Which Way is Down?

By Cdr. Angus Rupert

It's a simple question any toddler could answer. Twenty-five years later, after several maneuvers in three dimensions at night, in the goo, many a Naval Aviator has wished the answer to "Which way is down?" was as intuitive as it was at age two.

Every Naval Aviator, Flight Officer and Aircrewman receives extensive training, demonstrations and refreshers in the reactions of the human body to operations in the aerospace environment. In our terrestrial environment, we have three sensory systems to provide us accurate, redundant and concordant information on which way is "down"—our visual system, our skin-muscle-joint somatosensory system (often referred to as "seat of the pants" sensations), and our inner ear/vestibular organ of balance. A problem occurs in the aerospace environment because the inner ear and skin-muscle-joint sensors frequently provide false information on the direction "down." As a result, the only reliable orientation available to aircrew is obtained visually—either by the horizon outside the cockpit or the instruments on the panel.

But what happens when there is no horizon, and visual attention to instruments is distracted by other tasks? In this case, the sensory information provided by the inner ear and "seat of the pants" senses may provide the aviator with a confident, but false orientation. Where we think we are in relation to the ground can be wrong . . . in some cases, *dead* wrong.

Why is this such a problem in the aviation community? Human errors are responsible for the majority of class "A" mishaps in the armed services—60 to 70 percent, according to a 1996 Government Accounting Office report. The largest category within the human factors group is loss of spatial orientation and situational awareness.

In high-workload environments (such as a single-cockpit pilot managing aircraft control, navigation, communication and weapons systems in a fast-moving scenario), even the most experienced pilots can encounter "sensory overload" during emergencies. When class "A" mishaps caused by spatial disorientation/loss of situational awareness are compared, the most common event is a temporary visual distraction from the normal orientation

Opposite, flight surgeon/test pilot Capt. James Baker puts a T-34C *Turbo-Mentor* through aerobatic manuevers from the back seat without instruments or visual cues from outside the cockpit. Clockwise from below, Capt. Baker models the tactile suit; the Tactical Situational Awareness System is incorporated into a standard Navy survival vest; technician Niranjan Suri performs final preflight tactor testing while Capt. Baker waits to test the suit.

cues provided by the outside horizon and/or cockpit instruments. Current mission requirements compound the problem. Crews are expected to fly more at night, in all weather conditions, wearing night vision goggles—all factors conducive to disorientation.

A solution to this problem is to provide the pilot with *continuous* correct *nonvisual* orientation information so he or she can intuitively maintain spatial awareness when the mission requires visual attention to be directed elsewhere. A system that can do this, called the Tactile Situational Awareness System (TSAS), provides the pilot with continuous information in an intuitive fashion to keep him or her constantly aware of where "down" is.

Information from the aircraft attitude sensors (e.g., mechanical or ring laser gyros) is applied to the pilot's torso through miniature mechanical "tactors" (similar to those used in vibrating pagers) that are worn in a body-hugging vest. Much like a tap on the shoulder that directs our attention, the vest's vibrators can tell us where "down" is at all times. As the aircraft banks to the right, the stimulus is applied to the lower right side of the torso and as the aircraft continues to bank more to the right, the stimulus moves progressively up the right side. Similarly, as the aircraft is pitched up or down, the stimulus will move up the pilot's back or chest. In a complete loop, the stimulus would start at the lower back at the beginning of the maneuver, progress up the spine, be on both shoulders at the top of the loop and move down the chest to the abdomen as the loop is completed.

Captain James C. Baker, a test pilot and flight surgeon at the Naval Aerospace Medical Research Laboratory (NAMRL), Pensacola, Fla., has proven the capabilities of the TSAS in a series of flights at Naval Air Warfare Center Aircraft Division, Patuxent River, Md. Flying a T-34C *Turbo-Mentor* with all instruments removed from the rear cockpit and screened from outside cues with a canvas hood, Capt. Baker was able to complete all basic maneuvers, including aerobatic loops and rolls, using no instruments other than the TSAS. The orientation information provided by the TSAS is interpreted by the pilot so intuitively that only 30 minutes of training was required for Capt. Baker to become proficient in its use.

The system has also been used by several Army pilots flying an H-60 helicopter at Fort Rucker, Ala. Blindfolded pilots, who were placed in unusual attitudes, had no trouble returning to straight and level flight using only the TSAS for orientation.

The goal of the TSAS is not to replace traditional instruments, but to provide supplemental information when pilots are distracted in high-workload environments. TSAS could also be linked to electronic sensors to present the location of either friend or foe by providing a stimulus on the torso in the direction of the other aircraft. The use of the TSAS in both the prevention of midair collisions and for threat acquisition is an exciting possibility. The TSAS could also be integrated with other emerging information technologies, such as 3-D sound displays, with the hope of eventually answering once and for all the question: Which way is down?

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