FOR THE RJ and VERY LIGHT JET (VLJ) PILOT
HIGH ALTITUDE FLIGHT
THERE REALLY IS A DIFFERENCE!

When I left the Air Force in 1966 and went to work for the airlines there was a lot of misinformation about high altitude operation floating around, due partially to the overall lack of experience in the high altitudes plus a lot of left over speculations. Many pilots transitioning from the old props, DC-6's and Constellations etc. were being overwhelmed with the shear amount of new information they had to learn. The DC-8 course was two months long, and the captain and flight engineer had one more week on top of that. The instructors in the ground schools were teaching what they had been taught, and often had not been brought up to date as new things were learned and procedures changed.

Power Settings: Pitfalls and Consequences

The operators were now using engine pressure ratio (EPR) as the measure of the power the jet engine was producing instead of RPM or percent of RPM. EPR is the difference, expressed as a ratio, between the speed of the air passing a pitot tube in the intake of the engine and one located in the exhaust. Air density is part of this equation; so both altitude and temperature play a part in the computation. Most of the instructors teaching the engines course had, for the most part, taught and flown piston engine airplanes using rpm and manifold pressure for power settings, and were constantly worried about "over boosting the engine", which in the piston engine meant getting the manifold pressure too high and damaging the engine.

The early jets had also used RPM for the most part in power settings. In the later jets, EPR became the standard method of setting the power. Because the ratio of intake to exhaust air is being compared, if the aircraft slowed the ram effect of the air entering the intake would decrease and the EPR would go up, although the throttle position had not changed.

The effect that a change in airspeed played in the EPR was not always understood, and the concern for not "over boosting" would be a dominant part of the instruction. The fact that at the same throttle setting, as the indicated air speed or mach went down, the EPR went up, and vice versa, was not a significant part of the operational knowledge base. Some of the operators have reverted to using percent of RPM of the N1 compressor as the thrust reference for this reason.

If the flight engineer or one of the pilots pulled the throttle back to keep the EPR on target without noticing the speed was too slow, the obvious result was that the airplane would get even slower. This would typically occur as the transition from IAS to MACH for speed reference occurred. The process would repeat itself and the flight would begin to flounder below planned cruise altitude and many crews interpreted the low speed buffet as high speed buffet and compounded the problem by pulling even more power off.

Adding to the problem is the fact that as you climb through the tropopause the adiabatic lapse rate stops and you no longer have temperature decreasing with altitude; so the engine loses even more thrust because the air density decline with increasing altitude is not being off set by decreasing temperature.

The B-47 crews that descended to aerial refueling altitude and then tried to climb back to the same cruise altitude they had been using had discovered the **coffin corner**, the altitude at a given gross weight that the onset of high and low speed buffet occurred simultaneously. That was enough to confuse anyone. You could descend in the high speed buffet with reduced power to a suitable altitude and the buffet would stop. If the power was reduced and altitude was maintained the aircraft would enter “post stall gyrations” and would be lost.

If cruise thrust were set before reaching cruise speed at level off, the same process would often occur. There were crew caused upsets because of unfamiliarity and incorrect actions and responses. These are in addition to the incidents and accidents that occurred because of design flaws and procedures that were not adequate for the problems.

Turbine Engine Core Lock

If the crew retarded the throttles and the buffet became worse it was not unheard of that they would then close the throttles in an attempt to stop the buffet. This creates the conditions for a situation resulting in “**core-lock**”, an engine condition that results in flame out or very low idle speed and prevents traditional throttle up from idle. This condition requires high indicated airspeed and/or APU assist to overcome.

The condition of core lock and its solution was not generally known, and was not even mentioned in most flight manuals. The earlier version of this article was written before the crash of Pinnacle Flight 3701 at Jefferson .City, Missouri on October 14, 2004. The actions of the crew as shown by the flight data recorder, voice recorder, and the ATC tapes affirm my stated concerns about the training and lack of knowledge about high altitude flight. The Airline Pilots Association published an excellent article on the subject of **Core Lock** in its "Fact Sheet" that can be accessed at: www.alpa.org. Safety and Security, Ref # 05.022, June 13, 2005.

Mach Tuck

The shifting of the center of pressure aft as the mach increases is manifest by the nose of the aircraft wanting to drop, the old "mach tuck" problem. The earlier airplanes had several methods of dealing with it. The DC-8 ended up with the Pitch Trim Compensator, which held back pressure against the tuck in autopilot but would not trim the aircraft. There was an indicator attached to the Captains control column that indicated the amount of backpressure being held by the amount of the indicator rod showing.

The early Boeings had mach trim built into the autopilot and monitored by a Mach trim warning system and warning light. In those airplanes, the disengagement of the autopilot was monitored by one of the pilots with both hands on the yoke, ready to resist a rapid control column movement at disengagement. If the disengagement was involved with rapidly changing airspeed, as in a mountain wave encounter, the "bump" was noticeable and could be enough to cause an injury to a person not in their seat with the seat belt secure.

If there was an overreaction to the wave action and too much trim was used, it was possible for the aircraft to enter the other side of the wave in a situation that was beyond the capability of the trim system to overcome. Malfunctions in the mach trim system mandated certain altitude and speed restrictions. Failure at altitude required immediate corrective action. Hand flying at the higher altitudes is often described as "milking a mouse", small, smooth movements with both stick and throttle, and was nothing you would want to do for long.

These are some reasons why special training should be required for new pilots who will be flying at the higher flight levels for the first time, especially in new aircraft such as the RJ, and VLJ. The VLJ may be flown by a single pilot. Of course, there are many other reasons and all should be covered in the training, however, the physiological differences require special emphasis.

Physiology
There is a major difference between flight at FL370 and FL410 and above in the time of useful consciousness. The time from an explosive decompression until the subject is unable to don their oxygen mask. While the difference is measured in seconds, what can be accomplished in those few seconds is important.

The FAA recognized this a long time ago and produced a film that should be mandatory in all training syllabi for flying above FL410. The speed of rapid onset hypoxia and its effects are graphically shown and should make believers out of any skeptics. For the airlines, FAR 121.333 covers the requirement that one of the pilots must wear their oxygen mask above FL410, FL350 for the smaller airplanes. FAR 91.211 and 135.89 cover the private and charter operations.

Most airliners are certified to 42,000 feet, and some higher. Many of the crews do not wear the mask. The attitude of “what’s the big deal and what’s the difference” prevails because they do not understand the criticality of the difference. The “Big Deal” is measured in seconds of useful consciousness and whether you and your passengers live or die. Not always understood and not always correctly taught.

We hope the old problems are designed out of the new airplanes, but the old Human Factors problems still remain and must be dealt with through training and evaluation. Above all the trainers must understand and believe in what they are teaching, and understand it’s importance to safety, and it must be conveyed to the flight crews so that it is taken seriously.

Poss Horton
Senior Director
Aviation Operations Solutions
www.avops.com

I do not pretend to know all there is to know and invite any comments to correct errors or identify any dangers I have overlooked.
Thanks, Poss Horton