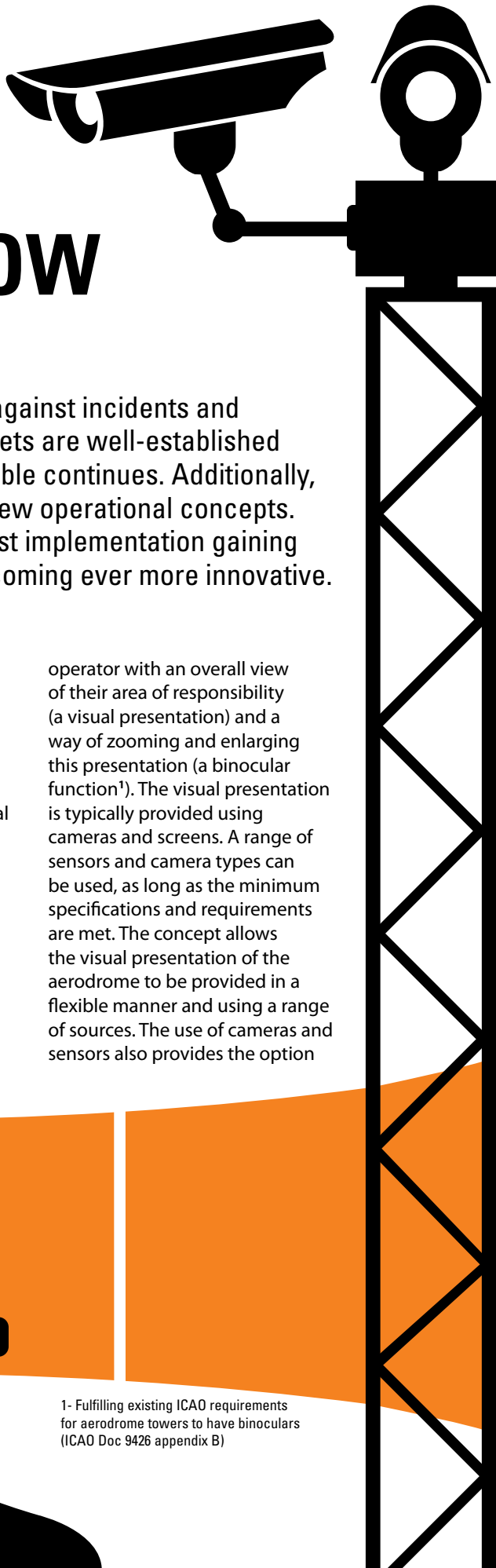
REMOTE TOWER TECHNOLOGIES AND THE SAFETY NETS OF TOMORROW



by Raluca Tudorica & Rory Hedman

In aviation, safety nets act as the last system defence against incidents and accidents. Current ground-based and airborne safety nets are well-established and development to make them more efficient and reliable continues. Additionally, future air traffic control safety nets may emerge from new operational concepts. One such concept is Remote Tower, with the world's first implementation gaining operational approval earlier this year and research becoming ever more innovative.

The arrival of Remote Tower is encouraging a re-think of what has been a convention in air traffic control since the first controlled civil airports were introduced in the 1920s at Croydon airport in the UK – that the Tower should be located at the airport being controlled.

Remote Tower enables the provision of ATS from a facility independent of the airport. Removing the controller from the aerodrome control tower means they can no longer use the out-the-window view to visually survey the airport and its vicinity.

When operating remotely the controller is expected to provide ATS to the same level as in current operations and to enable this, the remote facility has to provide the controller with a means of visual observation and sufficient situational awareness.

Before exploring a potential safety net that could emerge from Remote Tower, let us first look at the various technologies used to enable and support Remote Tower Operations.

The provision of ATS in a remote environment requires, as a minimum, a means of providing the operator with an overall view of their area of responsibility (a visual presentation) and a way of zooming and enlarging this presentation (a binocular function[1]). The visual presentation is typically provided using cameras and screens. A range of sensors and camera types can be used, as long as the minimum specifications and requirements are met. The concept allows the visual presentation of the aerodrome to be provided in a flexible manner and using a range of sources. The use of cameras and sensors also provides the option

1- Fulfilling existing ICAO requirements for aerodrome towers to have binoculars (ICAO Doc 9426 appendix B)

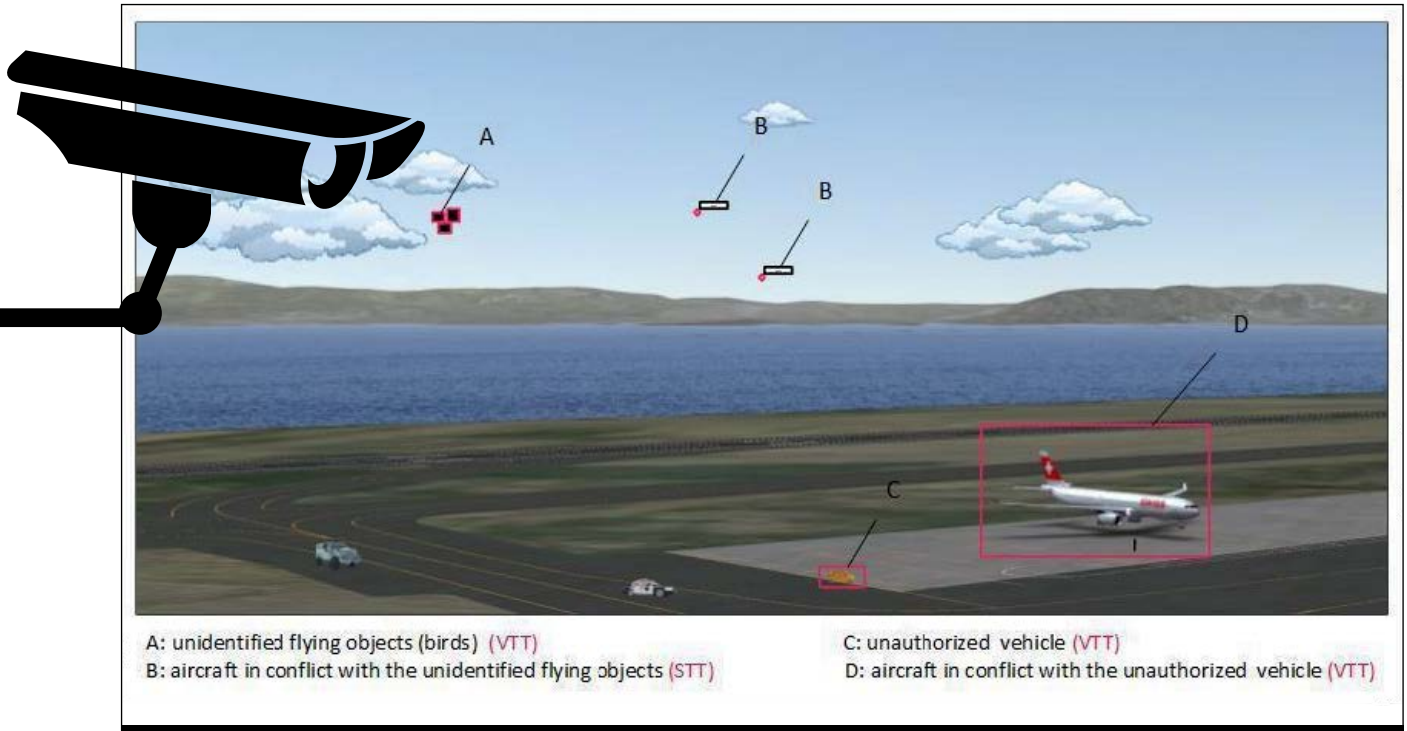


Figure 1: How can Target Tracking act as a safety net?

for additional situational awareness at designated points such as landing thresholds or to cover blind spots not visible from the standard tower.

Other technology is additional and, although not required to maintain safety or for the provision of ATS, can be applied to improve situational awareness, concept acceptance, working methods and capacity. For example infra-red technology and various sensors can be used to provide a variety of viewing angles. Also, the use of sensors and displays allows information such as meteorological data (QNH, Max wind speed, compass roses, etc.), aerodrome layout (highlighted runways and taxiways during low visibility and darkness and labels next to taxiway exit points etc.), target tracking information (for cooperative and non-cooperative targets) and other data may be overlaid onto the visual presentation. All of the above are considered by current research developments. Additionally, technologies such as the use of 3D monitors, speech recognition, eye tracking are also being considered for future Remote Tower applications.

The potential of Remote Tower Technologies as Safety Nets

Seeing the potential of these various forms of technology, and being actively involved in Remote Tower development, we dug deeper to see if any of these technologies are "safety net material".

Given the current stage of research, Target Tracking comes the closest to what is expected today from a safety net. By piecing together current research and ideas we look into the What? and How? of a Target Tracking safety solution. As part of the Remote Tower SESAR research programme, Target Tracking has been developed and refined to offer support for ATC in more complex working environments. Initial development was prompted when the research programme started to look into Multiple Remote Tower operations, where controllers felt that a technology which allowed them to quickly view the position of traffic and obstacles, both on ground and in the air, would be very useful.

This technology is based on two distinct capacities: Visual Target Tracking and Surveillance Target Tracking. Neither is unique to aviation, camera tracking algorithms which track targets in 2D have been available for more than 30 years and radar based tracking for much longer. Yet the way in which these technologies are used in Remote Tower operations, to assist airport operations and the provision of an aerodrome control service, is unique.

Visual Target Tracking (VTT)
This refers to the technical capability to detect the motion of an object, such as light aircraft and vehicles which may not be equipped with a transponder (non-cooperative targets). In the small rural airports, targeted by the first Remote Tower applications, visual tracking may also be valued for the targeting of birds, large animals, and other moving obstacles.

Surveillance Target Tracking (STT)
This refers to the use of positioning sensors, such as an Advanced Surface Movement Guidance and Control System (A-SMGCS), to determine the location of co-operative targets. This feature might prove beneficial for larger airports, where traffic consists mostly of transponder equipped aircraft.

The information gathered from VTT and STT can be displayed in a number of ways. Above is a basic illustration based on the current HMI used to display tracking information in Remote Tower, although of course this may look very different if integrated into a local tower. We can see how conflicts can be displayed, such as a possible bird strike (see unidentified objects and incoming aircraft), as well as a ground conflict (an unauthorised vehicle on the taxiway). The information coming from Target Tracking could be integrated onto various visual displays or even overlay the control tower windows. Information from the VTT and STT can be combined with labels, text and other visualisation in order to keep track of targets.

In its current form Target Tracking is only a controller support tool. Yet with improvements in reliability, it may be possible to integrate such tracking technologies into safety net applications. One such application may be a form of Aerodrome Area Incursion Alarm safety net covering both the aerodrome surface and the airspace in the vicinity. Similar to Area Proximity Warning (APW), a current well established ground based safety net, Target Tracking could provide controllers with short term notifications of conflict situations within designated areas.

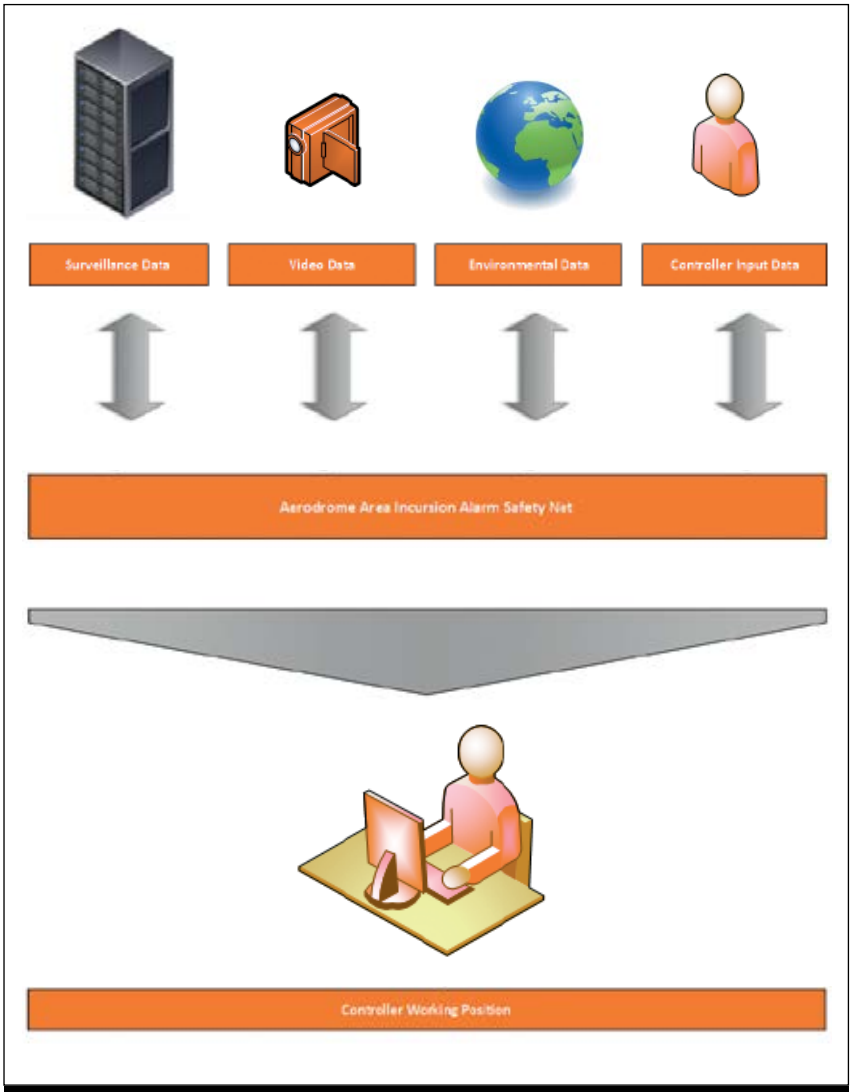


Figure 2: Working diagram for Aerodrome Area Incursion Alarm Safety Net

Current Visual Target Tracking technologies use 2D information gained from cameras placed at the airport. In order for such technologies to be adapted for use in an Aerodrome Area Incursion Alarm, the sensors must be able to identify specific areas and track movement in relation to the entire airport surface. For this, a 3D map of the airport is required. An arrangement of cameras, sensors and other specific surveillance devices could be used to create such a 3D view, which would allow visual tracking algorithms to run in the background and track movement, supported by surveillance sensors. The use of an accurate 3D map of the airport environment would enable alarms to be set off at the appropriate time.

The primary role of such an application could include:

- Warning the controller about unauthorised penetration of transponder equipped movements into unauthorised areas of interest (runways, taxiways, CTR etc.);
- Warning the controller about unauthorised penetration of non-cooperative movements into unauthorised areas of interest (runways, taxiways, CTR etc.).

Whether a viable safety net option will come from such Target Tracking technologies is not yet clear. But we can theorise about the actual application of such a safety solution and the key considerations required for such a tool.

As in Figure 2 the Aerodrome Area Incursion Alarm Safety Net could obtain its information from various sources. For instance, surveillance technology and an arrangement of camera sensors (video data) could provide the important high-resolution 3D map of the airport. The 3D airport map would also include all the airport geographic/environmental data to enable specific areas of the airport to be highlighted as safety-critical.

When cameras/sensors detect new objects in areas defined to be safety-critical, they could be recorded by the system and their status monitored. To maximise the effectiveness of the system as a safety net, it would also need to include track prediction so that the intended path of targets

could be forecast. If the object is predicted to have a dangerous behaviour or be moving in an erratic manner, then the controller would be notified. Additionally, if a continuous scan of the airport is being made by visual and surveillance sensors then non-moving objects could also be detected.

However, at the moment the technologies required are not available. Search algorithms still identify all targets continuously and without distinction (for example environmental data such as moving clouds, trees blowing in the wind etc.).

A paper on "Geometric Modelling for 3D Support to Remote Tower Air Traffic Control Operations", published by SINTEF (also involved in the verification work within SESAR project P12.04.09) explains how their research may facilitate the 3D mapping of the airport. These techniques can also support object recognition by generation of size and speed information.

Predicting aerodrome area incursions is complex and involves many factors such as object behaviour modelling. The first stage of development may target low capacity utilisation, as was the case for Remote Tower, due to a reduced number of targets and complexity. With faster more accurate algorithms, safety nets based on 3D target tracking may be implemented in more dense, increasingly complex environments. However, such environments also include a higher percentage of cooperative targets so may not always provide the most challenging implementation environment.

Predictive Target Tracking could improve controller confidence and may act as an enabler for Remote Tower operations in a wider range of environments (i.e. larger airports with high traffic density and Multiple Remote Tower applications) and importantly would allow tracking technologies to be used as a form of airport safety net.

Another aspect that needs to be addressed is how the algorithm could identify that the predicted track of an object was no longer in line with expectations. The solution to this is likely to involve integration with controller input data. Considering the human in the loop, it is clear that in order for such a solution to be an effective safety net, it should not rely upon manual intervention by the controller. Any required inputs would have to be normal inputs made by the controller as recorded on electronic flight data strips or data-link so as not to increase workload or alter working methods.

What next?

We think that as a possible contributor to or even as the primary basis of a future safety net, Target Tracking is very promising. Yet, there are still many factors that need to be considered in order to make this type of safety net application a reality. Some key considerations include:

- The Impact on Controller Human Performance;
- The Visual Presentation of the alert/s in the CWP (particularly in local tower environments);
- Integration with existing systems and working methods;
- HMI (alert sounds, use of colours, etc.);
- Ensuring nuisance alerts are excluded and reliability is ensured;
- The business case in terms of cost of implementation;
- Performance benefits

... and many more.

Target Tracking is not the only feature to emerge from the Remote Tower concept with the potential to improve safety. Some of the other technologies it embraces might be integrated into safety net solutions or used in daily operations as support tools and safety enhancers in their own right.

With the recent implementation of Remote Tower and other concepts to come out of SESAR, innovation and change is in the air. Now is the time to capitalise on this to fuel further cutting edge developments, not forgetting to explore all avenues for their safety potential.

RALUCA-ELENA **TUDORICA**

is Master's student in Air Transport Operations at Delft University of Technology and is currently doing an internship with Think Research Ltd. where she is looking into Remote Tower Research and Implementation. In 2013 she was a trainee in EUROCONTROL's Safety Unit where she supported Safety Maturity activities and the development of the Aerospace Performance Factor.

RORY **HEDMAN**

is a Lead Analyst at Think Research Ltd. His primary expertise is in Remote Tower operations, providing support as a contributing author to the SESAR operational concept document (OSED) and validation documents for simulation exercises and live concept trials in Sweden and Norway. He also has involvement with Remote Tower pre-implementation, standardisation activities (via EUROCAE working group 100) and conformity assessment.

EDITOR'S NOTE:

More on 'Remote Tower Service' can be found at:
http://www.skybrary.aero/index.php/Remote_Tower_Service