FALSE POSITIVE

Eric Gaba/Wikimedia Commons

The gauges showed 'fat on fuel' when the tanks ran dry.

BY MARK LACAGNINA

The fuel quantity indicator (FQI) showed that there was plenty of fuel aboard the ATR 72 when both engines flamed out high above the Mediterranean Sea. Accordingly, the flight crew spent precious minutes trying to restart the previously faultless engines rather than coaxing the maximum glide performance from the aircraft for a possible landing at a coastal airport — a theoretical possibility.

The restart attempts were futile because there actually was no fuel remaining in the tanks. The problem was not that the FQI was malfunctioning, the problem was that it was designed to be used in an ATR 42, not in the larger ATR 72 in which it had been installed before the flight.

The aircraft broke into three pieces when it was ditched in rough seas off the northern coast of Sicily. Fifteen passengers and the senior flight attendant were killed; 13 passengers, the captain, the copilot and the assistant flight attendant were seriously injured; and seven passengers sustained minor injuries.

In its recent report on the Aug. 6, 2005, accident, the Agenzia Nazionale per la Sicurezza del Volo (ANSV, the Italian Air Safety Board) said, "The ditching was primarily due to the

[flameout of] both engines because of fuel exhaustion. The incorrect replacement of the [FQI] was one of the contributing factors which led irremediably to the accident."

Not Interchangeable

The accident aircraft was operated by the Tunisian airline Tuninter, which had two ATR 72s and one ATR 42 in its fleet. Based in Tunis, the airline conducted "domestic and international scheduled service and charter flights, the latter chiefly to and from Italy," the report said.

The day before the accident, the aircraft had been used for five flights, of which four were conducted by the accident captain. He had noticed that the FQI display was difficult to read because of the failure of several light-emitting diodes. The captain recorded the fault in the aircraft's logbook after completing his last flight, which terminated in Tunis.

The captain also recorded that 790 kg (1,742 lb) of fuel remained in the aircraft after shutdown.

The FQIs in the ATR models compute the weight of fuel in the wing tanks based on measurements of the electrical capacitance of metallic probes inside the tanks. "The FQI is an instrument processing the signal from the capacitive sensors installed in the wing fuel tanks, based on an algorithm which is specific to each type of aircraft, depending on the shape of the tanks, their sizes and the number of probes," the report said. "The wing fuel tanks of ATR 42 and ATR 72 aircraft are different in terms of maximum capacity, shape, [and the] number and positioning of the capacitive probes. Therefore, ATR 42 and ATR 72 type FQIs use different algorithms and cannot be interchanged."

The FQIs for the two ATR models are almost identical in appearance, the only difference being the inscriptions on the gauge faces showing the maximum fuel quantity for each wing tank: 2,500 kg (5,512 lb) for the ATR 72 and 2,250 kg (4,960 lb) for the ATR 42. The installation procedure is the same.

Search for a Spare

Following up on the captain's malfunction report, a maintenance technician in Tunis had used a video terminal to search the manufacturer's illustrated parts catalog (IPC) for the correct part numbers for a replacement FQI. He found three: 748-681-2 (the same part number as that of the faulty FQI that required replacement), 749-160 and 749-759.

The ATR 72 broke into three pieces when it was ditched in rough seas. Some survivors climbed atop the center section to await rescue.

Agencia Nazionale per la Sicurezza del Volo

Though it looks almost identical and fits perfectly, this ATR 42 fuel quantity indicator will read high when installed in the larger ATR 72.

The technician then searched Tuninter's spare parts management system for FQIs bearing those part numbers but found none shown as either in stock or installed in one of the airline's ATR 72s. "As this result was rather strange, considering that at least the FQIs already installed on the aircraft of the carrier should have shown on the information system, the technician tried to look for FQIs recorded with a PN [part number] different from the one listed in the IPC," the report said.

(FQIs suitable for the ATR 72 actually were available in stock at Tunis, but their part numbers had not been entered in the spare parts management system's database exactly as they appeared in the IPC; the dashes in 748-681-2, for example, had been omitted. Thus, when the technician entered the part numbers that he had derived from his search of the IPC, the spare parts management system did not recognize them.)

The technician continued his search by entering "748-" in the spare parts management system. The system erroneously showed that PN 748-465-5AB was applicable for installation in both the ATR 72 and the ATR 42, and was interchangeable with FQIs of two different part numbers, one of them being 749-158. "The information relating to the applicability was wrong, as PN 748-465-5AB identifies an FQI only applicable to ATR 42 aircraft and not also to [the] ATR 72," the report said.

The spare parts management system showed that a PN 749-158 FQI was in stock. The technician's shift was nearly over when he retrieved the FQI from stock, so he prepared the gauge for installation and left it for the maintenance technician assigned to the next shift.

The maintenance technician on the next shift replaced the FQI in the accident aircraft. "The technician replacing the part did not complete, however, an IPC check for the applicability of PN 749-158 to the ATR 72 aircraft either before or after the replacement," the report said.

After it was installed, the FQI showed a total fuel quantity of 3,100 kg (6,834 lb), rather than 790 kg. No checks of the accuracy of this indication were performed or were required to be performed. "The replacement procedure did not require any manual checks, using the so-called dripsticks, of the actual quantity of fuel present in each tank or the subsequent comparison with the value shown by the FQI," the report said.[1] The job instruction card required only a check that the displays were illuminating properly.

Shuffled Schedule

The schedule for the accident aircraft, registration TS-LBB, the morning of Aug. 6 began with a round-trip flight between Tunis and Djerba, a resort island off the southeast coast of Tunisia. The flight crew assigned to these flights requested an initial fuel load that was about half the 3,100 kg shown on the centralized refueling panel, which simply repeats the quantity shown on the cockpit FQI.

It was decided that TS-LBB would have to be partially defueled. However, the defueling tanker would not be available for two hours. Rather than delaying the flight, the assigned crew agreed to conduct the flight in the other ATR 72 operated by Tuninter.

That aircraft, TS-LBC, had been scheduled for a flight to Palermo later that morning. However, when the dispatcher told the crew assigned to that flight that TS-LBC had been rescheduled and that they would have to take

TS-LBB instead, the captain refused. "He took this decision because, during previous flights using the same aircraft, a malfunctioning of the nosewheel steering [system] had repeatedly been notified," the report said. "It was his opinion that this fault had not been correctly handled and resolved." (The fault was excessive vibration and a loud noise when the nosewheel was fully deflected.) The dispatcher then offered the ATR 42 for the Palermo flight, and the captain accepted it.

'Missing' Fuel Slip

The captain who had reported the malfunctioning FQI in TS-LBB the previous day had been scheduled to conduct subsequent flights in the aircraft on Aug. 6, beginning with a positioning flight to Bari, which is on the southeastern coast of the Italian peninsula, and a charter flight to Djerba (ultimately, the accident flight).

The captain and the copilot assigned to the flights were Tunisian nationals. The captain, 45, had 7,182 flight hours, including 5,582 hours in type. He had been on duty more than nine hours the previous day and had a rest period of nearly 18 hours. The copilot, 28, had 2,431 flight hours, including 2,130 hours in type.

The dispatcher asked the pilots if the indicated fuel quantity, 3,100 kg, would be sufficient to complete the flights to Bari and Djerba without refueling in Bari. The copilot told the captain that he had calculated a departure fuel load of 4,200 kg (9,259 lb) as sufficient to avoid refueling in Bari. "The flight captain, responsible for the final decision, decided to request a block fuel value of 3,800 kg [8,377 lb]," the report said. "During [post-accident] interviews, the flight captain justified this decision with possible route shortenings, which are often allowed due to low volumes of traffic."

Accordingly, the aircraft was refueled to an indicated quantity of 3,800 kg. Because of the FQI's erroneously high readings, however, only 465 kg (1,025 lb) of fuel, rather than 700 kg (1,543 lb), was required to bring the indicated quantity from 3,100 to 3,800 kg. No one noticed the discrepancy.

Meanwhile, while reviewing the aircraft documents, the captain had noticed that there was no fuel slip showing that the aircraft had been refueled from the 790 kg he had recorded after his last flight the previous day to the 3,100 kg indicated before the refueling that morning. The fuel slip could not be found; indeed, it did not exist because the aircraft had not been refueled from 790 kg to 3,100 kg.

However, the dispatcher told the captain that "it was highly likely that one of the crews planning to complete the previous routes, subsequently cancelled, might have mistakenly kept the copy of this refueling slip," the report said. The dispatcher said that he would find the slip and give it to the captain when he returned to Tunis later that day.

The captain "trusted in the assurances given by the flight dispatcher" and agreed to depart without the fuel slip, the report said. "A diligent search for the aforementioned slip … making enquiries of the refueling company as well, would undoubtedly have led the crew to suspect that the fuel reading was not entirely reliable and, hence, to investigate further."

The fuel slip could not be found; indeed, it did not exist because the aircraft had not been refueled.

'Technical Problem'

The ATR 72's tanks actually contained a total of 1,255 kg (2,767 lb) of fuel — about one-third of the quantity indicated — when the engines were started (Figure 1, p. 30). The aircraft departed from Tunis at 1005 coordinated universal time (UTC; 1205 local time) and landed in Bari at 1146 UTC.

The crew had planned to have 2,700 kg (5,952 lb) of fuel aboard for the flight from Bari to Djerba, but the FQI indicated 2,300 kg (5,071 lb). The captain therefore decided to upload fuel. Again, no one noticed the discrepancy when the addition of 265 kg (584 lb) of fuel was sufficient to increase the indicated fuel quantity from 2,300 kg to 2,700 kg.

The tanks actually held 570 kg (1,257 lb) of fuel when the ATR 72 departed from Bari at 1232 UTC as Flight TUI 1153.

The aircraft was cruising at Flight Level (FL) 230 (approximately 23,000 ft) at 1320 UTC when the right engine flamed out. The copilot reported a "technical problem" to the Rome Area Control Center and requested clearance to descend to FL 170. "The [copilot] did not specify to air traffic control the type of problem occurring," the report said.

Recorded flight data indicated that the left engine flamed out about 100 seconds later. The copilot told the center controller that they wanted to land in Palermo, which is on the northern coast of Sicily. This radio transmission, however, was partially blocked by the controller's transmission of a clearance to descend to FL 170 and a question about the need for special assistance. Shortly thereafter, the copilot declared an emergency, repeated the request to proceed directly to Palermo and said, "We lose both engines."

The center controller decided to hand off the flight to Palermo Approach Control, which could provide greater assistance to the crew.

'Send Us Helicopters'

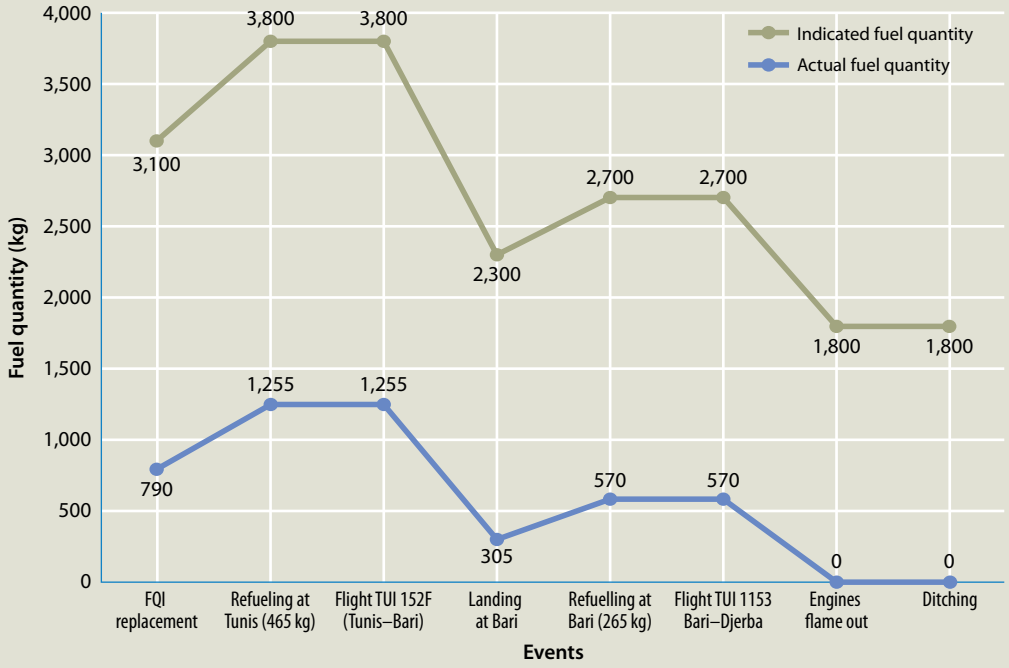
After establishing radio communication with the approach controller at 1325, the crew confirmed that they had lost both engines and asked three times in English for the distance to Palermo. The report said that the requests were "not sufficiently clear" and that the controller "had not perfectly understood" them but "finally replied that the current distance [to] Palermo was 48 nm [89 km]." At this point, the aircraft was descending through 15,000 ft.

The crew asked twice if there was a closer airport: "Any nearest airport where we can land?" The controller did not understand the question until it was repeated by the crew of another aircraft. The controller confirmed that Palermo was the closest airport.

At 1333 — after a series of radio communications in which the crew requested vectors direct to Palermo and the controller requested information about passengers, fuel and dangerous goods aboard the aircraft — the controller told the crew that they were 20 nm (37 km) from Palermo. The crew replied that they were at 4,000 ft and would not be able to reach the coast. "They also requested that emergency services be dispatched ('Can you send us helicopters or something like that?')," the report said.

The aircraft was at 2,200 ft when the crew radioed that they were turning to a heading of 180 degrees to ditch the aircraft as close as possible to two "big boats" they had spotted. The crew asked

Indicated vs. Actual Fuel Quantity



FQI = fuel quantity indicator

Source: Agencia Nazionale per la Sicurezza del Volo

Figure 1

the controller to advise the boats of the situation shortly before radio communication ended at 1337.

'Unable to Understand'

When the right engine flamed out, the pilots had noticed a low fuel pressure warning and had initiated the associated checklist. However, when the left engine flamed out, the captain told the copilot to stop reading the checklist. "For about a minute, the pilots tried to interpret the indications of the cockpit instrument warnings and identify the reasons for the failure of both engines, but unsuccessfully," the report said.

The pilots did not conduct the checklist related to flameout of both engines and, thus, did not feather the propellers. They focused on trying to restart the engines. The FQI showed 1,800 kg (3,968 lb) of fuel remaining. The low-fuel warning never appeared because the indicated quantity had not fallen below the requisite 320 kg (705 lb). Among the recommendations generated by the ANSV's investigation was that all public transport aircraft have a low-fuel-quantity warning system that is independent of the FQI system.

The aircraft was descending through 12,000 ft when the captain told the senior flight attendant to prepare the passengers for a possible ditching. The senior flight attendant used a megaphone to brief the passengers about donning their life vests; he also assisted some passengers who were having difficulty doing so. The assistant flight attendant was "greatly in distress," and "deficiencies have been found in her behavior," the report said.

"Before ditching, all passengers [and] the flight attendants were sitting with their seat belts fastened and ready for collision," the report said. Despite their instructions, however, some passengers inflated their life vests inside the aircraft.

Meanwhile, the pilots had continued trying to restart the engines, and the captain had summoned the maintenance technician assigned to the flight to assist. "Both the flight crew and the engineer were unable to understand what type of fault had occurred to the two engines," the report said. The last restart attempt was made shortly before the aircraft descended through 4,000 ft.

The captain flew the aircraft and also handled radio communication while the copilot began to conduct the ditching checklist. "The flight captain, in view of the imminence of the ditching, asked the copilot to assist him in the steering of the aircraft and to get ready for the impact," the report said. "The ditching checklist was not completed."

Violent Impact

The sky was clear and visibility was good, but the sea conditions were described by the report as "rough to very rough." The aircraft struck the water tail-first. The impact was described as violent and as having caused most of the fatalities.

"Although broken in three main parts, the aircraft remained floating for about 20 to 30 minutes after ditching," the report said. The center fuselage section, with the wings and engines attached, remained floating after the front and rear sections sank in nearly 5,000 ft of water.

"Almost all [the surviving] passengers remember that they found themselves outside the aircraft after the impact or that they immediately exited the aircraft from the openings in the fuselage," the report said. Rescue operations by helicopters and patrol boats began about 30 minutes after the ditching.

Recovered wreckage and the flight data and voice recorders were sequestered by Italian judicial authorities. The report said that the criminal investigation impeded the technical investigation of the accident by the ANSV and accredited parties to the investigation (see editorial, p. 5).

Calculations and two flight simulator tests performed by the ANSV indicated that if the pilots had configured the ATR 72 for optimum glide performance after the second flameout occurred at 21,800 ft and about 60 nm (111 km) from Palermo, and if they had maintained the appropriate drift-down speed, they *theoretically* could have reached the airport.

However, the report noted that maintaining drift-down speed while dealing with distractions and while flying with reference to standby instruments providing no distance readout would have been very difficult. One of the two experienced ATR crews that participated in the simulator tests was able to reach the runway; the other landed in the sea, about 1 nm (2 km) from the runway threshold.

This article is based on the ANSV's "Final Report: Accident Involving ATR 72 Aircraft, Registration Marks TS-LBB," available online at <ansv.it/EN/Detail.asp?ID=1083>.

Note

1. *Dripstick* is an outdated term that is still used to describe a modern fuel quantity measuring stick that, when manually unlocked, extends from a sealed tube in the wing tank through the bottom of the wing until a magnet at the top of the stick aligns with a magnetic float in the tank. The stick has calibration marks showing fuel quantity.