Notes for Remarks by

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Good morning, and thank you for the opportunity to be with you today.

This is the sixth time I have been invited to present a paper at an ISASI conference in this part of the world. On behalf of everyone at Bombardier Aerospace, may I say that I am very pleased and honored to have been asked here again.

I should also preface these remarks by noting that the opinions to follow are my own, and are based on my 17 years of accident investigation experience. These opinions may not necessarily reflect the position of Bombardier Aerospace.

In looking back at my past presentations I find I have discussed some operations and maintenance differences between mainline and regional airlines, cabin safety, icing, the role of flight data recorders in aircraft accident investigations and, most recently, the effects on aviation when safety system integrity is breached.

Today, I'd like to take a somewhat different direction with my presentation, and that is to look at aviation safety through the lens, or prism, of communication.

I think we all know intuitively, that aviation safety depends in large measure on communication.

What I would like to do today is to probe a little deeper, and show what happens when communication doesn't happen in a timely or efficient manner, and I'd like to go beyond communication as a hardware issue, and suggest to you that communication is, in fact, a system-wide safety consideration.

In the current Canadian best-seller, *The Ingenuity Gap*, Thomas Homer-Dixon, describes some interesting research that looked at flight-deck communication during the 44-minute emergency that overtook United Airlines Flight 232 from Denver to Chicago, in mid-July 1989.

As you may recall, this DC-10 aircraft suffered an uncontained engine failure in the tail-mounted engine. That failure destroyed the aircraft's three hydraulic systems and rendered its primary flight control systems useless.

The aircraft was kept under marginal control only by the application of differential thrust on the remaining engines.

You may also recall that a check airman who had been traveling as a passenger aided the crew in the emergency, controlling the thrust levers until the aircraft crash-landed at Sioux City's Gateway Airport.

In looking at flight deck communication during that period, researchers separated and noted every command, question, suggestion, observation, response or statement of emotional support during the 34 minutes of recorded conversation.

The researchers found that these 'thought units,' as they called them, were exchanged at an average of 30 per minute, reaching 50 to 60 per minute during peak periods.

By comparison, flight crews operating under normal circumstances exchange only about 15 such 'thought units' per minute, even during the most demanding periods of activity, such as during a night approach in bad weather.

The research suggests that the United crew's reaction to the emergency resulted in at least twice as much information being communicated every minute, and perhaps as much as four times as much as under normal circumstances.

The research also concludes that with 50 or 60 'thought units' exchanged every minute of the emergency, the crew was effectively at their limit.

> "They were processing information, making decisions…about as quickly as humanly possible."

With that research as both background and benchmark, I'd like to turn our attention to some of those situations in which information is not effectively processed, or in which we could say communication was not effective.

The focal point of my presentation today centres on an accident at Charles de Gaulle Airport at Paris, in January 1993. The accident aircraft was a Dash 8 Series 300 turboprop operated by Contact Air, as Lufthansa CityLine flight 5634 from Bremen to Paris.

The accident occurred at 19:24 local time when the aircraft crashed while on short final to runway 28, about 2.5 kilometres from the runway threshold. The aircraft touched down in a landfill site, slid down a hill and came to rest in a wooded area. Four of the 19 passengers were killed, and eight more were seriously injured, but all four crewmembers survived. Weather at the time was reported as poor, with rain and fog.

Now, let me supply you with a brief chronology of Flight 5634's final minutes, because that's where the core of my concern with communication lies.

I should also note that the French aviation accident authorities, the Bureau Enquêtes-Accidents, has not yet published a final report on this event, so this accident is still technically under investigation. Accordingly, you should note my comments as being based on preliminary information. I must add that in the absence of a final report, it is important to share this information with the safety community.

Flight 5634 proceeded normally in most regards, until the aircraft was well established on final approach to CDG's runway **27**, in instrument conditions at 170 knots, with the first officer flying. The flaps were fully retracted, the landing gear was up, and the autopilot was engaged.

One hundred seconds before the accident impact, and while still beyond the outer marker—perhaps 90 seconds from the threshold of Runway 27—the crew received a call from air traffic control, asking if the flight could accept a change of landing runway, to Runway 28.

The pilot-in-command immediately responded "Of course," and the aircraft began to turn to the left, towards Runway 28, descending at 960 feet per minute, in nighttime IMC conditions.

Incidentally, the runway change was requested because a Korean Air Lines 747 had scraped an engine pod while landing on Runway 27, a few moments before the Lufthansa flight was due to arrive, and the runway had been closed.

By T-80 seconds, the autopilot was disengaged and the aircraft was descending at 1,440 feet per minute. At T-45 seconds the ground proximity warnings began, at which time the aircraft was descending at 1,810 feet per minute.

At T-36 seconds, the landing gear was selected down. The aircraft was still descending, but more slowly. According to one calculation, the aircraft was just 1.5 nautical miles from the threshold of Runway 28.

At T-14 seconds the aircraft began another turn, again to the left. The landing gear was down. Engine torque, which had been 0 on each engine, started to increase slowly.

At T-10 seconds, one of the crewmembers called 'runway in sight.' Airspeed was 107 knots and the heading was 233 degrees. There was a momentary weight-on-wheels signal at T-5 seconds.

That's the chronology; now let me paint some of the important aspects of the geography.

Runways 27 and 28 are about 2.2 kilometres apart, measured on the centerline. More importantly, the runways are offset, with the threshold of Runway 28 at least 6,000 feet closer to Flight 5634 than that of Runway 27. In addition, the mean elevation of the terrain surrounding the threshold of Runway 28 was about 60 feet lower than that around the end of Runway 27.

Two other points are worth bringing to your attention in Flight 5634's approach and the accident itself.

First, the pilot-in-command never asserted his command authority. Throughout the moments leading up to the crash, he apparently just sat there, content to have his relatively inexperienced co-pilot fly the aircraft. The co-pilot had just 500 hours total time.

Whether the pilot-in-command was fully aware of the aircraft's position with respect to the new runway, and all the activities required for a safe landing, we just don't know. Whether the decision to accept the new runway was a good one is also open to serious question.

However, even assuming that the decision wasn't unreasonable, the runway change did require a change in the original plans: if the captain accepted responsibility for a change of runway, he should also have taken flying command of the aircraft.

Assuming control should have included a clear assertion of command authority and an equally clear order of the new responsibilities.

He should have said something like: "I have control. You re-tune the ILS."

That would have been good communication.

Secondly, the crewmembers seem to have ignored a total of 33 Ground Proximity Warning System alerts captured by the cockpit voice recorder. These included 26 consecutive 'terrain, terrain' warnings.

To be fair to the pilots, at the time, the Dash 8 300's MkII GPWS did have a history of Mode 2 nuisance warnings, but the flight crew should not have ignored 26 consecutive "Terrain Terrain" warnings.

Furthermore, GPWS warnings—regardless of their perceived cause—should never be ignored. The crew's apparent inaction on these warnings is a failure of fundamental airmanship.

In all regards, this accident fits the classic controlled-flight-into-terrain, or CFIT model. The pilots were distracted from their expected duties by a change of plans—admittedly at the last minute.

We know what was happening on the flight deck of United 232, and there is simply no comparison with Lufthansa 5634, where it appears there was no consideration given to the demands of the late runway-change request, and virtually no communication about what had to happen to complete the flight safely.

This calculation may seem blunt, but it is fair: effective communication helped the United crew maintain control of their aircraft in a very difficult situation, to the point of performing an on-airfield landing. Poor communication during Flight 5634 helped create an accident where there should not have been one at all…

This is also exactly the type of accident targeted by the Flight Safety Foundation's Approach and Landing Accident Reduction initiative, known as ALAR. In the simplest terms, when an aircraft reaches a certain pre-determined target point on its approach, it should be on-speed, on glidepath, on the localizer and configured for landing.

When the aircraft isn't stabilized within accepted norms, the approach should be terminated and a missed-approach procedure executed. Clearly, a go-around could have resulted in a different outcome for Flight 5634 and its passengers.

And, while the ALAR discipline is most easily recognized as a procedural safety feature, I think it also makes sense to treat the ALAR-mandated stable approach as a communication issue.

Meeting the stabilized approach criteria means asking and answering questions on airspeed, altitude, positioning and aircraft configuration.

If these questions are answered positively, the ALAR discipline effectively communicates to the crew that the aircraft can be landed safely.

The ALAR discipline never overrides the pilot's judgment to break off an approach, but it does eliminate guesswork as the foundation of decision-making going into the approach.

Bob Fowler, who was for many years Chief Experimental Test Pilot for de Havilland Canada used to say:

> "Your experience is what gets you out of trouble when everything else lets you down."

It's worth noting that Bob's thought is about getting out of trouble, not relying on your experience to justify or rationalize cutting corners or avoiding established procedures.

Hugh Whittington—who was editor of *Canadian Aviation* magazine for many years—has a funny photograph. The photo shows an old biplane, snagged in the top branches of a tall tree, looking much like Charlie Brown's kite, rather embarrassed and forlorn.

What impresses me about the picture is the legend at the bottom, which says:

> "The Superior Pilot is one who uses his Superior Judgment to avoid situations that would call for the use of his Superior Skills."

In reconstructing Flight 5634's accident, I also wondered whether another form of communication was at least partly to blame for this crash.

I don't mean the "can you hear me?" kind of communication, but communication that, like the ALAR discipline:

- Warns clearly, or
- Says, clearly, "it's safe to proceed with the intended activity."

The loss of Flight 5634 leads me to ask a number of questions about communication in this case. For example:

- Did the ATC runway-change request lead the crew of Flight 5634 into a false sense of security? In other words, did ATC, simply by making the request, lead the pilots to believe that they could accommodate the change?
- Did the speed with which the pilot replied, "Of course" indicate an 'automatic' response based on linguistic, cultural or corporate background? and,
- Did the differing first languages between the air traffic controllers and the pilots set up any particular expectations between the controllers and the pilots?

I really don't know the answers to these questions, but I have seen serious communication problems at work in more than one aircraft accident, and more than a few incidents.

I suspect poor communication is often the cause of runway incursions—when taxiing instructions are garbled or misunderstood on crowded radio frequencies; when bad weather or poor visibility obstructs the view; or when instructions are simply ignored in error.

Poor communication has been identified as one of the main causes in the collision of an Air Libertée MD-83 and a Shorts SD-330—also at Paris Charles de Gaulle—in May 2000.

In this accident, the SD-330 was cleared to line up for take off on the same runway as the MD-83. Controllers believed the Shorts was lining up behind the MD-83, when in fact, it was entering the active runway at an intersection ahead of, and not behind the jet.

The MD-83 reached V-1 speed 33 seconds after brake-release. Five seconds later, at about 151 knots, the left wing of the MD-83 hit the nose of the 330.

Although the 330's first officer was killed instantly, the accident could have been much worse, as the MD-83 was carrying about 150 passengers.

The accident investigation identified the use of two languages, lack of language clarity and light pollution caused by construction equipment and floodlights near the runway threshold, as having degraded the situational awareness of the controllers. Weather may also have played a factor, although the conditions were described as fair, with light rain.

The suggested solutions for runway incursions include traffic lights—like those for automobiles at intersections—and a variety of procedural safeguards. I don't pretend to know which is best, or even whether more than one proposed solution is workable in different situations.

What is clear is that we desperately need a more reliable system to inform pilots when it is safe, and when it is not safe, to enter an active runway—and this need is never greater than in bad weather or poor visibility. The air transportation system needs better communication on this important safety issue.

A further source of difficulty occurs when airport charts, signage and other forms of visual communication don't match the pilot's knowledge and experience.

This was the case in October 2000 at Taipei's Chiang-Kai Shek Airport, when a Singapore Airlines Boeing 747 aircraft tried to takeoff on a runway that had been closed for construction, prior to re-commissioning as a taxiway

At about 140 knots, 3.5 seconds after V1, the aircraft struck something on the runway and crashed back down, breaking into three sections and bursting into flame as the pieces slid down the runway. Eighty-three people were killed and about 40 were seriously injured, from a total of 159 passengers, 17 cabin crew and three pilots.

Although the accident investigation records indicate that the pilots were directed to the correct runway—in this case Runway 05 Left—many questions remain about how thoroughly Runway 05 Right was taken out of commission:

- The runway threshold was not physically blocked;
- The runway surface was not marked with painted Xs, to indicate it was not in use; and,
- The runway centre lighting was on—although the status of the edge lights is not known.

Bad weather, lack of adequate signage and lighting on the runway under construction, as well as inadequate airport construction information on the appropriate charts, also played a part here, but there was clearly a communication failure simply in allowing that aircraft to reach that runway.

There also remains some question over whether the airport signage and lighting conformed to international standards, and whether other aircraft may also have previously blundered onto the closed runway in error.

The recent disaster at Milan is a further example of what can go wrong when communication isn't effective.

This accident occurred in heavy fog, when an SAS MD-87 collided during takeoff with a Cessna Citation that was mistakenly taxiing on the active runway.

According to many reports, the airport's ground radar had been out of service for two years, and work-around procedures allowed two aircraft to be moving on the ground at the same time.

The accident itself was bad enough, but the situation deteriorated further <u>after</u> the crash, and here, three facts highlight communication problems as making a bad situation worse.

First, there was no crash-fire-rescue response triggered for approximately 11 minutes after the MD-87 collided with the Cessna Citation, <u>even after reports of explosions.</u>

Second, it took 20 minutes to find the SAS jetliner in the cargo building, where it had ended up after hitting the business jet and careening off the runway. And…

Third—and perhaps most frightening of all, another transport-category jet aircraft was cleared to take off on the same runway, almost immediately after the crash...<u>even though the SAS flight was required to make contact with ATC after takeoff and, of course, it didn't</u>.

So, as bad as the accident at Milan was, it could easily have been far worse, and poor, ineffective or non-existent communication was at the centre of it all. But it doesn't have to be this way.

Consider what happens at Dublin when there's fog. I understand they have a very simple system. That system means traffic gets backed up, but it's simple and it works. The system is this: only one aircraft moves on the ground at a time. It's not fast and it's not efficient, but it <u>is</u> safe.

One moving aircraft has an excellent chance of avoiding all the others. <u>More</u> than one aircraft moving raises the chances of a collision astronomically in the absence of a functioning ground radar.

Communication, or the lack of it, was also partially the cause of a China Airways Airbus A340 taking off from a taxiway at Anchorage, Alaska, earlier this year.

The pilot apparently mis-read or mistook the signage and nearly came to grief, as the aircraft accelerated for takeoff on the taxiway, rotated, struck its landing gear on a snow bank and climbed away successfully.

In another case, we participated in the investigation of a DHC-6 Twin Otter accident in which the aircrew had been fooled into descending below the minimum safe altitude by a black-hole effect. The aircraft was subsequently flown into treetops, resulting in a number of fatalities.

In following up this accident, the company and investigating authorities compared the company's arrival performance statistics for this particular airport with the weather at this flight's scheduled arrival time, over a number of years.

Incidentally, the airport is VFR, with PLASI.

The company found that, although 99 per cent of its flights had arrived as planned, the weather history dictated that only 93 per cent of its flights should have landed.

Put another way, six per cent of the company's flights should have resulted in go-arounds or diversions. Company pilots were routinely violating both the published operating limits and the company's own procedures.

Where is the communication issue here? Clearly, the company and its pilots were not communicating on the importance of the published limits, or on how the pilots were actually flying the approaches. That came to light only after the fact, during an accident investigation.

The same customer was also plagued by a series of Dash 8 hard landing accidents. Aircraft damage included numerous bent fuse pins, two occurrences of collapsed main landing gears, and one aircraft written off, over a comparatively short time period.

Our customer is therefore instituting a comprehensive ALAR training program. Like other good programs, it is both comprehensive and results in no disciplinary action for go-arounds.

Most of the company's pilots thought that it wouldn't be possible to achieve stability on all approaches. However, with the support of Bombardier, the operator's management, the operator's insurers and the Flight Safety Foundation, implementation of the program is now progressing well.

One high-time pilot who didn't take well to the program—and who had been involved in a hard landing accident in which the landing gear fuse pins had been sheared due to excessive loads—said he hadn't gone around in 20 years, and he didn't plan to start now. He was retired, as the world's highest-time DHC-6 captain...

We found a similar situation in Canada, in the investigation of the Air Canada Regional Jet accident at Fredericton.

The Regional Jet crew began the approach to Fredericton in weather conditions that made a successful landing questionable. However, it was perfectly acceptable under Transport Canada rules to begin the approach. In fact, Canadian Aviation Regulations allow any category approach to be commenced with RVRs of 1,200 feet, or 350 metres.

The aircraft stalled during a low-altitude, low-energy go-around, after landing had been committed. The aircraft struck the runway, accelerated, departed the runway and came to rest in trees atop a hill.

What were the communication issues here? In my opinion there were two significant issues.

First, given the potential for a missed approach due to the weather conditions and the experience of the First Officer, it would have been prudent for the Captain to fly the approach.

Secondly, having made the decision to allow the First Officer to begin the approach, the Captain should have taken control of the aircraft and begun a go-around at the first sign of approach instability, or the First Officer's inability to manage the approach.

In this instance there appeared to be inadequate direction from the airline with respect to the Captain and First Officer's responsibilities when conducting approaches in limiting meteorological conditions.

This is a particular concern with respect to the crewing of regional jet-type aircraft operated by mainline carriers, where crew experience can be less than that on the carrier's larger jet transport fleet.

Summary

I have said before in this forum and in others, that aviation safety is a sophisticated system that encompasses aircraft, operators, pilots and technicians who fly and maintain them, the air traffic control network, airports and the airways navigation systems.

I hope from what I have discussed with you today, that you now view communication as an integral part of that system.

Too often, we only recognize this importance when communication is absent, or when it is inadequate, or misleading, and the results are disastrous.

Communication truly is one of the important factors, the glue that binds the aviation safety system together and makes it work.

I would <u>never</u> suggest that our modern tools—such as radios and digital data links—are making communications too easy.
But perhaps the ease, clarity and reliability of modern systems have made us a bit complacent about what is going on around us.

The continuing problems with charts, airport signage, non-standard terminology, the use of more than one language, procedures and decision-making that I have outlined for you today suggest we need to pay more attention to the basics of communication. Is it clear, is it timely, does it reduce uncertainty and does it permit time for adequate consideration?

As Flight 5634 shows us unmistakably, the chain of events that led to the fatal accident can get going in just a few seconds—perhaps as brief as the time it took for the pilot to respond, "Of course," to the runway-change request from ATC.

In just about 100 seconds, all of the crew's skill and experience, and all the built-in safety equipment, systems and procedures of modern air transport failed, and the aircraft touched down on the landfill site, slid down a hill and struck trees.

Communication is an incredibly powerful safety resource for the entire aviation system. We can improve aviation safety for our passengers and ourselves by paying more attention to the importance of communication. Thank you for your time today...

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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).