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Runway Overrun Occurs After Captain Cancels Go-around

The Boeing 747 was configured for a dry-runway landing when heavy rain occurred on final approach to Bangkok, Thailand. The captain told the first officer (the pilot flying) to go around but then retarded the throttle levers when the main landing gear touched the runway. The airplane was substantially damaged. None of the occupants was injured seriously during the approach-and-landing accident, but the delay in evacuation of the aircraft focused attention on improving training for emergencies.

FSF Editorial Staff

At 2247 local time Sept. 23, 1999, a Boeing 747-438 operated by Qantas Airways (Qantas) was landed beyond the touchdown zone on Runway 21L at Bangkok (Thailand) International Airport, hydroplaned on the wet runway and ran off the end of the runway. The airplane was substantially damaged. The crew began a precautionary evacuation of the airplane 20 minutes after the accident. None of the 410 occupants was injured seriously.

The Aircraft Accident Investigation Committee of Thailand delegated the accident investigation to the Australian Transport Safety Bureau (ATSB).

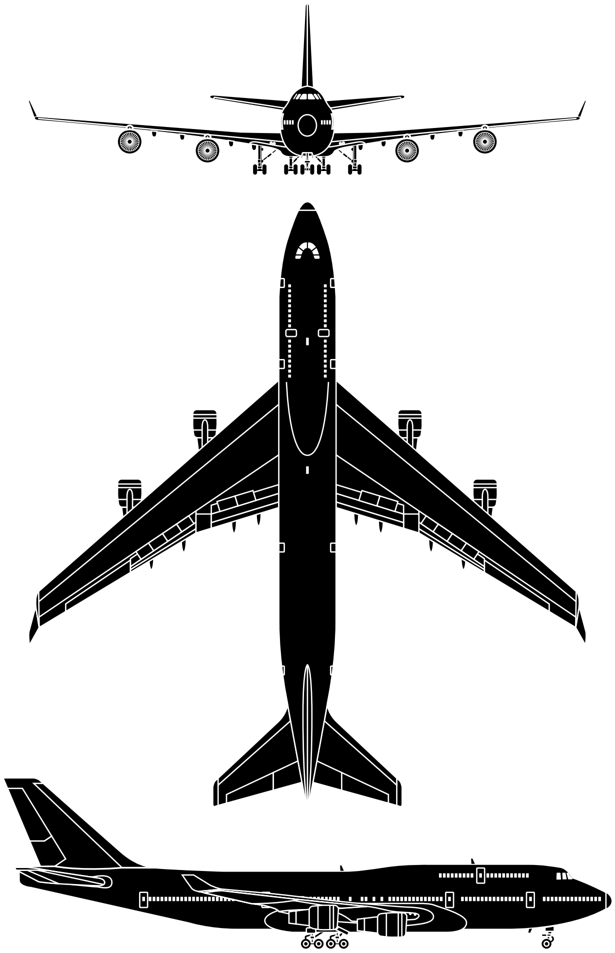
ATSB said, in its final report on the accident, that the investigation "identified several unsafe acts and active failures that had a significant influence on the development of the accident. These were:

- "The flight crew did not use an adequate risk-management strategy for the approach and landing;
- "The first officer did not fly the aircraft accurately during final approach;
- "The captain canceled the go-around decision by retarding the thrust levers;
- "The flight crew did not select (or notice the absence of) idle reverse thrust;
- "The flight crew did not select (or notice the absence of) full reverse thrust;
- "The flight crew did not consider all relevant issues when deciding not to conduct an immediate evacuation; [and,]
- "Some crewmembers did not communicate important information during the emergency period."

The report said that "other significant active failures" identified during the investigation were the following:

- "The runway surface was affected by water; [and,]
- "The cabin-interphone [system] and passenger-address system became inoperable."

The report said that "significant latent failures associated with Qantas Flight Operations Branch" were the following:



Boeing 747-400

An advanced, long-range version of the Boeing 747-300, the B-747-400 entered production in 1989. The airplane has longer wings with winglets, carbon (rather than steel) brakes, more fuel capacity and more fuel-efficient engines than its predecessor. The digital flight deck is configured for two-pilot operation.

The airplane has four engines — either General Electric CF6-80C2s, Pratt & Whitney PW4056 or Rolls-Royce RB211-524Gs. Each engine is rated at 58,000 pounds thrust (258 kilonewtons). Maximum takeoff weight is 870,000 pounds (394,632 kilograms). Maximum landing weight is 630,000 pounds (285,768 kilograms). Maximum level speed at 30,000 feet is 527 knots. Range at long-range cruising speed with 412 passengers and fuel reserves is 7,300 nautical miles (13,520 kilometers).

Source: *Jane's All the World's Aircraft*

- "Company-published information, procedures and flight-crew training for landing on water-affected runways were deficient;
- "Flight-crew training in evaluating the procedural [options] and configuration options for approach and landing was deficient;
- "Procedures and training for cabin crew in identifying and communicating relevant information during an emergency were deficient;
- "The processes for identifying hazards were primarily reactive and informal, rather than proactive and systematic;
- "The processes to assess the risks associated with identified hazards were deficient;
- "The processes to manage the development, introduction and evaluation of changes to operations were deficient;
- "The design of operational procedures and training were over-reliant on the decision-making ability of company flight crew and cabin crew, and did not place adequate emphasis on structured processes; [and,]
- "Management culture was over-reliant on personal experience and did not place adequate emphasis on structured processes, available expertise, management training and research and development when making strategic decisions."

The report said that "significant latent failures associated with [Australian Civil Aviation Safety Authority (CASA)] operations" were the following:

- "The regulations covering contaminated-runway operations were deficient;
- "The regulations covering emergency procedures and emergency-procedures training were deficient; [and,]
- "The surveillance of airline flight operations was deficient."

The report said that another significant latent failure was: "The redundancy provided by the normal and alternate cabin-interphone and public-address systems in B-747-400 aircraft was significantly reduced because components for both systems were co-located in the same relatively damage-prone position in the lower fuselage aft of the nosewheel."

The airplane, designated Qantas One, departed from Sydney, Australia, at 1647 local time [1347 Bangkok time] with 391 passengers, 16 cabin crewmembers and three flight crewmembers aboard. Estimated flight time to Bangkok was nine hours, 28 minutes.

The captain, 49, was employed as a cadet by Qantas in 1969. At the time of the accident, he held a senior management position in the Qantas Flight Operations Training Department and was a B-747-400 senior check captain. He had 15,881 flight hours, including 7,240 flight hours in type.

"His role as a management captain meant that he flew approximately one-third of the hours flown by a line captain," said the report.

During the 90 days preceding the accident, the captain flew 13 flight segments and conducted one night landing and seven day landings; he also conducted two night landings in a flight simulator. During the 30 days preceding the accident, he flew four flight segments and conducted two day landings.

On the day of the accident, the captain awoke at 0500 Sydney time and reported for duty at 1500. He had a 30-minute rest period and a two-hour rest period during the flight; he did not sleep during the rest periods.

"He reported that he did not feel tired or fatigued during the approach into Bangkok," said the report.

The first officer, 36, a former general aviation pilot and regional airline pilot, was employed by Qantas as a B-747 second officer in 1988. He began conducting line operations as a B-747 first officer in 1995. He had 8,973 flight hours, including 5,187 flight hours in type.

"In the 90 days prior to the accident flight, the first officer … completed 17 sectors, which was approximately his normal rate over the previous two years, [and conducted] five night landings and four day landings," the report said. "He … completed two sectors and one day landing in the 30 days prior to the accident.

"The first officer reported that he did not consider that his relatively low frequency of recent flying affected his manual control skills on the approach."

Runway 21L was not grooved and was not coated with porous friction concrete. Grooves in a runway and porous friction concrete coating increase runway-friction characteristics when the runway is wet.

On the day of the accident, the first officer awoke at 0730 and reported for duty "well before the sign-on time for the flight (1545)," the report said. During the accident flight, he had a 30-minute rest period and a two-hour rest period. He did not sleep during the rest periods.

"He stated that he often feels a little tired on such trips as the Sydney to Bangkok sector," the report said. "However, he did not believe he was fatigued at the time of the accident."

The B-747-400 was designed to be flown by two pilots. Qantas assigned a second officer to specific flights (e.g., long-range flights) to relieve the captain and the first officer, and to "monitor and assist" the captain and the first officer.

The second officer, 35, a former Royal Australian Air Force pilot, was employed by Qantas as a B-747 second officer in 1995. He had 6,685 flight hours, including 2,961 flight hours in type.

The report said that none of the pilots had a physiological condition or medical condition that might have affected his performance during the accident flight.

None of the pilots had flown together before the accident flight. They had received initial and recurrent (annual) crew resource management (CRM) training. The report said, however, that the Qantas CRM training program "did not contain all the elements of what is currently regarded as best practices in this area."

The departure phase and the en route phase were normal. The first officer, who was the pilot flying, conducted an approach briefing before the crew began the descent from Flight Level (FL) 350 (35,000 feet) at 2216. The airport was reporting surface winds from 250 degrees at 10 knots, visibility of nine kilometers (six statute miles) in rain and thunderstorms in the area.

The flight crew expected to land on Runway 21R, which was 3,700 meters (12,140 feet) long. [The report did not provide information on the width of Runway 21R.]

At 2219, a Bangkok Approach controller told the crew that they would land on Runway 21L, which was 3,500 meters (11,483 feet) long and 44.8 meters (147 feet) wide. The runway threshold was displaced 350 meters (1,148 feet), and available landing distance was 3,150 meters (10,335 feet), with a 100-meter (328-foot) stopway at the end of the runway.

Runway 21L was not grooved and was not coated with porous friction concrete. Grooves in a runway and porous friction concrete coating increase runway-friction characteristics when the runway is wet.

The *Qantas Route Manual Supplement* said that the Bangkok airport runways were "slippery when wet."

At 2221, the first officer conducted a briefing on the differences between Runway 21R and Runway 21L.

"He noted that the [instrument landing system] glideslope to Runway 21L (3.15 degrees) was slightly steeper than normal (3.0 degrees) and that the runway was narrower than Runway 21R," the report said. "The crew noted that they would have to roll through to near the end of the runway to exit via taxiway Sierra and should therefore select the autobrakes to position 2."

The B-747-400 autobrake-selector switch is on the bottom of the captain's instrument panel. The switch has eight positions: OFF, DISARM, 1, 2, 3, 4, MAX AUTO and RTO (rejected takeoff).

"The autobrake system [measures] the rate of deceleration of the aircraft on the runway and [compares] this to the rate selected by the crew according to the selector-switch position," the report said. "It then [meters] the hydraulic pressure to the brakes to provide the selected rate of deceleration, without brake-pedal operation, during the landing roll."

At 2225, the controller told the crew that rain was falling heavily at the airport. The captain told the first officer that the autobrake rate should be increased "for the water." Autobrake position 3 then was selected.

At 2227, the controller told the crew that visibility observed from the control tower was four kilometers (2.5 statute miles).

"The first officer suggested to the captain that they could go around and hold to the south if the rain looked 'bad' during the approach," the report said. "The captain replied that the visibility of four kilometers was fine and that it was 'just a shower.'"

In a postaccident interview, the captain said that the reported visibility of four kilometers was "well in excess" of the company's limit for first officers (Qantas required captains to conduct approaches when visibility was less than 1,500 meters [4,922 feet]). He said that the descent briefing had included a detailed discussion about go-around issues and that he did not believe further discussion of go-around issues was required.

"The captain said that, aside from changing the autobrake setting from position 2 to position 3, he had given no other consideration to the possible runway-surface conditions and their potential effects," said the report.

The first officer and second officer said that they, too, had not considered the possible runway-surface conditions and their potential effects at this point of the fight.

At 2229, the first officer leveled the airplane at FL 130. The airspeed stabilized at 250 knots soon thereafter. The airplane's heading was 360 degrees.

The airplane was more than 70 kilometers (38 nautical miles) from the airport at 2232, when the captain told the first officer and the second officer that he observed a "CB" (cumulonimbus cloud) over the airport.

The flight crew then completed the approach checklist. They planned to conduct the approach with flaps set to position 25 and at a final-approach target speed of 154 knots (V_{REF} [landing reference speed] plus five knots). Under the existing conditions, the required landing field length was 2,280 meters (7,481 feet).

At 2235, a Bangkok Arrivals controller told the crew to descend to 2,500 feet and to fly to a navigation fix approximately 10 nautical miles (19 kilometers) from the runway threshold on the instrument landing system (ILS) final approach course for Runway 21L.

The controller then told the crew of Thai 414 — an Airbus A330 that was about six minutes, 20 seconds ahead of the accident airplane on the approach — that there was heavy rain at the airport and that automatic terminal information service (ATIS) Information Tango was current.

The second officer of the accident airplane obtained Information Tango and briefed the captain and first officer on "relevant parts" of the report.

"The reported wind was from 280 degrees at nine knots, and visibility was five kilometers [three statute miles]," the report said. "Thunderstorms with rain were in the area, and there was a thunderstorm over the [airport]."

At 2239, the captain again told the first officer and the second officer that he observed a CB over the airport.

"The captain recalled that, after they had turned inbound, he had a clear view of the airport environment," the report said. "They were not in cloud at that point, and there was no rain. However, the storm cell over the airport was clearly visible and was also evident on the flight-deck weather-radar display.

"The crew stated that such conditions were a common occurrence in Bangkok and other tropical locations, and they were conscious of the possibility of turbulence, wind shear and reduced visibility."

During the next three minutes, the captain told the first officer several times that he should reduce airspeed. The crew extended the speed brake to reduce airspeed.

"The first officer reported that he was aware of the need to reduce speed, but he thought that the situation was under control and that the speed would reduce to the appropriate level during the approach," said the report.

Thai 414 landed at 2240. A special weather observation taken at this time showed that the visibility was 1,500 meters and runway visual range (RVR) for Runway 21L was 750 meters (2,461 feet).

"This information was included in [ATIS] Information Uniform … ," the report said. "The arrivals controller did not advise the crew of Qantas One that Information Uniform was current or that the visibility was now 1,500 meters."

The airplane was at about 7,100 feet, with airspeed decreasing below 250 knots, when the crew selected flaps 1. Airspeed was 207 knots when the crew selected flaps 5 about 45 seconds later.

At 2242:22, the airplane intercepted the ILS glideslope. The arrivals controller told the crew to change to the Bangkok

Tower frequency when the airplane crossed the final approach fix (the ILS outer marker, which was 4.1 nautical miles [7.6 kilometers] from the runway threshold).

The airplane was descending through 3,000 feet at 199 knots at 2243:17 when the crew selected flaps 10.

At 2243:26, the crew of Qantas 15 — a Boeing 747-300 that was about three minutes ahead of Qantas One on the approach — told Bangkok Tower that they were conducting a go-around.

"The crew of Qantas One did not hear this transmission because, at that time, they had not reached the final approach [fix] and had not transferred to the tower frequency," the report said. "The Qantas 15 go-around commenced from late-final approach, at approximately 250 feet above ground level.

"The controller did not inform [and was not required to inform] Qantas One that Qantas 15 had gone around, nor was there any communication between Qantas 15 and Qantas One on the company frequency regarding the go-around or weather conditions."

The crew of Qantas 15 told investigators that they began conducting visual flight procedures at about 2,000 feet. They said that they encountered rain at about 700 feet and that the rain became very heavy at about 500 feet.

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"The primary reason for the go-around was a loss of visual reference in the heavy rain when only the precision approach path indicator (PAPI) lights had been visible," the report said. "They could not see any runway lights."

The accident airplane was descending through 2,700 feet at 201 knots at 2243:32 when the crew extended the landing gear. At 2,200 feet and 182 knots, the first officer disengaged the autopilot and autothrottles, and selected flaps 20.

"The first officer reported that he decided to fly the approach 'manually' in order to maximize the opportunity for some 'hands-on' flying," the report said. "There was no concern about visibility at this stage."

The airplane was descending through 1,900 feet at 165 knots at 2244:25 when the crew selected flaps 25. At 2244:48, the airplane crossed the final approach fix, on the glideslope, at 1,600 feet; airspeed was 163 knots.

At 2244:53, the tower controller said, "Caution, runway wet, and braking action reported by Airbus three three [Thai 414] is good." The controller said that the wind was from 260 degrees at 11 knots and cleared the crew to land on Runway 21L.

"The crew reported that they had assumed the Airbus mentioned by the tower controller had landed immediately in front of them in the approach sequence," the report said. "They considered that they had no reason to think that the runway conditions were not appropriate for landing. They had landed in rain on many occasions (at Bangkok and other locations) and had not experienced any braking difficulties."

The crew completed the landing checklist at 2245:12. They did not discuss the option of a flaps-30 approach or the use of full reverse thrust after landing.

"It was assumed by all the crew that flaps 25 and idle reverse thrust would be used," the report said. "The crew stated that, based on the company procedures, their experience and the information available to them at the time, they had no reason to think that a different approach/landing configuration was required."

The *Qantas B747-400 Performance Limitations Manual* said that flaps-25 landings were preferred because they maximized carbon-brake life and reduced fuel, time and noise. The manual said that a flaps-30 setting reduces landing speed and landing distance, and should be used when landing field length requirements are critical and when landing on a "contaminated" runway or in low-visibility conditions. The manual said that idle reverse thrust should be used in normal conditions and that maximum reverse thrust should be used in abnormal conditions.

Qantas adopted these procedures in 1996. Before 1996, standard procedure for Qantas B-747-400 pilots was to use a flaps-30 setting and maximum reverse thrust.

"The company's pre-1996 policy of using flaps 30 and maximum reverse thrust as standard practice provided inherent defenses for contaminated-runway operations," the report said.

The report said that, compared with a flaps-25 landing, a flaps-30 landing results in a 6 percent to 7 percent shorter stopping distance primarily because of the lower approach speed for the flaps-30 configuration. Maximum reverse thrust contributes 15 percent to 20 percent to the stopping force on a wet runway.

The airplane was descending through 970 feet (as measured by the radio altimeter [RA]) at 2245:20 when the crew decided to continue the approach using visual procedures. The *Qantas Flight Administration Manual* said that visual procedures are conducted with manual airplane control and with the captain and first officer either "head free" (head up) or "placing increasing emphasis externally as the aircraft progresses down the approach path."

At 2245:32, the first officer said that the airplane "doesn't want to slow down." The captain acknowledged the first officer's statement. Airspeed at the time was 166 knots, and the airplane was descending through 770 feet RA.

The first officer had reduced the thrust settings to about 1.10 EPR (engine pressure ratio) and did not want to reduce further the thrust settings. The report said that 1.13 EPR to 1.14 EPR is a typical thrust setting during an ILS approach on a three-degree glideslope.

"The first officer said he was trying to slow the aircraft to the target speed (154 knots)," the report said. "He was becoming a little uneasy about the excess speed but thought that the captain appeared to be comfortable with the situation. Although still above the target speed, the airspeed was decreasing. … "

"The captain said that he was aware that the speed was high, but it was within company limits and was decreasing. He thought the situation was under control."

The pilots said that visibility was good and that they had the runway lights in sight until the airplane flew into rain at 350 feet RA. The rainfall intensity increased soon thereafter. The first officer said that he then observed the runway lights at brief intervals corresponding to the movement of the windshield-wiper blades.

The airplane was descending through 230 feet RA at 162 knots when it crossed the ILS middle marker, 1,000 meters (3,281 feet) from the runway, at 2246:07. Descent rate was 990 feet per minute (fpm), and the airplane was on the glideslope. Thrust settings were increased to 1.19 EPR and remained at this level for six seconds.

At 2246:08, the cockpit voice recorder (CVR) recorded the sound of heavy rainfall. The airplane was descending through 200 feet RA at this point.

"The different altitudes at which Qantas One and Qantas 15 encountered heavy rain was probably due to movement of the storm cells in the period between their approach times," said the report. "The first officer and second officer [of Qantas One] stated that the rain was the heaviest they had ever experienced during an approach."

At 2246:12, the airplane began to deviate above the glideslope as it descended through 140 feet RA. Airspeed was 170 knots; rate of descent was 600 fpm.

The captain said, "You're getting high now. You happy?"

The first officer said, "Ah, yes."

At 2246:18, the airplane flew over the runway threshold at 76 feet RA. Airspeed was 169 knots, and descent rate was 600 fpm.

"The aircraft was 20 knots above V_{REF} and 32 feet above the ideal threshold-crossing height for a 3.15-degree glideslope," said the report.

At 50 feet RA, the airplane's pitch angle increased from three degrees nose-up to 3.6 degrees nose-up. The captain said, "Get it down. Get it down. Come on, you're starting your flare."

The *Qantas B747-438 Flight Crew Training Manual* says that the pilot flying should begin the landing flare when the main landing gear is approximately 30 feet above the runway. The report said that the early flare conducted by the first officer probably was the result of "degraded visual cues due to the presence of rain on the [windshield] and the absence of [runway] touchdown zone lighting."

At 2246:27, the captain told the first officer to go around. The airplane was at 10 feet RA; airspeed was 157 knots.

"The captain reported that he made the go-around decision because the aircraft was 'floating' and the visibility had decreased to the extent that he was not sure that he could see the end of the runway," said the report.

The first officer advanced the throttle levers but did not select the autopilot TO/GA (takeoff/go-around) mode. (Selecting the TO/GA mode results in an increase in thrust sufficient to provide a 2,000-fpm climb rate — or maximum thrust if the TO/GA switch is pushed twice — and a flight-director guidance display.)

"The first officer said that his reason for manually advancing the [throttle] levers (rather than using TO/GA) was that he intuitively thought that method would commence the go-around quicker," the report said. "His intention was to increase the thrust manually and to then select TO/GA."

At 2246:30, the main wheels contacted the runway 1,002 meters (3,288 feet) from the runway threshold. The captain placed his right hand over the first officer's left hand, which was on the throttle levers, and moved three of the four throttle levers to the idle stop. The report said that the first officer probably did not have a firm grasp of the throttle lever for the no. 1 engine; the throttle lever for the no. 1 engine was not moved to the idle stop.

"The captain gave no verbal indication of this action or of his intentions [to continue the landing, rather than go around] and did not take control of the aircraft from the first officer," said the report.

The captain said that he could see the end of the runway and believed that the airplane could be stopped on the runway.

"[The captain] thought that there was no need for him to say anything as it should have been evident that the first officer retained the role of handling pilot," the report said. "The first

The nose-landing gear and the right-wing landing gear collapsed when the airplane struck the instrument landing system localizer antenna. The airplane continued over wet ground and came to a stop 220 meters (722 feet) from the end of the stopway.
(Photo: Australian Transport Safety Bureau)

officer also thought that there was sufficient runway remaining to stop the aircraft. He reported that … he was initially confused as to who was in control of the aircraft and whether the intention was to go around or continue the landing. The second officer expressed a similar view."

At 2246:39, the first officer said, "OK, we're on." He then moved the throttle lever for the no. 1 engine to the idle stop. At this time, airspeed was 160 knots.

When the throttle lever for the no. 1 engine was moved to the idle stop, the spoilers deployed automatically. Nevertheless, because the throttle lever was moved to the idle stop more than three seconds after the main wheels touched down, the autobrake selector moved automatically to the "DISARM" position. None of the flight crewmembers observed that the autobrakes were disarmed.

The captain said, "Got it?"

The first officer said, "Yeah, I've got it."

Boeing, in a February 1977 document titled *Landing on Slippery Runways*, said that the nosewheel must be lowered immediately upon touchdown to reduce wing lift and increase weight on the main wheels. The nosewheel of the accident airplane contacted the runway 11 seconds after the main wheels contacted the runway.

The first officer began to apply manual (pedal) braking at 2246:38. The airplane was halfway down the runway. Airspeed was 153 knots.

"The first officer reported that the reason he commenced manual braking was that the aircraft did not appear to be slowing down," the report said. "However, even after he started manual braking, there did not appear to be any change in the rate of deceleration. The captain and first officer reported that they were both applying maximum manual braking soon after this point."

The crew did not apply idle reverse thrust or full reverse thrust at any time during the landing roll.

"The crew reported that they did not realize that idle reverse had not been selected," the report said. "They did not think of using full reverse thrust at any stage of the landing roll. They all said that they were looking down the runway and could not understand why the aircraft was not decelerating."

The report said that dynamic aquaplaning (hydroplaning) will occur when a B-747-400 travels down a wet runway at groundspeeds above approximately 111 knots.

"[Dynamic hydroplaning] occurs when the tire is lifted off the runway surface by water pressure [and] requires surface-water depth greater than tire-tread depth and sufficient groundspeed to prevent the water [from] escaping from the tire's contact patch or footprint," the report said. "Under these conditions, the tire is wholly [buoyed] or partly buoyed off the pavement by hydrodynamic force and results in a substantial loss of tire friction. Dynamic [hydroplaning] can occur in depths of water as little as three millimeters [0.1 inch]."

The report said that weather conditions were changing rapidly. The rainfall rate at the time of the accident was sufficient to cause runway-surface water depth to exceed three millimeters.

"It was likely that distribution of water on the runway changed during the six minutes, 20 seconds between [the time that] Thai 414 landed (and apparently experienced no braking difficulties) and the time that Qantas One landed (i.e., by then, braking action is more likely to have been closer to 'poor')," said the report.

The Australian *Aeronautical Information Publication* and the *Jeppesen Route Manual* for Australian operations contained the following braking-action definitions:

- "*Good* — pilots should not expect to find the conditions as good as when operating on a dry runway, but should not experience any directional control [difficulties] or braking difficulties because of the runway conditions;
- "*Medium* — braking action may be such that the achievement of a satisfactory landing or accelerate-stop performance, taking into account the prevailing circumstances, depends on precise handling techniques; [and,]
- "*Poor* — there may be a significant deterioration both in braking performance and directional control."

At 2247:04, the airplane overran the stopway at 88 knots. The nose-landing gear and the right-wing landing gear collapsed when the airplane struck the ILS localizer antenna. The airplane then continued over wet, spongy ground and came to a stop with the nose on an airport-perimeter road 220 meters (722 feet) from the end of the stopway.

The first officer shut down the engines. The tower controller asked the crew if they had vacated the runway. The first officer twice said that they had overrun the runway and that they required assistance, but his radio transmissions were weak and were not understood by the controller.

A witness reported the accident to the tower at 2248:30. Tower personnel closed Runway 21L and activated emergency services. Emergency vehicles could not be driven on the wet ground; drivers used the airport perimeter road and arrived at the accident site at 2257.

The captain attempted without success to make a public-address announcement to the cabin occupants and to call the customer-service manager (CSM) on the cabin-interphone system. (The controllers for the public-address system and cabin-interphone system were damaged when the nose-landing gear collapsed.) The captain then told the second officer to go to the cabin and tell the CSM to come to the flight deck.

"The second officer returned to the flight deck and reported that there was no sign of fire and that the situation in the cabin was under control," the report said. "The CSM … told the captain that the cabin crew were at the exits and were ready to [conduct an evacuation of the airplane]."

The captain told the CSM to assess the condition of the passengers and cabin. When the CSM returned to the flight deck, he said that none of the occupants was injured but that there was some damage to the cabin (several ceiling panels had fallen in aisles, and items had become dislodged from the galley and from overhead baggage lockers).

After discussing the situation with the first officer and second officer, the captain told the CSM to conduct a "precautionary disembarkation."

The report said that company manuals contained procedures and checklists for various emergency situations but did not contain definitions for, or guidance for choosing, an emergency evacuation or a precautionary disembarkation.

The report said that the flight crew did not consider all relevant factors before deciding to conduct a precautionary disembarkation, rather than an immediate emergency evacuation, and that information was not communicated adequately among the cabin crew and flight crews.

"Although the flight crew considered a number of relevant factors in their decision making process, other factors appeared not to be given appropriate consideration," the report said. "Most importantly, the crew did not appear to consider what gaps they had in their available information about the condition of the aircraft and possible hazards. They were not able to obtain any information from anyone outside the aircraft and, consequently, had minimal information concerning the extent of external damage, particularly beneath the aircraft."

Some cabin crewmembers had detected a smell "like burning wires" in the cabin. The flight crew was told, however, that a "strong smell" had been detected in the cabin.

"Important available information that did not reach the flight crew included observations regarding flashes from an engine during the landing roll, damage to the no. 3 engine pod, cabin-floor deformation and the full nature of 'fumes' detected [in the cabin]."

The report said that some cabin crewmembers did not enforce the company's requirement that passengers not carry baggage with them during a precautionary disembarkation.

The airplane's landing gear, no. 3 engine nacelle and lower fuselage were damaged during the runway overrun. The airplane came to rest with its nose on an airport-perimeter road. (Photo: Australian Transport Safety Bureau)

"Cabin crew reported that they allowed some passengers latitude to carry small articles because the disembarkation was not a 'full emergency' situation or because they did not wish to confront or upset passengers," the report said. "They also reported that some passengers argued with cabin crew who tried to enforce the company safety requirements."

The report said that, after exiting the airplane, many passengers were not given appropriate directions by crewmembers or by emergency-services personnel.

"All passengers should have received clear directions, from either emergency services or the aircraft's crew, to immediately move away from the aircraft," said the report.

Thirty-eight of the accident aircraft's passengers who responded to an ATSB questionnaire said that they received some form of physical injury. Seventeen passengers said that they received whiplash injuries or bruises. Three passengers said that they were struck by dislodged passenger service units. Thirteen passengers said that they received minor injuries during the evacuation.

"No passenger reported attending a hospital, although four [passengers] reported subsequently visiting a doctor … ," the report said. "Based on the available information, all of these injuries were minor."

The report said that Qantas Flight Operations Branch management personnel were "largely unaware" of the procedural deficiencies and training deficiencies found during the investigation.

The *Qantas B747-438 Operations Manual* included information about conducting landings on wet runways, slippery runways and icy runways in a section titled "Cold Weather Operations."

"It became evident during the investigation that many Qantas pilots (including the crew of Qantas One) viewed this section of the [operations manual] as relevant only to cold weather operations, such as those encountered in winter in Europe or Japan, or when strong crosswind conditions existed," the report said. "They did not associate the information with water-affected runways at locations in warmer climatic areas. …

"There was no other information in company documentation for the B747-400 … provided to pilots regarding the techniques for landing on water-affected runways and the importance of reverse thrust as a stopping force in such conditions."

The report said that contaminated-runway issues were covered extensively in Qantas pilot training in the 1960s and 1970s, but had not been covered in training since then.

"Some company management pilots believed that line pilots should have possessed adequate knowledge and understanding of water-affected runway operations, simply on the grounds that they were professional pilots and, as such, should take some personal responsibility for maintaining their knowledge and expertise," said the report.

Postaccident interviews with Qantas pilots indicated that many pilots did not know that dynamic hydroplaning can occur

Three passengers said that they were struck by passenger service units that dislodged during the accident. (Photo: Australian Transport Safety Bureau)

with as little as three millimeters of water on a runway or that reverse thrust contributed significantly to stopping distance on a water-contaminated runway.

“ Many pilots believed the term ‘contaminated’ was associated with snow, ice or water to a depth of 13 millimeters [0.5 inch] … ,” the report said. “Some pilots commented that Qantas B747-400 aircraft generally operated in good weather and to [airports] with long and good-quality runways. Crews rarely operated to limiting runways. Pilots rarely experienced, or heard about others experiencing, significant reductions in braking effectiveness due to the presence of water on runways.”

The report said that, although Qantas had a “no-blame policy” for internal incident investigations, pilots were reluctant to report incidents involving crew-performance issues.

“The incident-reporting culture in the airline was not strong, with flight crew appearing to report … only those incidents for which they believed a mandatory reporting requirement existed,” said the report.

The report said that the company did not conduct a formal risk assessment before adopting the flaps-25/idle reverse thrust landing policy in 1996 and did not use in-flight data recorded by quick-access recorders (QARs) to study the results of the new policy. Investigators found that QAR data recorded after the policy change showed a significant increase in the frequency of approaches conducted at speeds greater than V_{REF} plus 15 knots for three seconds or more below 50 feet RA.

The report said that the company had no systematic plan for safety audits. The company typically conducted audits on specific safety issues after concerns about those issues were identified.

“The Flight Operations Branch had in place a number of processes for identifying operational hazards or deficiencies,” the report said. “These processes had proved successful in ensuring the operator maintained a high level of safety in many areas. However, the processes were predominantly reactive and/or informal.”

The report said that Australian Civil Aviation Regulations (CARs) and Civil Aviation Orders (CAOs) about contaminated-runway operations and emergency procedures were deficient.

“A regulatory requirement existed for operators to provide landing distances for conditions worse than ‘wet’ [i.e., landing distances on runways contaminated with slush, snow or standing water],” the report said. “However, this requirement was not clearly stated and [was] not clearly understood by CASA FOIs [flying operations inspectors] or the airlines.”

The report said that regulations about emergency procedures and emergency-procedures training were “minimal and lacked detail.”

Plans by CASA for surveillance of Qantas were reduced substantially several times in the seven years preceding the accident.

“CASA personnel reported that surveillance targets for Qantas had not been achieved for several years prior to 1999,” the report said. “The December 1999 review [of CASA by the Australian National Audit Office] noted that the reasons for the low levels of surveillance of Qantas included low staff morale within CASA (due to a variety of reasons) and uncertainty over proposed major changes to the method of surveillance.”

The flight times and duty times of the Qantas One crew complied with the requirements of CAO 48, “Flight Crew Limitations.” The report said, however, that CAO 48 includes limitations on nonflying duties only for situations involving single-pilot operations or two-pilot flight crew operations.

The report said that, although the accident pilots believed that their performance was not affected by fatigue and no overt signs of fatigue were found during the investigation, “it is possible that both the captain and first officer were experiencing some fatigue due to their number of hours of continued wakefulness, the time of day and the captain’s recent nonflying workload.”

The accident occurred at 0145 Sydney time. The captain had been awake almost 21 hours; the first officer had been awake about 19 hours.

"In addition, the captain's management duties involved a high [nonflying] workload over the previous weeks," said the report.

The report said, "On 5 December 2000, Qantas reported that all deficiencies identified during the investigation … either had been [addressed] or were being addressed. … CASA was also in the process of making substantial changes to its surveillance processes and the Australian aviation safety regulations."

Based on the findings of the investigation, ATSB made the following recommendations:

- "CASA [should ensure] that all Australian operators of high-capacity jet aircraft have in place procedures and training to ensure flight crews are adequately equipped for operations on wet/contaminated runways;
- "CASA [should] review the intent of CAO 48 to ensure that operators consider all duties associated with a pilot's employment (including managerial and administrative duties) when designing flight-time and duty-time schedules, and that this requirement is not restricted to situations where there are one or two pilots;
- "[The U.S. Federal Aviation Administration and the European Joint Aviation Authorities should] review the design requirements for high-capacity aircraft to ensure the integrity of the cabin interphone and passenger-address systems, particularly with respect to cabin/flight deck communications, in the event of runway overruns and other relatively common types of events which result in landing-gear [damage] and lower-fuselage damage;
- "CASA should consider including the following issues as requirements of operators during its current development of new legislation in the area of emergency procedures training:
  - "How flight crew should gather and evaluate relevant information and make a decision regarding which type of emergency response is most suitable;
  - "How cabin crew should communicate with each other and the flight deck in emergency situations (in terms of technique, terminology and methods to ensure that accurate information reaches the flight deck);
  - "How cabin crew should communicate during an emergency on the ground when there is a loss of [passenger-address] and interphone communications;
  - "How cabin crew should systematically and regularly identify problematic situations in an aircraft during an emergency (including guidelines on what types of information are most important and ensuring that all areas of the aircraft are examined);
  - "Leadership and coordination functions of cabin-crew supervisors during an emergency situation. For example, how the supervisors should assess the situation (particularly in circumstances that had not been clearly defined), assign roles and responsibilities among the cabin crew, coordinate the gathering of information and coordinate the distribution of information;
  - "How cabin crew should effectively obtain information from passengers concerning safety-related issues;
  - "How cabin crew should effectively use language and assertiveness for crowd control and managing passenger movement toward exits during emergency situations, as well as passenger control outside the aircraft; [and,]
  - "That cabin-crew supervisors are provided with appropriate resources to ensure that they can effectively communicate with other areas of the cabin during emergency situations (e.g., providing the supervisor with ready access to an 'assist' crewmember at their assigned location); [and,]
- "CASA [should] consider widening its existing skill-base within the Compliance Branch to ensure that CASA audit teams have expertise in all relevant areas, including human factors and management processes."♦

[This article, except where specifically noted, is based on Australian Transport Safety Bureau Investigation Report 199904538: *Boeing 747-438, VH-OJH, Bangkok, Thailand, 23 September 1999*. The 170-page report contains diagrams, tables, photographs and appendixes.]

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