Avoiding mild Hypoxia: The concept of ZERO Hypoxia in flight.

During our first daylong and high reaching flights in the Andes in 2002 (15 hours above 20.000 ft), we learned that we must often be suffering from mild to moderate hypoxia, up to the most live threating one, although we were using the Electronic Delivery System from Mountain High, USA (EDS-D1). Furthermore we started to question accident reports, concerning fatalities involving highly experienced alpine pilots, that ended always with the uniform conclusion: "*pilot's error*". How could an experienced and skillful pilot have made such a deadly mistake? Mild hypoxia could well be the likely answer.

Together with Heini Schaffner (a swiss anesthesiologist and alpine glider pilot) we began in 2005 a more thorough thinking, about what could be the underlying causes. A bachelor degree-thesis at the Dept. of Aviation of the Zürich University of Applied Sciences (ZHAW) unveiled the design secrets of the blackbox EDS in their laboratory and in the hypobaric chamber of the Swiss Air Force. For practical testing of the logical concept of "zero hypoxia", a non pressurized, non heated Pilatus PC-6 was used, as well as my organization for later practical application in high reaching Patagonian wave flights extreme conditions. With Heini, myself and some other (more notorious) pilots as guinea pigs, using recording wrist-pulse oximeters, that allowed breath to breath post flight analysis together with the synchronized IGC file and my time related written notes during the flight, we came to unexpected, but sense making causes.

Our findings confirmed, depending on age, fitness and medication of the pilot, and his actual flight altitude, that the high flying glider pilots may still be exposed to life threating dangers. This is not due to the EDS itself, which is a purely mechanical device, but essentially to overestimation of its new operating principle in relation to the increased O_2-requirements of the pilot's body (shivering, sun exposure, increased muscular activity in rotors and during stress) and the organization of the life on board.

Still in effect FAR 91.211 is not only of no substantial help, but rather contra productive in this environment: one just cannot start with supplemental oxygen only at 12,500 to 15,000 ft when daylong and high reaching flights are scheduled. Even the new EASA rules with its lowered ceiling to 10.000 ft (after 30 min) are only a ducks step in the right direction, but still not sufficient for a glider pilot, who has a much higher physical and brain-workload than autopiloting pilots of power planes. Furthermore, the FAR 23.1447 (intended and sense making for continuous flow systems) that requires switching to a mask (which one?) above 18.000 ft is neither a good idea in combination with the EDS (late triggering and O_2-dilution into mask dead space). Diluter demand systems, although feasible at high altitude, are limited to the modest oxygen reserves in modern powered gliders. We then successfully tested a modified A-14 mask with an inverted flow, and put on **over** the remaining nasal cannulas and observed a 4-5 % higher SatO2 while the F-setting of the EDS remained unchanged; but we felt its universal use by the average glider pilot would be too complex to promote this aid. The Perlan Group had also abandoned this idea.

Episodic patterns of periodic breathing have been observed in all investigated pilots above 8.000 ft, replacing the usual, regular respiration with short periods of involuntary hyperventilating deep breath, followed by shallow breathing or temporary respiratory standstill. This not unexpected phenomenon resulted in variations of up to 12 % in post flight analyzed recorded blood-oxygen saturation. Other potentially dangerous in-flight findings have been chaotic breathing (and consequently random triggering of the EDS) during stressful peaks, failure of triggering the EDS during an unexpected attack of lasting slight cough, or (by another tall and fit pilot) when using unsuitable (tiny, although delivered with the EDS) nasal cannulas within wide nostrils. At 24,500 ft, breath holding to apply belly-pressure during voiding resulted sometimes in temporary hypoxic and/or hypotensive dizziness.

We therefore concluded that, when a long and high flight is the "*menu of the day*", the EDS has to be used right from take-off (with nasal cannula properly positioned and checked on the ground). We have identified three consecutive F-settings on the tested EDS-O2D1 that led to the same O_2-pulse length of 0.5 sec above 13,000 ft. Not surprisingly, the O_2-demands on the EDS (F-settings) doubles between the young and lightweight pilot versus the life experienced elderly flyer with age related impairment of its lung function when "zero hypoxia" shall be achieved. We also applied preventive pre-oxygenation before starting a discussion with ATC at 20,000 ft, when eating a sandwich or a having to void. We practiced it before all anticipated situations and at least during 3 to 5 min (F-setting R/M) above 20,000 ft and believe this to be a must to prevent or delay fainting from marked hypoxia and/or hypotension.

Where needed, we also applied a suitable breathing technique (very deep inhalations, inspired breath holding for one second before exhalation with squeezed lips. This helped increasing an insufficient blood SpO2 at the given max. O_2-pulse length (F settings), thus maximizing the efficiency of the EDS.

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