen running off the top of the starboard wing by the maintenance crew onboard. The crew feathered the propeller and shut down the engine.

While single-engine en route to Watson Lake, the lights of Ross River became visible through the cloud cover, and the captain elected to descend and land on the community's 5,500-foot gravel strip.

On final approach 14-degree flap was selected. Landing gear extension was delayed to reduce drag. When the landing gear was finally selected 'down,' the nose gear unsafe indication illuminated. The crew then cycled the gear selector handle.

By the time the gear had cycled into a confirmed 'down-and-locked' position, the captain decided his position for a successful landing had been compromised, and he began a single-engine overshoot. His decision put the flight into an environment with rising terrain and deepening darkness.

Although the aircraft initially began to climb, it subsequently lost altitude and ran into treetops. The aircraft rolled, cartwheeled, and eventually came to rest down a 20-foot embankment. Both the landing gear and flaps were found fully retracted.

Two aircraft mechanics flying as passengers were thrown free as the flight compartment and cabin broke up on impact, and survived, although one suffered severe injuries. The two pilots were killed.

When the approach began only 10 minutes of twilight remained before the valley was in total darkness; the time of the crash, 17:13 local coincided with the start of darkness.

So, what are the contributing causes of this accident? We can identify these four major factors:

First, lack of communication at the operator's maintenance facility. That allowed the aircraft to depart with an incorrect gasket, with the resulting loss of oil;

Secondly, the pilot's decision to make a single-engine descent through a sucker-hole in the clouds, into a deep valley with no published approach or missed-approach procedures. In addition, the terrain just off the end of the runway rises steeply, 2,000 to 4,000 feet, so any overshoot would require a precisely flown, tightly circling climb-out.

Here I think we have to be fair, as the alternative was a 180-mile night flight over high terrain back to Watson Lake. With only one engine operating, that would not have been a very appealing choice.

However, as the Canadian Aviation Safety Board noted in its report:

> "The crew evidently did not realize that this decision effectively foreclosed the option of a single-engine go-around should one become necessary."

A few sentences later, the report continued, with regard to the flight crew's considerations and briefings:

> "The flight crew should have drawn the conclusion that an overshoot would not likely succeed and therefore should not be attempted…
>
> Once the approach was begun, the aircraft would have to be put down on the runway, regardless of any additional or abnormal situations;"

Thirdly, the pilot's decision to attempt all of that in failing light conditions, with intermittent snow showers.

Finally, at the aircraft's weight, with 14 degrees of flap selected, the single-engine climb rate is 270 feet per minute at 77 knots; at zero flaps, single engine, the speed requirement increases to 94 knots.

Accordingly, the decision to raise the flaps during the climb—before the aircraft attained sufficient airspeed, resulting in the aircraft's inability to maintain altitude—may have indicated a lack of familiarity with the aircraft's single-engine performance at a high gross weight.

In this accident, while the pilot probably did not know of the gasket issue, I think we have to question his decision-making in electing to return and land in an environment where his ability to execute a single-engine go-around was so tightly constrained.

The pilot may have had faith in his ability to fly out of the Faro valley if he needed to, but his faith wasn't matched by his understanding of the performance limits of his aircraft.

The third accident I'd like to present today is the most recent of the four, and this one involves a modified de Havilland DHC-3 Otter on a parachutists' flight. This event occurred in late March, in Texas. On this aircraft the Otter's original Pratt & Whitney R1340 radial piston engine had been removed and a turbine powerplant had been installed.

Shortly after takeoff, and at an altitude of 200 to 300 feet AGL, the pilot reported that the aircraft suddenly rolled sharply to the right at a rate he estimated at 30 degrees per second. The aircraft continued to roll to about 90 degrees. The pilot reported applying full left aileron, full left rudder and pushing the control column forward.

During this recovery the pilot applied full power to continue the climb. However, he soon realized that the aircraft did not have sufficient altitude to clear a stand of trees.

He reduced power to idle, and the aircraft tail struck the ground, the left wing struck the trees, and the aircraft came to rest in a muddy bog. The pilot and five passengers received serious injuries, while another 13 passengers sustained minor injuries.

Investigators found the left wing separated from the airframe and the left side of the airplane crushed and buckled inwards.

The pilot told investigators he originally thought there had been asymmetrical lift, possibly due to a flap disconnect. He also recalled that the aircraft had experienced a similar 'bump-and-roll' sequence two weeks earlier when he had flown through a "dust devil".

In fact, he said, the events were so similar that he now concluded that he had flown through another "dust devil", although this time the aircraft had not had sufficient altitude to allow recovery.

He also told investigators that "a band of clouds associated with a front," had passed through the area some time earlier.

What can we see in this case? The first thing that jumps out at me—if you will pardon the pun—is that the airplane had 19 people on board.

The Otter was originally designed to carry 11 passengers and it can carry a considerably greater payload safely, provided that the fuel load is managed effectively and the aircraft is loaded within the prescribed weight and balance limits.

However, the weight-and-balance issue may not be as critical in this case as that of passenger restraint.

We initially made contact with the NTSB following the accident to gather information, but it is difficult to know at what point an aircraft manufacturer's responsibility ends.

We can provide some expert advice to the investigation on the performance of original equipment, such doors, or seats, structure or similar components from our type-certificated aircraft.

However, when it comes to significant powerplant and system modifications in which we have had limited or no involvement we are generally not in any position to comment. This is particularly true when such changes affect the aircraft's weight-and-balance, performance, and operating and handling characteristics—we simply have no basis on which to comment.

I should also add that we have never seen the turbine aircraft's flight manual—although I suspect it looks a lot like the original.

I also suspect that the jumpers were not properly secured by a restraint harness, as required by regulation, but probably sitting front to back in rows, with their legs around each other. This is common practice for parachute drop flights, but it gives the jumpers very little protection if anything goes wrong, as it did here.

Or, as it did in Perris, California in April 1992, when 16 sport parachute jumpers were fatally injured in a takeoff accident. Or, as it did at Chicago in September 1992, when 11 jumpers were killed in a takeoff accident.

I think we should also examine the pilot's recognition of relevant weather patterns, and question his decision to take off, even if the conditions did permit it—especially in light of his own experience two weeks before when he encountered similar low-level convective activity, consistent with windshear.

The final example I'd like to bring before you today also deals with a modified aircraft. Like the first event I described, it's unusual because virtually the entire accident sequence is captured on videotape.

The accident occurred in August 1992 at the Gimli Industrial Park in Manitoba—a famous site in Canadian aviation history, where an Air Canada Boeing 767 known as the Gimli Glider was dead-sticked onto a drag racing strip, following fuel exhaustion.

The accident aircraft is a highly modified de Havilland aircraft. In this case a Caribou had been converted to turbine power and was operated under the EXPERIMENTAL category of CAR 4b.

The conversion was accomplished at Gimli, and the aircraft first flew in mid-November 1991, before accumulating about 23 hours on 12 flights by month end.

These preliminary tests revealed the need for the replacement of the aircraft's mechanical vacuum pumps with a Bendix suction system, the addition of in-line fuel boost pumps and the installation of a newly designed hydraulic pump.

The accident occurred on August 27, 1992 on the first of several planned trips to flight-check the fuel and hydraulic systems. The aircraft had been hangared in a partially dis-assembled state over the winter, and had only recently been re-assembled, including the re-installation of the complete tail section.

I'll let the video show you what happened—and I will caution you right now that this footage is extremely graphic…

[Video…]

The accident investigation used this videotape and some 35mm photographs as a key resource in determining what went wrong at Gimli.

With the exception of a slightly higher-than-normal nose attitude at lift-off, the aircraft's initial climb appeared normal. At about 35 feet AGL, the aircraft made a noticeable pitch-up movement.

When I tell you that the photography revealed that the elevator control surfaces were observed to pitch trailing-edge-up for rotation, neutralize and then remain in the neutral position through the balance of that short flight, I expect most of you will come to the same conclusion as the Transportation Safety Board of Canada. The aircraft's control gust locks were at least partly engaged.

A very close examination of the video does indicate rudder movement and minimal elevator movement, during the start of the takeoff roll.

On the standard Caribou, the gust lock control handle is located forward of the power quadrant, and it has two positions—forward for Unlocked, and aft for Locked. If the control surfaces are not in the neutral position when the lock is engaged, any movement of the surfaces through the neutral position will cause the lock to engage.

In addition, on the factory-standard Caribou, the control handle is designed so that when it is in the aft-Locked position, the power levers cannot be fully advanced. This is intended to prevent power application and takeoff when the gust lock system is engaged.

The accident investigation further revealed that the aircraft's takeoff distance was approximately 20 per cent longer than anticipated for the conditions. This may provide further evidence that the gust locks played a part in this event.

Analysis of the recovered debris indicated that, although the aileron and elevator locking mechanisms were in their respective Disengaged positions, the rudder locking mechanism was found to have been in the fully engaged position at impact.

Further investigation revealed that in fact, it had been jammed there by the forces of the impact. In addition, the analysis determined from the damage evidence that the aileron control lock had been dis-engaged at the time of impact.

In its synopsis of the accident, the Transportation Safety Board concluded that the control gust lock system had not been fully disengaged prior to flight and that one or more of the locking pins had become re-engaged after lift-off.

What could have prevented this accident? The most obvious solution was that a complete six-point control check prior to takeoff would have revealed that free and proper movement of the control system was compromised.

No control check was seen by witnesses on the ground, nor was one recorded on video or still photography. As noted earlier, some rudder and elevator movement was observed, at the end of the runway at the start of the takeoff roll.

The Caribou's standard procedures do allow for locking the control surfaces for ground operation, but the aircraft flight manual also requires a six-point control check prior to takeoff.

Another point—although not one addressed by the TSB in its review—concerns the crew. We understand that shortly before the flight, the scheduled co-pilot—a very experienced piston-Caribou captain—was replaced by another pilot with considerably less total time and experience on type. He was, in fact, the aircraft owner's son.

We therefore speculate whether a more experienced co-pilot might have caught the missed six-point control check, or might have been more aware that the aircraft was not responding as it should have.

During the post-accident autopsy, a knob from the gust lock handle was found embedded in the captain's right wrist. The TSB concluded that the captain was attempting to operate the gust lock handle when the aircraft hit the ground.

Our expectation was that the pilot flying would have had his hand on the power lever quadrant, which is located immediately aft of the gust lock handle. It is therefore conceivable that, during the impact sequence, his hand might have moved forward, and that this might account for the autopsy finding.

This accident investigation was problematic for us as the aircraft's original manufacturer, as we had not been involved in the turbine conversion, system modifications, or subsequent flight testing.

As I noted earlier, the conversion required extensive modification of a large number of the aircraft's systems, and we know from the investigation that these included a re-designed throttle quadrant.

The TSB report concludes that the newly designed system did not interfere with the positional relationship between the throttle levers and the gust lock control handle, as full power could not be obtained with the lock handle in the engaged position.

However, in our minds, since we did not design or participate in the modification process, we cannot conclusively rule-out interference with normal operation of the aircraft's original systems.

In this accident investigation our contribution was therefore essentially limited to the identification of components familiar to us, confirming the operation of the original gust lock system, and confirming the deflection of the control surfaces' spring tabs when operation is attempted against the locks.

We had not reviewed the turbine aircraft flight manual but here again, we suspect it was substantially similar to the original aircraft flight manual.

The original manufacturer's ultimate responsibility in an accident involving a heavily modified aircraft has not yet—at least to my knowledge—been fully delineated.

This remains a very problematic issue, as the original manufacturer may be implicated—at least in the early stages—of lawsuits arising from an accident.
This may be as a result of a 'deep-pockets' strategy by plaintiffs or as a result of a legitimate concern over product liability issues.

Regardless of the motivation, however, we have to recognize that modifying an aircraft substantially from its original configuration poses risks and unforeseeable challenges which are far more extensive—and therefore potentially much more dangerous—than simply beefing-up, or swapping the engine in a sports car.

And of course, the more sophisticated the aircraft, the more complex the systems and the analysis required to ensure safety of flight.

I noted at the outset that the accidents I would present today have some common elements, and I acknowledge that these common elements are difficult to discern.

So, let me take a step back and give you some perspective.

Aviation is protected by a complex and interconnected set of rules and regulations that, when observed and enforced, ensure that airplanes provide an incredibly safe and reliable means of transportation for millions of people every day.

From the manufacturer's perspective, these rules and regulations start with the airworthiness standards that govern how aircraft are designed and built.

From an air carrier's perspective, the rules and regulations focus primarily on how aircraft are to be operated and maintained.

From an international regulatory perspective, these rules and regulations focus on issues of common concern among nations, such as standards for air navigation aids, airways and airport specifications.

My point is that these sets of rules are interconnected and together form a safety system, or perhaps a safety net for air transportation.

In each of the cases I have described today there have been very serious breaches of the aviation safety net:

- from the Dash 8 pilot who elected to continue to land following an unstable approach;
- to the Caribou pilot, who chose so disastrously to fly single-engined into a dark, mountainous valley;
- to the Otter pilot who routinely took off into “dust devils” with a heavy load of unsecured passengers;
- to the Caribou maintenance team whose lack of effective communication and care allowed an unfit aircraft to take-off;
- to the last-minute change from a second experienced captain, to an inexperienced first officer; and, finally,
- to the Caribou crew who took off without confirming the control gust locks were disengaged and who took off without completing the required six-point check to ensure free movement of the flight controls,

the message really should be clear to everyone—our safety system is strong, but it cannot withstand direct assaults caused by treating safety as an exception.

As we know from our own experience—some of it heart-wrenching—aviation safety does not equate to the absence of accidents. Instead, aviation safety is actively built by insistence on the use of established procedures, and by training that puts safety ahead of all operational and commercial considerations.

I have said before in this and other forums, that training is the most effective way to enhance aviation safety, and this assertion is borne out in each of the accidents I described for you today.

I don’t want to belabor this point, or outstay my welcome, but I do want to describe one more incident for before I go.

Fortunately, this event turned out well. However, I question whether the operator and crew adequately addressed the dozens of serious safety concerns that arose. And here I am talking about the recent Twin Otter rescue mission flown to the South Pole to evacuate a U.S. doctor.

The flight was a first in many ways, and not strictly in good ways:

- The flight was the first in total Antarctic darkness, about six weeks later into the season than any previous flight;
- The air temperature was probably colder than ever experienced by the Twin Otter, and was estimated at about 40 degrees colder than permitted by the aircraft flight manual; and,
- The flight involved a 10-hour final leg, when the aircraft was expected to arrive with fuel for about another 100 miles, and the nearest alternate about 500 miles away.

On a positive note, the operator was probably the world's most experienced in Twin Otter operations in extreme conditions.

I don't know the details of the mission planning, and I don't know whether there was any more reasonable way to extract the U.S. scientist.

What I can gauge with a good degree of accuracy is that this mission presented multiple opportunities for things to go wrong, without any reasonable avenue of escape.

So, while I can be glad that the mission ended successfully, I have to believe there was every likelihood that we would now be facing another accident investigation and wondering why this had to happen.

Clearly, we still have a lot of work to do to change people's minds and change their behavior.

Thank you for your time today.

Jim Donnelly began his aviation career flying commercial helicopters in the Canadian Arctic in the early 1970s. In 1979 he was employed by the de Havilland Aircraft of Canada as a Field Service Representative and lived for six years in various locations worldwide, including: Monterey, California, Port Moresby, Papua New Guinea, Sana'a, North Yemen and Barranquilla, Colombia. In 1986 he joined the Air Safety Group of Boeing Canada, de Havilland Division. Jim is currently Manager, Product Safety, Bombardier Aerospace, Regional Aircraft, based in Toronto, Ontario Canada. His responsibilities include providing assistance to government authorities investigating aircraft accidents involving de Havilland Canada aircraft (DHC-2 Beaver, DHC-3 Otter, DHC-4 Caribou, DHC-5 Buffalo, DHC-6 Twin Otter, DHC-7 Dash 7 and DHC-8 Dash 8) as well as those involving the Canadair Regional Jet airliner (CL600-2B19).