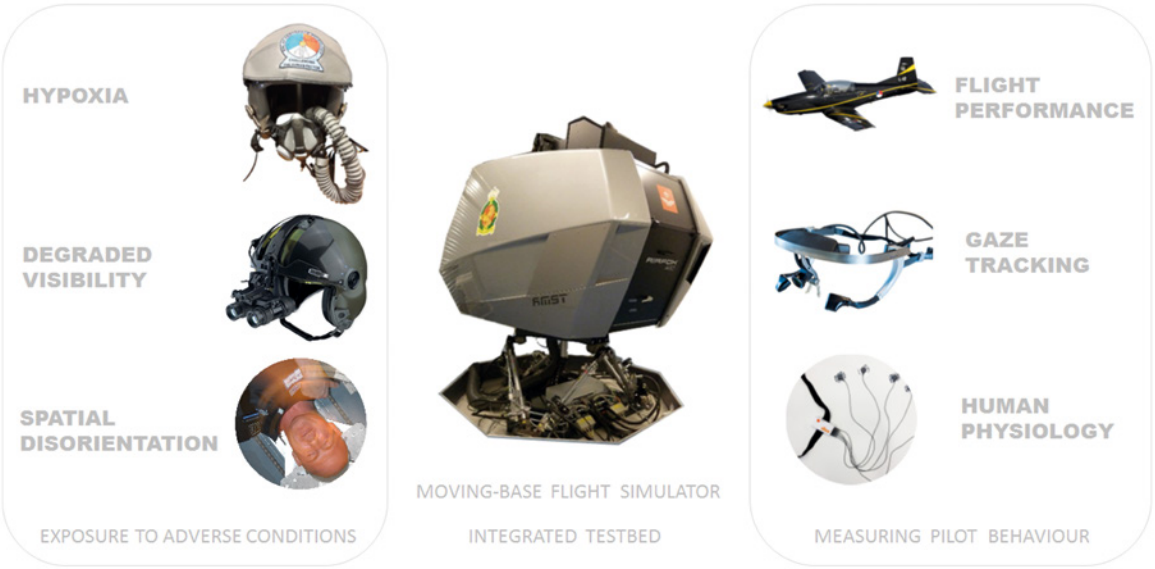
OPERATION ORIENTED SIMULATION

INTEGRATING ADVERSE FLIGHT CONDITIONS IN A SIMULATOR TO ASSESS THE EFFECTS OF COGNITIVE, PHYSIOLOGICAL, AND PHYSICAL STRESSORS ON FLIGHT PERFORMANCE



TNO innovation for life

TNO and the Royal Netherlands Airforce (RNLAF) integrated challenging stressors in a moving-base flight simulator, improving the operational realism of the simulated flight environment. This enables research on the effects of individual and combined stressors on flight performance, mental workload and physiological responses.

MOTIVATION

A military pilot is exposed to a range of physical and cognitive stressors, such as spatial disorientation, hypoxia, and degraded visibility. Currently, physiological effects of exposure to these stressors are demonstrated in dedicated simulators (e.g. a moving-base flight simulator, hypobaric chamber, or night vision terrain board). Separately, flight performance, techniques and tactics are trained in a fixed-base flight simulator with a high-fidelity representation of the cockpit and flight model. Although there is an increasing and crucial need for realistic simulation, even to substitute live training, current flight simulators lack the ability to adequately simulate the operational environment providing a combination of various stressors.

OPERATION ORIENTED SIMULATION

TNO and the Center for Man and Aviation (RNLAF) extended current simulation capabilities towards the operational military aviation domain by integration of motion and spatial disorientation, hypoxia, and degraded visibility as operational stressors in a moving-base simulator (Airfox ASD, AMST-Systemtechnik GmbH). Combined with a dedicated data acquisition system, it enables research on the effects of these environmental stressors, as well as their possible interactions, on flight performance, mental workload and physiological responses.

MOTION AND SPATIAL DISORIENTATION

The ASD simulator features a moving base – a hexapod plus turntable to allow continuous yaw rotation – to simulate aircraft motion, and to demonstrate vestibular illusions (e.g. somatogravic illusion, Coriolis illusion, vestibular leans). Furthermore, the simulation environment includes scenarios to present visual illusions as well (e.g. false horizon, black hole approach, brown/white-out, runway illusions).

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

HYPOXIA

To simulate flying at altitude, the flight simulator is provided with a hypoxia set-up (a gas bottle with flow regulator and Douglas bags) inside the simulator. This allows a pilot to become hypoxic by breathing a reduced oxygen gas mixture via a mask, while performing flight-relevant tasks. Hypoxia causes the brain being deprived of adequate oxygen supply, as a result of decreasing air pressure with increasing flight altitude. This results in hypoxia symptoms like increased breathing and heart rate, cognitive impairment, poor judgment, drowsiness, decreased (night) vision, euphoria and in the end loss of consciousness.

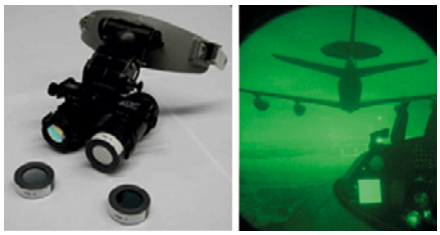
Hypoxia set-up inside the flight simulator

DEGRADED VISIBILITY AND NIGHT VISION

In addition to pre-programmed scenarios incorporating several types of degraded visibility, specific degradations can be programmed or added such as atmospheric effects, medium and low light level or flying with a simulated Night Vision Goggle (NVG) image.

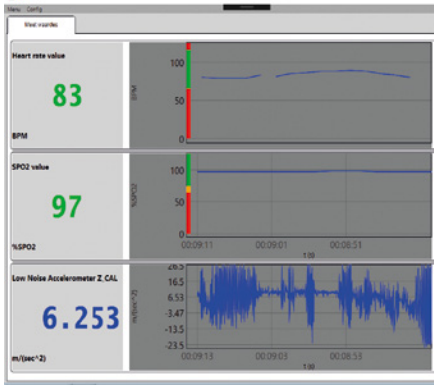
In addition, a better and cost-efficient way to realize night scene projection for use with a real NVG is being developed. The method is based upon two TNO patents, and allows deeper darkness, more realistic bright spots and better NIR contrast reproduction than conventional projection methods. The activity takes place in a different simulator facility, but such a setup may be integrated into the ASD in the future.

DATA ACQUISITION AND MONITORING



Night Vision Goggles (left) and image viewed with NVG (right)

A synchronized data acquisition system allows for real-time monitoring of the physical environment, the physiological state of the pilot and flight performance. Sensor data include pulse-oximetry, near-infrared spectroscopy (NIRS), electrocardiography (ECG), eye tracking, and galvanic skin response (GSR). The modular system allows for easy addition of other sensor data.



Screenshot of the data acquisition and monitoring system

APPLICATION AND FUTURE DEVELOPMENTS

The integrated flight simulator environment enhances the operational realism for future pilot training, and enables research in a holistic approach. It particularly offers the possibility to investigate interactions between operational stressors. For instance, the effect of combined exposure to hypoxia and degraded visibility on flight performance and pilot state, and the sensitivity and response to spatial disorientation events. In addition, it provides a valid testbed for new applications and sensor technology development with respect to human performance in adverse environments.

In the near future, other operational stressors and response measures may be added. Likely candidates being heat and thermo-physiological responses, startle/surprise and pilots' coping mechanism, sleep deprivation and attention impairment.

JOINT INNOVATION

This research and development defense program V1427 'Simulation' is part of Aeolus, a joint innovation center focusing on human performance under extreme conditions in military aerospace. As an independent center with two founding partners Royal Netherlands Air Force and TNO, Aeolus supports government agencies and businesses with state-of-the-art knowledge and innovative ideas that improve human performance in real and virtual environments.

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