Despite large strides being made in increasing air travel safety, in-flight loss of control remains the primary cause of fatalities. The best means to achieve this desired passenger safety in existing aircraft is by providing pilots with high quality upset prevention and recovery training via high-fidelity flight simulators. However, this is typically limited to nominal flight conditions of the aircraft due to simulator hardware and software limitations. Upset-related accidents, such as Air France 447 with its combination of faulty equipment and inadequate cockpit crew reaction, could have been prevented by means of appropriate preventative recovery training, which is currently commercially limited. Consequently, there is a need to provide an efficient, safe training environment for pilots in upset prevention and recovery training (UPRT).

We cover this commercial deficiency by providing a flight simulator to realistically train pilots in the prevention of, and recovery from upsets. The flight simulator revolves around a cabin attached to a robotic arm on a linear rail, akin to the DLR Oberpfaffenhofen-Wessling Robotic Motion Simulator. Inside, the pilot is trained in a cabin environment using innovative techniques including virtual reality (VR), haptic gloves, and a sustained motion cueing seat. To ensure that multi-pilot training is considered, a secondary pilot is located offboard and acts in the same virtual environment. The design shows an advantage over conventional simulators by integrating a larger and smoother cueing range via the robot arm, while maintaining a realistic representation of the pilot’s aircraft via VR.

We put a great deal of emphasis on sustainability by ensuring that this simulator provides an 80% reduction in carbon emissions compared to real aircraft training, while still guaranteeing reliable and complete training. Additionally, we utilise multiple standardised parts for lower design risk and cost. Furthermore, we plan for product upgradability, thereby increasing the lifetime. Lastly, we achieve a high level of social sustainability by creating a safe working environment, adhering to robot arm certification standards, eliminating motion-induced injuries for the pilot and creating an easily accessible system for the operator.

We came to this design knowing that there were big risks associated, with the two biggest risks relating to the knowledge gap and the design experience gap. To mitigate these issues, we utilised project management and system engineering (PMSE) tools as well as the knowledge of field experts that were willing to help. The PMSE tools gave insight into the design experience, whereas the experts gave insight into the knowledge gap. With the use of the PMSE tools, we identified that a large focus of the project revolved around the training systems and kinematics. The training curriculum was analysed and adjusted to ensure adequate training performance provided by the simulator hardware and software. Current UPRT syllabi and frameworks exist that create a standard for UPRT. However, these guidelines do not take into account industry acknowledged phenomena such as emotional response and disorientation of the crew. By tackling these shortcomings, we developed a qualitative comprehensive UPRT curriculum, with the potential for future improvement.

Given the foregoing, the kinematics are designed around the training curriculum. The robotic arm with a linear rail system presents a seven degrees of freedom motion platform, representing all required degrees of freedom from an aircraft. The linear rail provides a smooth transition in simulator trajectory, enhancing the training provided. Acceleration deficits and vibrations will be compensated by a sustained motion cueing seat, capable of creating an illusion of up to 2.8 g’s in vertical motion acceleration. The planning of the robotic arm is performed by an onboard database-based planning algorithm, followed by an optimisation routine that generates the best compromise between simulator performance and motion continuity.

As of this moment, the next two weeks will be spent verifying and validating our subsystems, providing operational, productional and logistical insight into the integration of the product, and creating an initial, realistic presentation of the internal and external layout of our product.