Executive Ability

China Southern Airlines prepares flight crews to optimize operational safety and profit.

BY WAYNE ROSENKRANS | FROM BEIJING

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A simple drawing of a circle overlapping a square can help clarify how airline captains simultaneously must be safety professionals and line managers of their companies, says Zhou Yizhi, an Airbus A330 captain instructor for China Southern Airlines. Called the *square-circle model,* this visual aid to risk assessment and management also has been an instructional tool to improve the *executive ability* — analytical skills that can be taught and improved — of flight crews. The model helps in adequately considering company profit in relation to operational risk assessment, especially in abnormal or emergency situations, he said.

In crew debriefings, for example, the model has been used to address decisions made impulsively without scientific analysis of the actual margin of safety. “Profit yield will be significantly less if the crew’s improper decisions lead to unnecessary diversion or the cancellation of flights,” he said.

Zhou, who also is a crew resource management instructor for the International Air Transport Association (IATA) and a member of the IATA Safety Group, presented three case studies during the joint meeting of the 62nd annual Flight Safety Foundation International Air Safety Seminar (IASS), IATA and International Federation of Airworthiness 39th International Conference, held here in November.

When an airline flight concludes safely, this does not necessarily validate that the flight crew’s decisions were logical or reasonable — or that the margin of safety was adequate, he said. China Southern teaches that “decision making primarily shall be based on safety factors,” Zhou said.

“Within the safety margin, however, the crew must consider the company profit. A low profit of the company could be caused by improper risk assessment and excessively conservative decisions, while the potential threats could be increased as a result of unchallenged bold decisions.” In his experience, favorable outcomes of flight crew decisions tend to depend largely on consistent application of executive ability.

Square-Circle Model

In the model, a square signifies executive ability, with a larger size signifying better executive ability. The perimeter of a circle signifies the actual risk or the crew’s assessed risk (Figure 1). The area of the circle signifies the effect on company profit of one decision compared with others. By superimposing the “assessed risk,” “actual risk” or both circles on the square, parts of the square covered or revealed can be interpreted.

“The non-overlapping area represents the safety margin,” Zhou said. “We want both a safety margin and a greater company profit; they can vary from big to small. In different risk assessments, we will have different company profits. If the circle is too small, the safety margin appears larger, but the company’s profit will be the inverse [that is, decreased]. Some circles are just inside the square, so the square covers the circle. Then executive ability can cover the decision making required. If the size of the circle extends beyond the boundaries of the square — the crew’s decision exceeds their ability — an unsafe event would occur.”

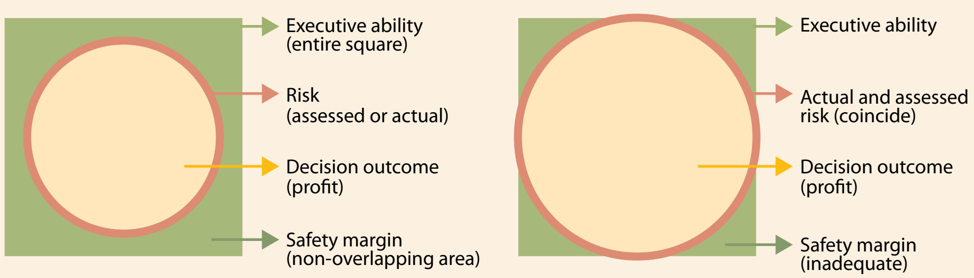
Model Applications

One case study looked at risk factors during a final approach at sunset after an asymmetric trailing edge flaps malfunction on a China Southern Boeing 757 operating from Chengdu to Jiuzhaigou. This uneventful flight was flagged for safety analysis.

“Jiuzhaigou is a most challenging airport to fly into,” Zhou said. “They just cut off the top of a mountain and set up the runway. The airport elevation is 11,311 ft, and only Runway 20 may be used due to terrain limitations. The flaps seized between positions 20 and 25 at about 2,000 ft above ground level [AGL] roughly 7 nm [13 km] from touchdown, or two minutes to go. In normal conditions, the Boeing 757 aircraft lands at this airport with flaps set at 25. In this case, there was a tail wind at 3 to 4 mps [6 to 8 kt], a wet runway with partial standing water, no braking action reports and time pressure.”

Pilots with the desired executive ability consistently recognize that timely

Square-Circle Model and Landing at Jiuzhaigou



Notes: The left drawing identifies common elements used in square-circle model analysis. The right drawing shows risk for an actual landing with an asymmetric trailing edge flap malfunction on approach to this high-altitude airport. Risk factors included tail wind, wet runway with partial standing water, nonadherence to procedures and no braking action report.

Source: Zhou Yizhi, China Southern Airlines

Figure 1

decisions to go around are essential when critical tasks cannot be completed before landing. "[In this 757 approach] at the edge of night, some of the crew did not think in that way," he said. "On the actual flight, both pilots had captain qualification per company policy. The copilot on the observer's seat carried the quick reference handbook [QRH, and one minute elapsed as the non-normal checklist was performed]. Immediately after completion of the non-normal checklist and normal checklist, the height of the aircraft was 500 ft AGL, so the crew mostly could see the runway. The captain could see the increased landing distance and selected maximum autobrakes. Finally, the aircraft landed safely."

The risk of this landing was analyzed retrospectively. If braking action on the 3,000-m (9,843-ft) wet runway had been good, the required landing distance for this non-normal configuration of flaps setting 20 and V_{REF20} (landing reference speed) of 144 kt would have been 1,584 m (5,197 ft), providing an adequate safety margin. If braking action had been medium, the distance would have been 2,465 m (8,087 ft) and if poor, 3,253 m (10,673 ft), he said.

For all these landing distances in the QRH, however, the aircraft must be 50 ft over the runway threshold and land at the touchdown point, and the crew must apply maximum manual braking and select maximum thrust reversers.

Zhou analyzed the crew's decision to land with medium braking action assumed, leaving a safety margin of 535 m (1,755 ft) and touchdown groundspeed of 190 kt (98 mps). "Clearly, the threat on that day was significant," he said. "This crew did not consider properly the non-normal landing distance [or the need] to apply maximum braking and maximum reverse thrust. Their groundspeed was almost 100 mps [328 fps]." Thus, every second of flight before flare reduced the runway available for deceleration by 100 m (328 ft) so just a two-second aircraft handling error would have reduced the distance safety margin to 339 m (1,112 ft) with maximum manual braking — and less with the maximum autobrakes used.

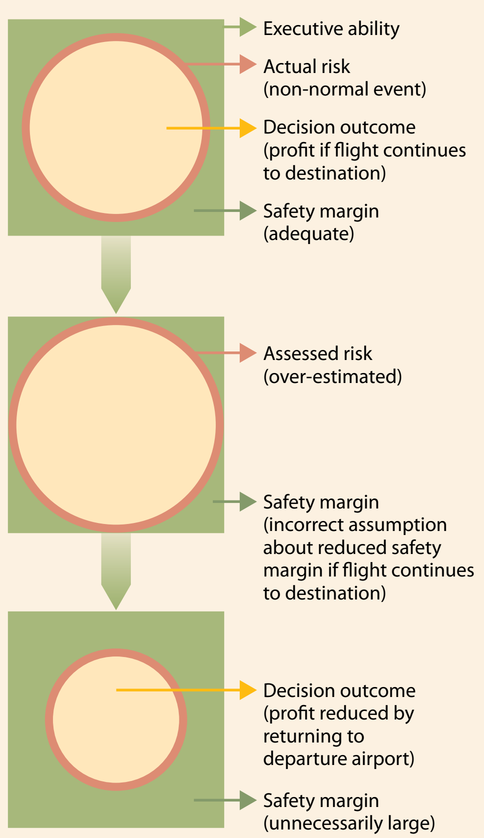
The square-circle model (Figure 1) showed the perimeter of the "actual risk" circle coinciding with the "assessed risk" circle. Overlaying both circles on the "executive ability" square left some safety margin visible. "Probably, they did not have enough safety margin, so I can say that even with a safe flight, the decision to land probably was not reasonable," he said.

Another case study looked at the decision by a captain operating a 757 from Guangzhou to Urumqi (Figure 2); the crew had returned to the departure airport. "Just as the crew lifted off and during the process of aircraft acceleration and flap retraction, the message 'TRAILING EDGE FLAPS DISAGREE' appeared," Zhou said. The crew complied with standard operating procedures, engaging the autopilot, reducing airspeed to flap maneuvering speed, climbing to a safety altitude of 1,200 m (3,900 ft), notifying air traffic control and conducting the corresponding non-normal checklist.

"One of the last items was 'Alternate Flaps Selector — Set. Extend or retract flap as required.'" Zhou said. Executive ability influenced the decision. "The actual situation was 'flaps extension and retraction [are] normal in alternate mode,'" he added. The crew had told safety investigators, "Possible problems after flap retraction were considered at the time, and there was no guarantee that problems wouldn't occur during the remaining [five-hour] flight."

The square-circle model showed that the crew had created an "unnecessary safety margin," he said. "By correctly assessing the threat, within the safety margin, the crew's decision should minimize operational cost as much as possible," Zhou said.

Incorrect Risk Assessment Near Guangzhou



Note : The flight crew observed a "trailing edge flaps disagree" message after takeoff from Guangzhou on a five-hour flight to Urumqi. They returned to Guangzhou.

Source: Zhou Yizhi, China Southern Airlines

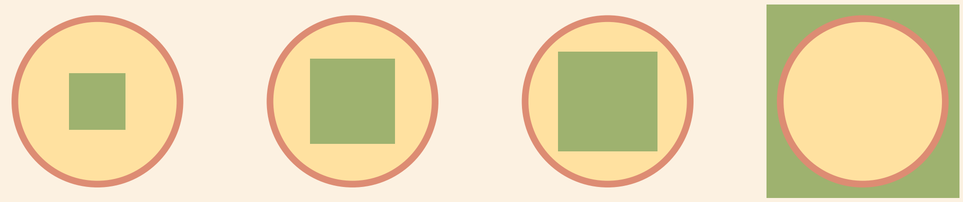
Figure 2

Another case study interpreted actual and hypothetical crew responses to a dual malfunction of the automatic cabin pressurization systems. The actual flight cited was from Guangzhou to Kunming, which has an airport elevation of 6,220 ft. "After departure, the crew was instructed to climb to Flight Level 197 [6,000 m, approximately 19,700 ft]," he said. "While climbing through 6,000 ft, a malfunction occurred with the annunciation 'CABIN AUTO INOPERATIVE 1 AND 2.'" The crew correctly leveled off above the safety altitude, but below 10,000 ft, and conducted the non-normal checklist as they were trained.

"If the cabin altitude cannot be controlled manually, the crew obviously will return to the departure airport," Zhou said. "[When it can be controlled manually,] the choice the crew must make is to continue or return to the departure airport, considering the safety margin and company profit."

If the decision is to continue to the destination, the crew implicitly accepts responsibility to comply with a deferred item — select landing altitude — on the normal checklist; a procedure for manually adjusting cabin altitude during descent based on the specific change of altitude; and a deferred item on the non-normal checklist for which the QRH says, "When at pattern altitude: CABIN ALTITUDE MANUAL CONTROL — CLIMB. Position to CLIMB until outflow valve [is] fully open."

Flight Crew Decisions With Different Executive Abilities: Kunming Arrival



Note: In these hypothetical scenarios, the flight crew is alerted soon after takeoff that both aircraft systems for automatic control of cabin altitude are inoperative. Perimeters of circles signify almost the same initial risk in continuing the flight using manual control. Squares signify different executive abilities demonstrated by these crews (bigger size means greater ability) while continuing to the destination.

Source: Zhou Yizhi, China Southern Airlines

Figure 3

"Suppose that at the cruise altitude to Kunming — which was 8,400 m or 27,600 ft — the cabin altitude is 3,000 ft and after about two hours, the aircraft will descend," he said. "Also suppose we have four crews [Crew A, Crew B, Crew C and Crew D of different executive abilities]."

Crew A forgets to select the pressurization setting item in the normal checklist and the non-normal checklist items, so the cabin door cannot be opened safely.

Crew B forgets during descent the landing-altitude setting on the normal checklist but remembers to conduct the deferred item on the non-normal checklist. At the pattern altitude of 10,200 ft, the crew fully opens the aft floor valve and cabin altitude rapidly rises from 3,000 to 10,200 ft. This causes severe eardrum discomfort and possible ear injury, and triggers a cabin altitude warning.

Crew C manually sets landing altitude to 6,220 ft before descent and conducts the deferred items but fully opens the aft floor valve at pattern altitude. The consequences are less severe than for Crew B because the cabin altitude only rises from 6,220 to 10,200 ft, but the effects are similar: uncomfortable ear pain for occupants, possible ear injury and a cabin altitude warning.

Crew D manually sets landing altitude before descent, gradually increases cabin altitude from 7,000 to about 9,000 ft, then on final approach below 10,000 ft performs the deferred checklist item to open the aft floor valve. This action safely maintains comfortable cabin altitude, and there is no cabin altitude warning.

"For these crews, the decisions in the circles [Figure 3] were almost the same but the result varied due to the difference in their executive abilities," Zhou said. "Crew D's executive ability covered the decision making required. Executive ability of Crew A, Crew B and Crew C could not. So only Crew D was safe; Crew A, Crew B and Crew C were unsafe."

Regardless of executive ability, however, altering one variable would mask any difference in performance among these crews. "Suppose the destination is Shanghai, airport elevation 9 ft, instead of Kunming," Zhou said. "Both pattern altitude and the cabin pressure then would be 3,000 ft, and even if all crews continued to the destination, the threats discussed for Kunming would have been much smaller, so all would have the same safe outcome."