HYPOXIA IN A MOVING BASE FLIGHT SIMULATOR

IMPROVING OPERATIONAL REALISM OF A HYPOXIA TRAINING ENVIRONMENT

TNO innovation for life

In a collaborative research project, TNO and the Royal Netherlands Airforce (RNLAF) developed an integrated hypoxia testbed in a moving-base flight simulator. The new hypoxia flight simulator environment aims to improve the operational realism of hypoxia training, and enables research on the effects of hypoxia in relation to flight tasks.

HYPOXIA

Hypoxia is a condition in which blood or tissues of the human body are deprived of adequate oxygen supply. When flying this typically is the consequence of decreasing pressure in the atmosphere with increasing flight altitude. This produces a reduction of oxygen partial pressure, which impairs the oxygen diffusion across the alveolar-capillary membranes into the blood and to the tissues of the body. Although physiological mechanisms compensate to some extent for a lack of oxygen, pilots flying at higher altitude without pressurized cockpits and without (adequate) oxygen support systems are vulnerable to the effects of oxygen deprivation. Hypoxia is particularly dangerous because its signs and symptoms are not easily recognized by the pilot, as their judgement itself can be impaired due to hypoxia. Depending on altitude and individual sensitivity, hypoxia symptoms are represented by increased breathing, heart rate, cyanosis (blue-colored lips and nails), mental confusion, anger, euphoria, poor judgment, drowsiness, decreased (night) vision, and in the end loss of consciousness.

HYPOXIA FAMILIARIZATION TRAINING

Because in-flight hypoxia can have serious consequences, hypoxia awareness training is mandatory for military aircrews to improve their responses to hypoxic incidents. Besides academics on atmosphere, gas expansion, respiration and circulation, etc. student pilots are familiarized with hypoxia symptoms, protective oxygen equipment, cabin pressurization and rapid decompression in a hypobaric chamber. During a

The hypobaric chamber located at the RNLAF Centre for Man and Aviation, Soesterberg, The Netherlands

hypobaric flight, simulating altitudes up to 27,000 ft, students perform mental puzzles, perception and psychomotor tasks to recognize and experience both the symptoms and effects of hypoxia. This approach is very useful to demonstrate the primary effects of hypoxia, but it may be difficult for the students to translate these effects to their operational environment.

FLIGHT SIMULATOR WITH HYPOXIA SET-UP

In addition to a hypobaric chamber facility, so-called reduced oxygen breathing devices (ROBD), or gas bottles with a reduced oxygen gas mixture, offer the possibility to induce normobaric hypoxia. Such a ROBD system or gas mixture holds the potential to offer hypoxia familiarization training inside a (moving-base) flight simulator, allowing students to experience hypoxia while performing flight-relevant tasks in a relevant scenario.

TNO and the RNLAF integrated a normobaric hypoxia set-up in the Advanced Spatial Disorientation (ASD) flight simulator. This integrated testbed offers the advantage to experience hypoxia during an operationally relevant scenario while actively controlling the aircraft or rotorcraft. The ASD simulator has a moving base to reproduce the physical motion, and to create vestibular illusions. This offers the possibility to investigate the interaction between hypoxia and the sensitivity and response to spatial disorientation events.

The RNLAF ASD moving-base flight simulator, located at TNO Soesterberg, The Netherlands.

Subject flying the RNLAF ASD flight simulator, while breathing a reduced oxygen gas mixture via the (normobaric) hypoxia set-up, and being connected to sensors for measuring electrocardiography (ECG) at the chest, oxygen saturation (SpO2) at the forehead by means of pulse-oxymetry, and relative concentration changes in cerebral tissue saturation at the fronto-temporal part of the brain by means of Near InfraRed Spectroscopy (NIRS).

A synchronized logging system allows for real-time monitoring of the subject's wellbeing and measurement of physiology and flight performance. This system includes all kind of (new) measurement systems, such as pulse-oxymetry, near-infrared spectroscopy (NIRS), electrocardiography (ECG), eye tracking devices, galvanic skin response (GSR), etc.

APPLICATION

The integrated flight simulator environment, including the (normobaric) hypoxia set-up, physiological monitoring and synchronized performance logging, enhances the operational realism for future hypoxia familiarization training, and enables hypoxia research in a more realistic simulated environment. Furthermore, it provides a valid testbed for new applications and sensor technology development with respect to human performance in adverse environments.

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JOINT INNOVATION

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