

# SPATIAL DISORIENTATION INVESTIGATION TOOL

## VISUALISATION OF IN-FLIGHT MOTION AND ATTITUDE PERCEPTION



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In a collaborative research project, TNO and The Boeing Company developed a 'Spatial Disorientation Investigation Tool' (SDiT) to support the analysis of recorded aircraft motions for their potential of inducing spatial disorientation in pilots. The currently available tool automatically recognizes the vestibular illusions which generally occur in-flight. At this moment, the tool has been validated for fixed-wing. As a next step, the tool will be further developed to make it applicable for rotary wing operations in Degraded Visual Environments.

### SPATIAL DISORIENTATION

Spatial disorientation arises when there is a mismatch between the pilot's perception of the aircraft motion or attitude, and the actual motion and attitude of the platform.

When unrecognized, this perception error may lead to inappropriate control inputs, and consequently, to Loss of Control in-flight (LOC-I), or Controlled Flight Into Terrain (CFIT): today's main causes of fatal aircraft accidents.



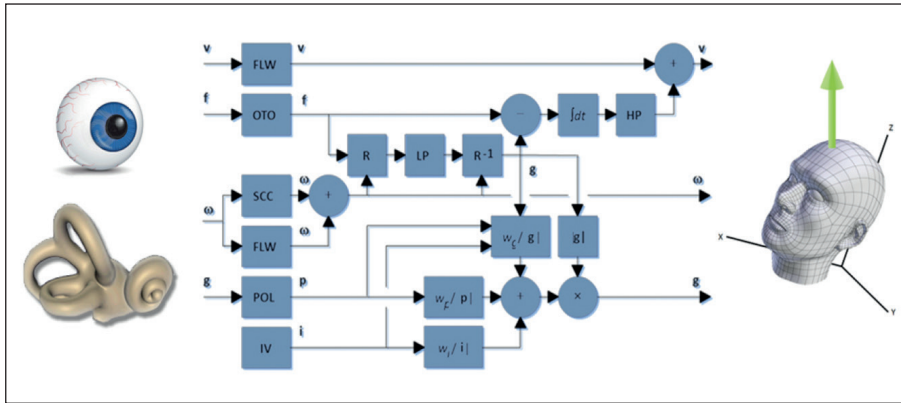
Transport aircraft in unusual attitude (Desdemona)

Whereas spatial disorientation originates in misleading information from the human sense of equilibrium (vestibular system), it becomes a safety risk under the following conditions:

- › Lack of visual reference (IMC, DVE, darkness, brownout, whiteout,...)
- › Distraction
- › Poor crew resource management

### FLIGHT SAFETY

There is a need for a valid, accessible tool to support accident investigators in analyzing flight data to determine if spatial disorientation was a contributing factor to a flight safety event. This was the reason for Boeing and TNO to develop the 'Spatial Disorientation investigation Tool' (SDiT).



TNO Motion perception model

### PERCEPTION MODEL

The software tool is based on TNO's mathematical 'Motion Perception Model', developed and validated over 25+ years of research. The model consists of transfer functions representing the dynamics of the human vestibular system. The SDiT uses this perception model to determine the error in vestibular information about aircraft motion, and visualizes this with a 3D animation of both perceived and real aircraft attitude.

### TOOL'S CAPABILITIES

The Spatial Disorientation Investigation Tool automatically detects and recognizes the dominant vestibular illusions from recorded aircraft motions:

- › Somatogravic illusion, i.e., confusing a linear acceleration with an attitude change;
- › Somatogyral illusion, i.e., incorrect perception of angular motion;
- › Sub-threshold motion, i.e., aircraft motion that remains undetected by the pilot.

The stand-alone software application uses recorded flight data (e.g., from the 'black box'), and its graphical user interface allows for visualization and analysis of the resulting vestibular illusions as a function of time.

### ROTARY WING OPERATIONS

The tool was originally developed and validated for fixed wing operations, where spatial disorientation events are primarily related to vestibular illusions. Spatial disorientation in rotary wing operations often relates to visual illusions.

In response to recent brownout flight safety events, the need arises to further develop the current model into a support tool for helicopter operations in degraded visual environments (DVE).

### DEBRIEFING TOOL

TNO is currently working on the integration of the SDiT in Flight Animation Systems to enlarge the pilot's awareness of spatial disorientation risks during commercial flight operations.

This extension of Flight Data Monitoring (FDM) and its subsequent analysis contributes to Flight Operational Quality Assurance (FOQA) and therefore increases flight safety.

### APPLICATIONS

The tool offers possibilities for

- › Investigation of flight safety events
- › Debriefing from actual flight data
- › Debriefing in combination with simulator training (instructor station)
- › Optimization of motion fidelity of flight simulators
- › Examination of possible negative training
- › Real-time in-cockpit SD alerting system



Flight simulator, spatial disorientation trainer

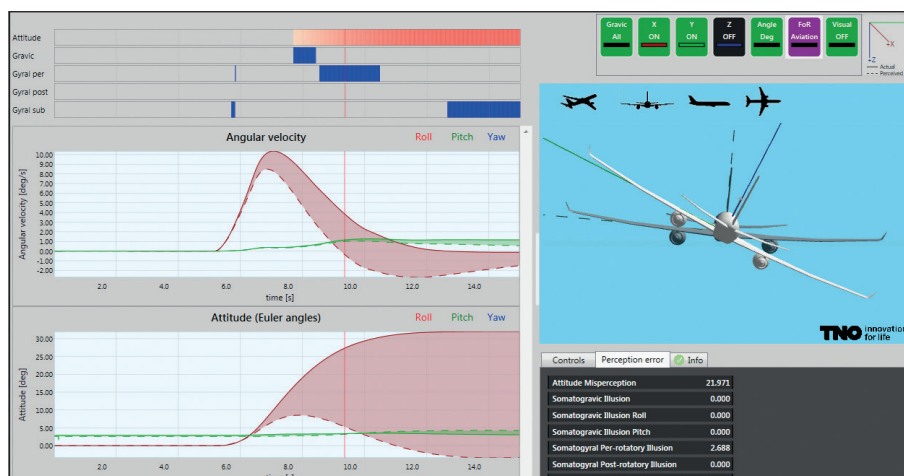
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TNO Human Effectiveness  
www.aeolus-hpi.org

Drs. ing. Jan Bos  
sr. Business Developer Aerospace  
Jan.Bos@tno.nl

Dr. Eric Groen  
Senior scientist  
Eric.Groen@tno.nl



Screenshot of the SDiT, showing perception mismatch during 30 deg bank angle