

Validation of an innovative experimental safety assessment for virtual control tower HMI designs

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Abstract—Current aerodrome control procedures rely essentially on the availability and quality of the controller’s out of window view. The safe perception of visual cues focusing on aircraft motion, vehicles and weather conditions is mandatory to afford at least the current level of safety and capacity at the aerodrome. The substitution of the out of window view by display systems is the subject of research in various research projects as e.g. Advanced Remote Tower (ART) by Saab AB and the Swedish ANSP LFV, Remote Airport Traffic Control Center (RAiCe) by German Aerospace Center and Virtual Control Tower Research Studies (ViCToR) by Deutsche Flugsicherung GmbH. The chosen design of the virtual control tower console (VCT) consisting of a set of well selected display systems seems to be a valid candidate to deliver an equivalent level of safety compared to conventional operations. Assuming optimal sensor surveillance availability, the consoles design impacts safety in operation significantly by inadequate perceptibility of surveillance data that results in a corrupted or incomplete virtual representation of the real situation. Our console design was experimentally derived through an experimental correlation analysis between common consoles layouts and their probability to generate severe consequence occurrences according to ESARR 2. The implemented experimental VCT console environment is scalable, allows to be validated individually by using of proposed safety metrics and related hazard event indicators. Those homogenously cover the area of responsibility of the tower controller. The validation methodology also comprises triggering of the safety metrics by providing typical threat events such as runway incursions or blocked runways at the airport which shall be handled through professionals as a real time experiment.

Keywords- air traffic control, aerodrome control, safety assessment, visual information evaluation, fault tree analysis, human-in-the-loop validation, distributed interactive simulation.

I. INTRODUCTION AND STATE-OF-THE-ART

The tower controller monitors the traffic situation, confirms or reorganizes sequences of departing and landing aircraft and controls vehicle movements on the airport’s maneuvering area according to ICAO PANS ATM Doc 4444 [1]. The need for visual information is multifaceted and consists of both local positions, heading and velocity of ground vehicles and aircrafts and a large amount of system specific information such as e.g. weather information, surface conditions and wild life observations. The authentic and immediate availability as well as the diversity of visual information turns the

out of window view today into a mandatory requirement for the control work. A comprehensive overview about control tower operations and tasks is given at [22].

The idea to substitute the common out of window view by means of display systems in a virtual control tower (VCT) was already and still is subject of various projects such as the Advanced Remote Tower (ART, figure 1) [2], Remote Airport Traffic Control Center (RAiCe) [5][6] and Virtual Control Tower Research Studies (ViCToR) [8] and [9]. A short overview of systems substituting the out of window view is summarized in table 1.

TABLE I. OUT-OF-WINDOW-VIEW SUBSTITUTE SYSTEMS

Project	Systems that substitute the out of window view
ART [2]	Video-Panorama Projection (360°), Radarscreen, Pan-Tilt zoom, weather and status monitor [3]
RAiCe [7]	Video-Panorama Screen (180°), Radarscreen, Augmented Tower Vision, Pan-Tilt zoom

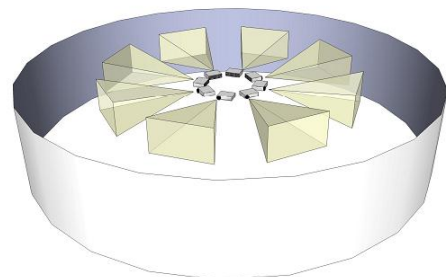


Figure 1. Advanced Remote Tower environment, with a camera array of the 360 degree panorama display [3].

As often happens, the selected console design concepts have yet not been finally validated by means of a reliable safety assessment that include the visual cues. All ideas circling around virtual towers claim for advantages in increased flexibility and efficiency in human resource allocation, safety aspects are seen as a secondary, downstream problem. Especially at airports with limited traffic demand, to remotely perform aerodrome control services and further to centralize control services of various aerodromes seems to be attractive. From the overall system development problem, the separated

- Varying aerodrome control procedures
- Operator training
- Clouding of consciousness

This methodology can contribute to perform the PSSA [17] and potentially improve the ability to mitigate risk by identifying parameters that have the biggest effect on the frequency of severe consequences. By the help of this identification, safety requirement can be derived that have a verified effect on mitigating risk. This contributes to achieve a valid system that is compliant to the TLS of ESARR 4 [19] and EUROCAE [20].

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