Grappling WITH THE Unexpected

BY WAYNE ROSENKRANS | FROM BEIJING

Ice-induced engine rollbacks, runway excursion alerts and proposed aid to criminal investigations capture industry attention.

Although the U.K. Air Accidents Investigation Branch (AAIB) has not completed its final report on a Jan. 17, 2008, accident at London Heathrow Airport, a Boeing Commercial Airplanes official in a seminar presentation here briefed an industry audience on the significance of key laboratory test results. Ice in the fuel system apparently caused dual engine rollbacks on the Boeing 777-236ER that forced the flight crew to land short of Runway 27L.

Mark Smith, an air safety investigator for the company, said that the tests have shown that ice was generated in the airplane fuel system from suspended free water — the water droplets normally in fuel when industry-standard jet fuel is uploaded. In a phenomenon not understood before these tests, however, this water turned to ice that collected on the walls of 2-in (5-cm) and 1.5-in (3.8 cm) diameter fuel lines, then was released downstream as a high concentration of swirling ice flakes, termed an "ice snake," that apparently caused a flow restriction at the inlet to the engine's fuel-oil heat exchanger, he said.

The purpose of the briefing was to help provide understanding of data that led to conclusions and recommendations in *AAIB Interim Report 2,* published in March 2009. The accident airplane was being operated as a British Airways flight from Beijing to London.

"We believe every airplane is doing this, not just the 777, and that it is a new, unforeseen threat," Smith told a joint meeting of the 62nd annual FSF International Air Safety Seminar (IASS), International Air Transport Association (IATA) and International Federation of Airworthiness 39th International Conference.

"Ice was simply what [investigators] were left with after we eliminated everything else. Ice was generated within the entire fuel system — everything upstream of the fuel-oil heat exchanger — then the restriction occurred at the face of the engine fuel-oil heat exchanger. This is the theory of what caused the accident. Suspended free water is the threat for this icing phenomenon we're seeing. Water is present in all fuel — like humidity in the air — and we cannot get rid of it."

The function of the fuel-oil heat exchanger is "to take hot oil from the engine and use the cold fuel flowing from the tank to cool the oil and, conversely, for the hot oil to warm the fuel," he said. The restriction phenomenon was observed in a 70-ft (21-m) test run of fuel line and associated fuel system components.

Boeing also has investigated a second event that occurred in November 2008 on a Delta Air Lines 777 also equipped with Rolls-Royce Trent 800 engines. In this event, a single-engine rollback occurred at cruise. The engine recovered power after the flight crew conducted Boeing procedures developed during the AAIB's investigation. They are the only known events, he said.

"What is important to understand is what occurred on very short final [at Heathrow]," Smith said. "At about 700 ft on final approach, one engine rolled back. About seven seconds later at 550 ft, the second engine rolled back. 'Roll back' is a key term here. The engines did not flame out. They continued to produce power; they did not go sub-idle. They continued to produce power at a thrust level that was above idle but below the thrust that was commanded by the throttles and below the thrust that was necessary to maintain airspeed."

Experimentation on a test rig that simulated 777 fuel lines and their operating environments showed that one temperature range caused ice in fuel to behave as "sticky ice." "The ice in the sticky range will accumulate, and it is that temperature range where we get our biggest accumulations [at the face of the fuel-oil heat exchanger]," he said. Engineers also found randomness in the extent of ice formation that could not be explained.

One countermeasure has been to modify the face of the fuel-oil heat exchanger so that none of the 1,200 2-mm (0.08-in) tubes that pass through the oil protrude beyond the face, where in tests some ice appeared not to melt normally because of the distance between the ends of the tubes and the hot face plate. Only the Rolls-Royce engine uses this heat exchanger design that is subject to ice choking.

China Safety Reports

Li Jiaxiang, administrator of the Civil Aviation Administration of China (CAAC), summarized at IASS the current role of safety in achieving the government's far-reaching air transport goals. "In the past, China advocated a safety week, safety month or safety year, but now we think that that has been a limitation," he said. "If we only focus on safety in phases, we make it hard for people to concentrate on safety all the time. Since last year, we have introduced pioneering concepts of safety management systems [SMS] from advanced countries and other civil aviation organizations, specifically promoting the concept of continuous safety — which means to make safety work our regular work."

He credited the government's "Reform and Opening Up Policy" of the past 30 years for the civil aviation industry's latest annual growth rate of 17.2 percent, the highest among all industrial sectors of China. "In the third quarter of 2009, civil aviation maintained double-digit growth in passenger volume [and] cargo volume as well as international flights. For the first three quarters, China's civil aviation made a profit of $1.35 billion (¥9.21 billion). This positive trend is reflected in continuous upgrading of the position of aviation within the national transportation system. It also means that quality of life of Chinese people has improved, and they prefer aviation when they take a journey."

In addition to establishing or updating regulations, the CAAC has worked to improve personnel qualifications, establish and improve the processes of flight management and oversight, and assign safety responsibility within the overall aviation system through new measures and practices, Li Jiaxiang said.

Top: Wayne Rosenkrans; bottom: J. A. Donoghue

Top: Li Jiaxiang; bottom: Li Jian

"We refer to many countries, especially those that have good practices in SMS, to improve oversight regulations and practices of China," he said. "I frequently remind my Chinese colleagues that flight safety is a career with a starting point but without an ending. I am very appreciative of recognition of China by our friends. On the other hand, I am worried that colleagues will become proud … self-satisfied about China's achievements in flight safety. We have a saying: 'Search more for problems so one may err less; talk less of achievements so one may achieve more.'"

Safety has a prominent role in China's strategic plans through 2020, added Li Jian, a captain and deputy administrator of the CAAC. "At the end of October, our civil air transport accumulated 17.4 million safe flight hours in 59 months and achieved a rate of 0.21 major accidents per million hours in the last decade," he said. "Even in the global economic crisis, we still have kept civil aviation developing and safe."

In the near term, the CAAC will focus on four areas: development and implementation of its strategic safety plan and further long-range plans; intensification of scientific and technological innovation and support to civil aviation safety; popularization of SMS; and intensification of work to build safety culture.

"The CAAC will standardize and systematize all civil aviation governing organizations, enhance safety oversight and push for long-term SMS development," Li Jian said. Increased investments will help spread valuable research and development achievements, including prioritized work on the next-generation air traffic management system and China's roadmap for performance-based navigation.

To promote and direct safety culture development, the CAAC also has developed a safety policy concerning liability determination and safety information management among other issues. "Our *Policy on Civil Aviation Safety Oversight* has new provisions for methods and standards of safety monitoring, safety auditing, safety oversight and a safety information reporting system free of punishment," Li Jian said.

William R. Voss, president and CEO of Flight Safety Foundation, was one of several

Several IASS presenters advocated adjustments to existing safety strategies in light of recent accidents.

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leaders of international organizations who recognized the IASS host country's safety performance. "China is a place where no one listens passively," Voss said. "They listen actively. They take the advice you give and move forward upon it, and they change the direction of aviation in the region. Everyone respects the safety record that we have seen here."

All developing countries addressing pent-up demand for air travel face an extremely difficult balancing act, Voss added. "Personally, I respect the disciplined and thoughtful approach that China has taken during times of great growth," he said. "When demand is at the door and [countries] are being pushed for more and more capacity, I can only recall one country — China — that has stepped back and said, 'Safety is first. We will only expand at the rate that we can do so safely.'"

He contrasted these positive reports of recent years with what global aviation safety nearly experienced. "We have to acknowledge that if the year [2009] had ended in July instead of in December, we would have had the worst aviation safety record in a decade," Voss said. "There have been a lot of unexpected incidents and accidents … pilots reacting in unexpected ways to unexpected events … new types of failures and new types of reactions."

Günther Matschnigg, IATA's senior vice president, safety, operations and infrastructure, also noted the challenges and comparisons to the recent Chinese safety record. "The industry is losing, unfortunately, this year another $11 billion," he said. "Together with last year, it is about $29 billion in losses. The forecast for 2010 is another $3 billion to $4 billion loss. The question is, 'How will a 15 percent revenue shortfall impact safety?'"

Considering IATA's global accident data for the first 10 months of 2009 in this economic environment, airlines had an "incredible performance" in safety, Matschnigg said. "The total accidents have decreased by more than 40 percent and the total fatal accidents have decreased by about 45 percent. The overall rate, as we count it, has decreased to the level … of 0.52 fatal and 0.54 overall [Western-built jet hull losses per million sectors]. Unfortunately, the number of total fatalities has increased to 669. If you look at North Asia and China, in particular, it is the second year without an accident, and I sincerely congratulate [the CAAC leaders] for more than 17 million flight hours without an accident in this country."

Wayne Rosenkrans

Matschnigg

The *IATA Six-Point Safety Strategy* will be "adjusted slightly" in 2010 because of some of the types of accidents that occurred in 2009, he added, with content changes on global data sharing, SMS, fatigue risk management and training. The newly launched IATA Global Safety Information Center initially provides members content consolidated from IATA Operational Safety Audit reports, IATA Safety Audit for Ground Operations reports, the IATA Safety Trend Evaluation Analysis and Data Exchange System, flight data analysis, ground damage reports and the IATA Accident Report.

New Slant on Criminalization

Gerard Forlin, a United Kingdom–based lawyer who has represented corporate clients in more than 200 safety-related events, recommended that airlines take another hard look at the growing trend toward criminalization of accident investigations.

"Last August, within three days of the takeoff accident at Barajas International Airport, Madrid, a judge was involved in looking at various engineers and maintenance issues in an investigation for manslaughter," Forlin said. "That would not have happened a few years ago. In the aftermath of an accident, criminal investigators now are looking to see whether there is corporate


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Lelaie

manslaughter or manslaughter individually. The days of blaming the front line operator — the pilot, the air traffic controller — haven't ended, but they're beginning to end."

Airlines, crewmembers, air traffic controllers and aviation executives should not expect to win over police, prosecutors, coroners and investigative judges to their point of view. Instead, they should focus on common ground where criminal prosecution can be warranted in narrow circumstances, Forlin said.

In his experience, these officials see commercial aviation as no different from mining, nuclear power or any other industry. "I am afraid this is now a train out of control," he added. "So what we need to do as an industry, as a global position, is to deal with the reality and try our best to sort out and harmonize our approach to the inevitable criminal prosecutions that are going to increasingly follow."

The industry position should be that prosecutors should not seek manslaughter charges, for example, against defendants such as airlines, industry executives, pilots or air traffic controllers, "unless it is really gross negligence, not on a human level, but where profit has been put before safety," he said. "We must say, 'Prosecute when safety has been put under the altar of profit. We will agree with you then, and we will back you and help you. For the rest, leave us alone … or safety is driven underground.' It is catastrophic if that happens because without open confidential reporting, we are going to have more aircraft accidents."

Prosecutors today may want to make an example of one airline, he said, as a means of changing the safety behavior of many airlines.

Runway Excursion Answers

A number of the IASS presentations cited runway excursion accidents as a significant challenge, requiring measures identified in the new *Runway Excursion Risk Reduction Toolkit* (*ASW,* 8/09, p. 12). Two explained relevant new technologies.

Claude Lelaie, experimental test pilot, SVP Product Safety, Airbus, introduced the company's runway overrun protection system, which was certificated in October by the U.S. Federal Aviation Administration (FAA) for the A380. The system originated from concepts employed in the A340-600 brake-to-vacate system, which was intended to reduce runway occupation time, brake wear and braking energy, he said.

"From statistics within Airbus, the majority of aircraft accidents are runway excursions," Lelaie said. "Some of the reasons are autobrake settings and wind shear, but the vast majority are approach unstable, long flare, long derotation, and so on. There are many causes."

With the brake-to-vacate system armed, the runway overrun protection system activates so exact lines across a runway where the aircraft will stop are computed when the aircraft descends below 500 ft, and the system then generates an immediate warning if a risk of excursion is computed from that time to landing.

"In flight, this allows the system to trigger a go-around," he said. "If it appears that there is a risk of overrun when you are on the ground, and the system detects that there is a risk of overrun, there is nothing else you can do except to stop. It automatically selects max braking [on the A380], and you have max braking at touchdown, which is very impressive. You have an audio alert to select max reverse or to keep max reverse at low speed [below 80 kt] because it is not urgent to protect the engine, it is urgent to remain on the runway."

If the aircraft is moving too fast for the wet or dry conditions, or is above the glideslope, an amber "wet bar" and a magenta "dry bar" appear in the primary flight display and move up or down to indicate where the aircraft will stop, including off the runway. "In the case of the wet bar moving out of the runway, that means on a wet or damp runway, you will not be able to stop on the runway," Lelaie said. "The procedure is quite simple, go around if the runway is wet or damp."

The primary flight display also has text annunciations, and the system provides the same alert as a repetitive audio callout — "runway too short, runway too short" — "to really push the pilot to go around," he said.

"In the case of the A340 accident at Toronto, the crew would have had two warnings on short final with this system, and if they still had decided to land, they would have been pushed to have max reverse immediately instead of after 11 seconds," he said. "Then they would have had a runway excursion at a speed much lower than what they had. We believe that with this protection, crews will avoid the vast majority of the runway excursions that we have today.

"For this reason, we have decided to prepare a retrofit kit that [we] will install on all our fly-by-wire systems in 2011–2012. On the single-aisle family, the A320, and the A330 and A340 families, the braking would be manual and the pilot would be pushed to conduct manual braking with a strong audio warning."

Another FAA-approved solution for mitigating runway excursions — called the stabilized approach monitor system — uses data already aboard thousands of large commercial jets to perform calculations based on fundamental laws of physics, said Don Bateman, corporate fellow–chief engineer of Honeywell International, the manufacturer.

He called for continued effort to address this category of accident on all fronts, including the possible effects of problematic instructions and pressures from air traffic control that "encourage a pilot to make an approach when he or she should not accept the approach," airport and runway design, and airfield lighting and visual aids.

"The industry has about 55,000 Enhanced Ground Proximity Warning Systems (EGPWS) on airplanes — about 90 percent of all the current commercial aircraft," Bateman said. "I look upon that as an asset — a platform we can use … to get the pilot's attention that something isn't right."

The system requires no changes to the hardware and normally no changes in wiring or to the cockpit displays. "If you get high and you've got less than 3 nm [5.5 km] to the runway, and you don't have your flaps down, that is typically violating standard operating procedures," he said. "So the system can say 'flaps, flaps.'"

If the crew is on a 5, 5 1/2 or 6 degree flight path, the system will annunciate "too high, too high" and duplicate that alert in text on the navigation display. "Likewise, if the airplane is 40 or 50 kt above V_{REF} [landing reference speed] the system can say 'too fast, too fast,'" Bateman said. "If the crew gets to 3 1/2 or 4 nm [6.4 or 7.4 km] and still is not 'in the box,' either for speed or slope to the runway, the system can say, 'unstable, unstable.'"

Similarly, when the airplane is over the runway but has overflown the touchdown zone, the system can issue the alert "long landing, long landing" if specified by the operator, and call out the distance remaining to the end of the runway, either in meters or in feet, he said.

Roadmap Workshops

Kicking off a series of IASS reports about regional safety initiatives throughout the world, Bill Bozin, vice president, safety and technical affairs, Airbus Americas, provided details of several workshops that introduced the *Global Aviation Safety Roadmap* to aviation stakeholders in a number of countries from late 2008 to late 2009.

"The *Roadmap* has become unique because it is the one accepted way to proceed … a good blueprint to use," he said. "Hopefully, it reassures people that their money and their efforts, whether in time or treasure, are well spent and well directed."

Conducting workshops generates viable, self-sustaining industry-government regional safety teams prepared to conduct gap analyses, develop action plans, commit resources, establish priorities and implement plans with measurable outcomes.

The most recent workshops have been successful as first steps toward comprehensive changes and generating regional and global assistance in some cases, he said. They have in common a narrow initial selection of priority focus areas identified by country representatives; high-level support from government leaders; and high likelihood of positive impact relative to all focus areas to be considered eventually in the *Roadmap* process.

In the period covered by Bozin's briefing, workshops were conducted in Ouagadougou, Burkina Faso; Maputo, Mozambique; and Brazzaville, Congo; and in Moscow for the Commonwealth of Independent States (CIS). The regional participants from states of sub-Saharan Africa chose as focus areas inconsistent regulatory oversight, inconsistent coordination of regional programs, inconsistent use of SMS and insufficient number of qualified personnel. The Interstate Aviation Committee (MAK) in the CIS and workshop participants selected as their priority focus areas the inconsistent use of SMS and insufficient number of qualified personnel. Reports were not yet available from later workshops in Khartoum, Sudan, and Bogotá, Colombia.