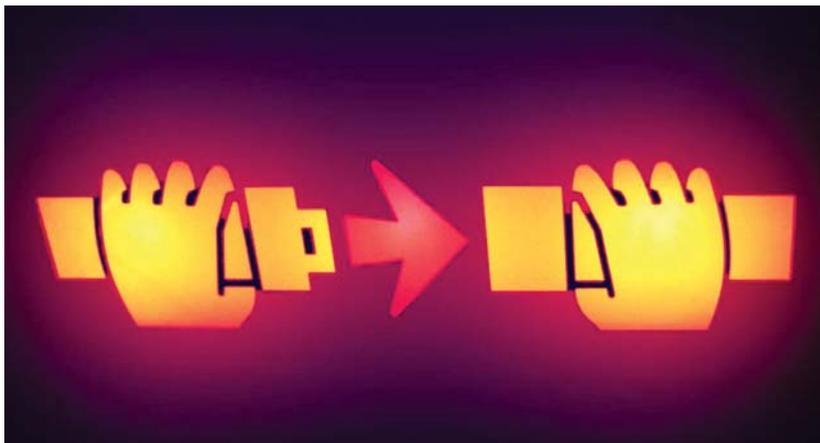




On Sept. 14, 1999, an F900 was subjected to violent vertical load oscillations, which killed most of the passengers, after incorrect crew response to a minor pitch control malfunction. **Michael R. Grüniger and Capt. Carl C. Norgren** analyze the accident and highlight the impact of not following the good practice of wearing seat belts



LIFE-SAVER

Passengers must always fasten their seat belts when the seat belt sign is illuminated.

Struck by Oscillations

The Falcon 900B, Flight OAL3838, descended towards Bucharest airport on the 14th of September 1999. The short flight had taken off from Athens an hour earlier with 10 passengers and one cabin attendant.

The pilots expected a night time landing. During the descent, the PIC called the cabin attendant and informed her of the remaining flight time. The cabin attendant had not reported 'cabin secured' yet. The passengers were not wearing their seat belts during the descent.

Descending through FL 150, the Falcon suddenly experienced 10 violent oscillations in the pitch axis. The oscillations lasted for 24 seconds. They significantly exceeded the maneuvering load factor limits of +2.6g and -1.0g. The accelerometer recorded maximum vertical accelerations of +4.7g and -3.26g.

The oscillations threw the unfastened passengers against the cabin ceiling and aircraft furniture causing fatal injuries to seven passengers, serious injuries to the cabin attendant and one passenger as well as minor injuries to the remaining two passengers.

24 Seconds later, the oscillations ceased and the PIC regained control of the aircraft. He declared an emergency and landed the aircraft without further incident.

Both pilots immediately submitted to medical examinations and blood tests. No traces of alcohol or drugs were found.

Knowing the Details of the Flight Guidance and Autopilot Systems

The flight crew operating Flight OAL3838 were both rated on B737 aircraft in addition to the Falcon 900B. Both flew mainly on the Boeing 737-400 and only occasionally flew on the Falcon 900B.

The report concludes: "The crew overrode the A/P on the pitch channel during the last three to four seconds before the A/P disengaged. The crew applied inputs on the control column for nose-up, while the A/P trimmed the aircraft for nose-down." The report further suggests that "the possible explanations for the A/P overpowering on the control column could be a pilot's brief distraction and/or his flying skills acquired on Boeing 737-400 aircraft."

Modern aircraft control systems have no direct connection between the control wheel on the flight deck and the control surfaces. Hence, pilots do not get a direct feedback on the control forces. Instead, aircraft are equipped with mechanical or electronic mechanisms which provide artificial feedback to the pilot simulating the forces on the control surfaces.

In the Falcon 900, artificial flight-control feel is provided by a system of springs. An automatic spring-load-adjusting system, called the "Arthur



Q” or simply “Arthur” unit adjusts the artificial feel of the elevators according to airspeed and horizontal-stabilizer position.

When this artificial feedback mechanism fails, there is a danger of overcontrolling resulting in powerful pitch oscillations. The loss of such feedback mechanisms must be treated with great care and respect.

The “Pitch Feel” light illuminates when the difference between the position of the Arthur unit actuator and the position of the horizontal stabilizer passes a certain threshold. In this case, a lock will operate and the unit actuator will return to its low-speed position.

With Pitch Feel on, even on high speed flights only small input forces on the control wheel are sufficient to move the control surfaces. It is easy for a pilot to oversteer the input in such conditions.

In fact, as the Arthur Unit Checklist specifies, light pitch control may result in pilot induced high load factors if large displacements or rapid movements of the control surfaces are commanded.

The PIC had tested the flight control in climb after the Pitch Feel light illuminated. At that moment, at a speed of approximately 210 knots, he judged the control forces to be “normal”. This led him to the conclusion that the Pitch Feel light did not indicate a major hazard to the flight.

The PIC, when approaching the cleared level of FL150 in descent, was discussing operational issues with the cabin attendant. Concurrently, the pilot-non flying was receiving the ATC clearance to further descent to FL050 and started pre-selecting the new flight level into the altitude window of the autopilot. At this moment, the pilot flying most likely noticed that he was about to bust the level and was startled. He applied a Boeing

737 procedure to halt the descent and manually pull the control wheel to an attitude maintaining FL 150. The autopilot began to counter the pilot’s nose-up elevator input by moving the horizontal stabilizer to trim the aircraft nose-down.

The pilot felt a progressive increase in effort on the control column and continued to pull back on the control column to maintain a nose-up movement. Eventually, the elevator-servomotor torque reached the maximum value. Immediately the Falcon’s autopilot disconnected. The series of pilot-induced oscillations started.

After 24 seconds and 10 oscillations, this dramatic phase was over. The load factors generated were tremendous. The cabin attendant later recalled that the aircraft behaved like a “scared horse”. She could not brace herself before hitting the upper part of the cabin and the jump seat with her entire body.

The cabin interior was destroyed. Blood was everywhere. A metal catering container hit the ceiling and penetrated the upper-fuselage skin 127mm by 25mm.

Legal Ramifications

The accident killed the Greek foreign affairs deputy minister, Giannos Kranidiotis, his only son and five other passengers. None of the passengers killed were wearing their seatbelts.

The Greek prosecuting authorities charged the crew with manslaughter and causing bodily injury.

The report by Greek legal investigators Alex Fischer and Akrivos Tsolakis says the primary cause was a malfunction in the aircraft’s Pitch Feel system, and although the relevant alert light was on, the pilots ignored it as a false warning.

The report alleges that the Pitch Feel and the cockpit voice recorder



(CVR) malfunctions were long-term defects which had not been rectified, hence the decision to prosecute the Greek CAA for poor safety oversight and Olympic Airways, responsible for the aircraft’s maintenance. The Pitch Feel system should have incorporated an approved Dassault modification which had not been carried out, says the report.

Furthermore, the aircraft’s checklist did not contain the procedure for Pitch Feel failure, which entails reducing the indicated airspeed (IAS) to less than 260 Kts. The aircraft’s IAS at top of descent was 332 Kts. Had the checklist reminded the pilots of this speed limitation, the oscillations might have been much less violent.

The CVR was not working and had probably been inoperative for a long time. The flight data recorder (FDR) information was used extensively in the investigation.

The report lists the following four causal factors for the accident:

- Inadequate risk assessments of flight-control “Pitch Feel” malfunctions
- Overriding of the autopilot on the pitch channel by the crew
- Inappropriate inputs on the control column at high speed with the Arthur Q unit (a flight-control-artificial-feel-adjusting system) failed in the “low-speed” position, leading to pilot-induced oscillations
- Seat belts not fastened during descent flight phase.

CALAMITY
The fatal accident caused a catering container to stick into the ceiling of the Falcon 900B (top right).

SAFETY SENSE



Sentenced to Imprisonment

The Athens First Degree Court found the captain guilty, sentenced him to five years' in prison and acquitted the co-pilot. On appeal, the court rejected the probable cause scenario and reduced the sentence to 36 months. The authors do not know how the appeal to the Supreme Court ended.

The engineers responsible for maintenance control and maintenance performance were acquitted. They had been charged for omitting to rectify the Pitch Feel malfunction.



For Your Safety and Comfort, Keep Your Seat Belts Fastened

According to the operator's standard operating procedures, the seat belt sign should be activated by the crew five minutes before landing unless there were special reasons to activate it earlier.

Contrary to Dassault's recommended top-of-descent procedure published in the Aircraft Flight Manual, the report says, the seat belt sign was not on.

Fastening a seat belt might seem like a trivial task. But trivial it isn't. The aircraft might behave like a scared horse. In such an event, even if the turbulence is less dramatic than it was in this accident, the impact of not following the good practice of always wearing the seat belt while seated can be disastrous.

While safety is in any case enhanced, passenger comfort might suffer a bit, despite the well-known figure of speech. Crews should

always prefer safety over comfort, in particular when considering the legal implications, not mentioning the moral implications, for not directing passengers to fasten seat belts.

The fasten-seat-belt sign should be switched on in time prior to descent. Even more important, cabin attendants or the pilots, if no cabin attendants are on board, should remind the passengers of the benefits of always keeping the seat belt fastened.



Michael R. Grüniger is Managing Director of Great Circle Services (GCS) Safety Solutions and **Capt. Carl C. Norgren** is a freelance contributor to *Safety Sense*. GCS assists in the whole range of planning and management issues, offering customized solutions to strengthen the position of a business in the aviation market. Its services include training and auditing (IS-BAO, IOSA), consultancy, manual development and process engineering. GCS can be reached at www.gcs-safety.com and +41-41 460 46 60. The column *Safety Sense* appears regularly in *BART International* since 2007.

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