WHAT IF CONTROLLERS WOULD NO LONGER BE LIMITED BY WHAT THE HUMAN EYE CAN SEE OUT OF THE TOWER WINDOWS?

RETINA PROJECT

RETINA Project deals with Augmented Reality for panoramic control centres. Specifically, it is a SESAR exploratory research project investigating the applicability of Augmented Reality display techniques for the Air Traffic Control (ATC) service provision by the airport control tower.

The study motivation lies in the process of evolution of the airport control towers (Fig.1). With the introduction of automation, the controller sight was progressively pulled away from the out of the tower window view, as the majority of information is available on the head-down interface inside the control tower. This interface affects controllers' workload by forcing them to repeatedly switch their sight between the head-down equipment and the out of the window view.

On the other hand, AR technologies offer the opportunity of moving information from the head-down interface to the head-up view, by means of digital transparent overlays registered to the real environment, similarly to the vision currently provided in the aircraft cockpits with head-up displays.

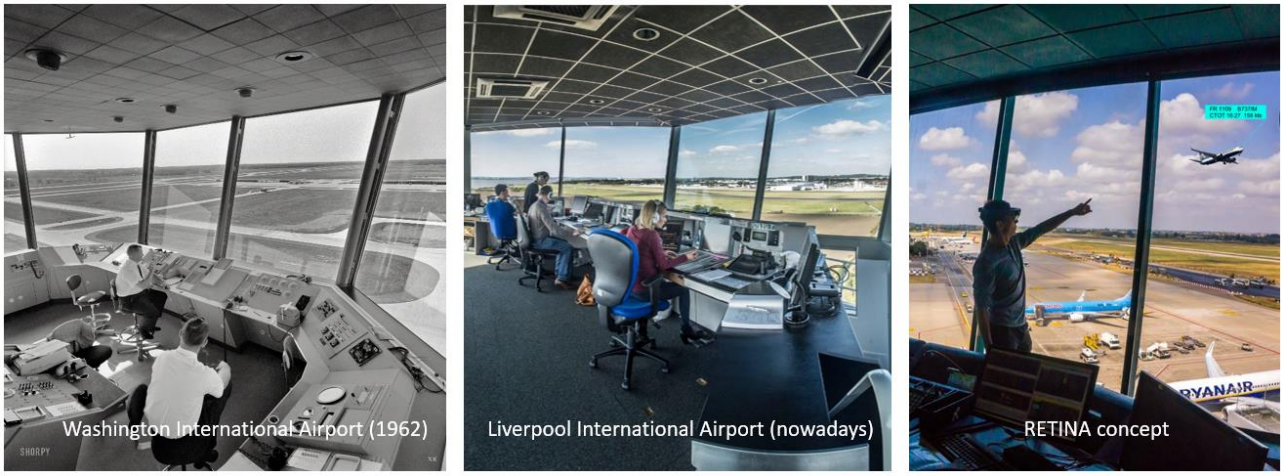

Figure 1 RETINA motivation and concept

RETINA Project considers two different Augmented Reality technologies: See-Through Head-Mounted Displays and Spatial Displays (which are large conformal head-up displays that are supposed to coincide with the tower windows).

This choice derives from a selection process where the state of the art of augmented reality display techniques was deeply analysed and evaluated, considering predictions on possible improvements of such devices in the near future as well.

Such technologies provide the placement of additional information over the actual "out of the window view" that the controllers have. The digital overlays superimposed over the physical world are represented in RETINA by flight tags, aircraft bounding boxes, airside layout, runway status, meteorological data and warning detection (see Fig.2 showing the comparison between the out of the tower window view without AR overlays and the same one characterized by additional digital data in bad visibility condition).

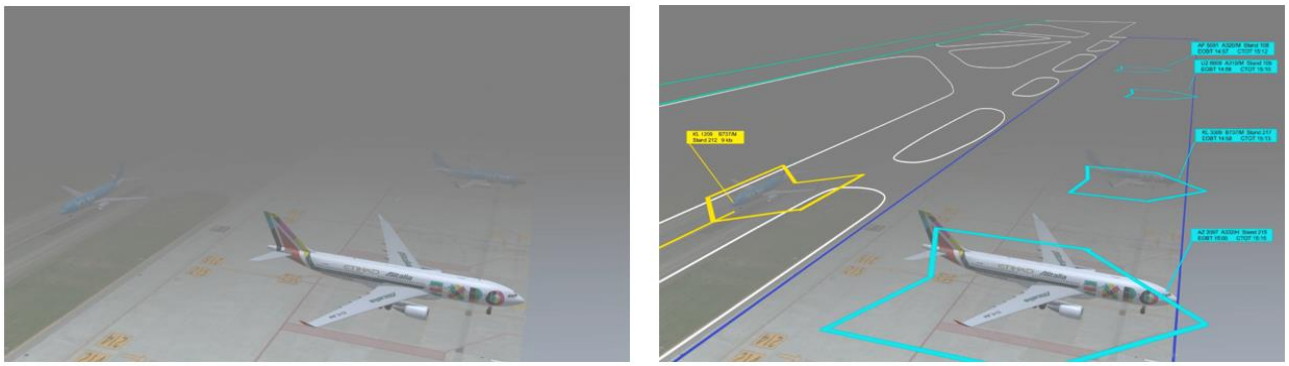

Figure 2 In low-visibility conditions the use of synthetic overlays enhances the ATCO's situation awareness

The project target was to demonstrate the positive impact of the proposed Augmented Reality tools, in terms of human performance (situational awareness and the human factors), safety (the capability to detect some typical hazardous situations such as runway incursions) and efficiency (workload and maintenance of capacity in poor visibility conditions).

In order to pursue this objective, the RETINA concept was validated in a laboratory environment by means of human-in the-loop real-time simulations involving controllers, who were placed in an immersive 3D virtual environment represented by 3 rear projected screens, simulating a high-fidelity and photorealistic out of the window view from the Bologna Airport Control Tower (LIPE). The operators were also provided with head-down equipment replicating the current one in the control tower and with a voice communication with a pseudo-pilot post located in a control room, with the role of monitoring and updating the traffic on the airport model according to the clearances given by the controller.

Three different main equipment were considered (Fig.3): a baseline equipment, that is the current way of working in the control tower and two AR equipment: Microsoft Hololens device (that played the role of Head Mounted Display technology) and superimposed digital overlays inside the simulated virtual environment, playing the role of the Spatial Displays coinciding with the tower windows.

It was necessary to simulate Spatial Displays via software, as the big formats of this type of technology are not yet on the market nowadays, so that it was not possible to integrate the hardware in the simulation loop. The Spatial Display augmentation was considered for 9 out of 32 Control Tower windows.

The subjects were asked to perform all tasks as Tower and Ground controller during the same exercise, as no distinction of roles between Tower and Ground position was necessary due to the simplicity of the selected airport scenario. The validation exercises were characterized by: two different real observed traffic conditions (medium traffic and medium-high traffic) and three different visibility conditions (from good weather condition to extremely bad one).

For each exercise performed using Augmented Reality tools, a similar exercise was conducted adopting the baseline equipment, in order to compare data obtained in terms of the human performance, safety and efficiency validation targets.

Figure 3Three different equipment were considered during the RETINA validation: a baseline equipment and two AR equipment, namely Microsoft Hololens device and Spatial Displays.

The results obtained through the validation of the RETINA concept are fully demonstrating the soundness for the introduction of Augmented Reality in the Airport Control Tower. Major benefits are related to the use of such technology in low visibility conditions to restore the same level of airport capacity as in normal visibility conditions, with positive impact on the whole ATM system in terms of safety, efficiency and resilience.

In particular, compared to the current tower operations (Baseline equipment), RETINA tools:

- provide controllers with a unique conformal representation of all the needed information and stimulates controllers to work in a head-up position, increasing situational awareness and safety.
- provide quantified benefits in terms of mental workload, temporal workload, performance, effort, frustration and information accessibility.
- lead to the reduction of the current restrictions due to Low Visibility Procedures, increasing the throughput of the airport.