The Remotely Operated Virtual Tower Case Study

Report prepared for students from SESAR's Original Description by

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Abstract

Nowadays the cost of running small and medium-sized airports consists largely of personnel costs. To overcome this constraint, EU SESAR Joint Undertaking projects have elaborated technical solution enabling airport towers, the main air traffic manager structures, to be remotely operated via a digital network.

The Remotely Operated Virtual Tower concept that will be introduced in this document aims at remotely controlling the airport air traffic from a single Remotely Operated Virtual Tower Centre (RTC), located in a detached workplace from the airport itself. In addition, one controller could potentially provide all the Air Traffic Services (ATS) for two to three towers simultaneously, namely two or three airports together.

Apart from staffing, costs savings can be achieved through not having to replace existing towers that have reached the end of their economically viable service life. In this way the Remotely Operated Virtual Tower could be a valuable and reliable solution for small and medium-sized airports in order to stay competitive.

Moreover, new features such as object tracking and alerting, infrared vision and image enhancement, are introduced in this new digital environment and will enhance the controller's situational awareness.

A demonstration platform of this innovative technical solution has already been implemented at Ängelholm airport, Denmark. The Remotely Operated Virtual Tower Centre was located at Malmö airport, approximately 100km away, with trials successfully concluded.

The document is structured as follows. Chapter 1 introduces the Remotely Operated Virtual Tower concept. Chapter 2 provides an overview of the scenario. A detailed description of the functioning of the Remotely Operated Virtual Tower is described in Chapter 3: first the current operating method is introduced, and then the new operating method. Finally, in Chapter 4 one possible use case is presented.

1 Common Terminology

In this chapter we introduce the main notions that will be used in the following chapters. For more details see Appendix 1.

- **Air Traffic Service (ATS)** is a generic term that denotes a service which regulates and assists aircrafts in real-time to ensure their safe operations. In particular, ATS comprises the following services:
  - prevent collisions between aircraft;
  - conduct and maintain an orderly flow of air traffic;
  - notify concerned organizations and assist in search and rescue operations;
  - air traffic control services, which is to prevent collisions in controlled airspace by instructing pilots where to fly;
  - air traffic advisory service, used in uncontrolled airspace to prevent collisions by advising pilots of other aircraft or hazards;
  - flight information service, which provides information useful for the safe and efficient conduct of flights;
  - alerting service, which provides services to all known aircrafts.

In particular, at aerodromes, ATS provides different services, depending on the aerodrome size and typology:

- **Airport Flight Information Servic (AFIS)** provided by an **Airport Flight Information Service Officer (AFISO) .** Airport Flight Information Service is provided at airfields where, despite not being busy enough for full air traffic control, the traffic is such that some form of service is necessary. It can be seen as a half-way between an uncontrolled and controlled airfield. As part of the FIS, the AFISO provides flight information service including, traffic information, meteorological information, information on runway state and other information useful for the safe and efficient conduct of a flight. The pilots must use this information and make up their own minds about choosing flight routes.
- **Air Traffic Control Service (ATC)** is a service provided by ground-based controllers who direct aircrafts on the ground and through controlled airspace. Its primary purpose is to prevent collisions, organize and expedite the flow of traffic, and provide information, as well as every support for pilots. The operator working at the ACT is called **ACTO (Air Traffic Control Operator).**
- **Remotely Operated Virtual Tower** is where ATS are remotely provided through the use of direct visual capture and visual reproduction e.g. through the use of cameras.
- **CWP (Controller Working Position)** is the operator (ATCO/AFISO) work station including necessary ATS systems.
- **Visual Reproduction** is the term used to denote the collected visual airport sensor data (from cameras and/or other sensors) and presented to the ATCO/AFISO in order to provide situational awareness.
- **Remotely Operated Virtual Tower Module (RTM)** is the term for the complete module including both the CWP(s) and the Visual Reproduction display screens.

- **Remotely Operated Virtual Tower Centre (RTC**) is a building where ATS are provided to one or more airports. It usually includes several RTMs (or only one, if that single Remotely Operated Virtual Tower Module (RTM) enables ATS to more than one airport).

2 Introduction to the Remotely Operated Virtual Tower Concept

The objective of the Remotely Operated Virtual Tower is to provide the ATS (Air Traffic Service) for more than one airport by a single operator (called ATCO or/and AFISO), from a remote location, meaning not from the individual control towers located in the airport. The full range of ATS should be offered in such a way that the airspace users are not negatively impacted, (and would possibly benefit), compared to the local provision of ATS.

The remote provision of ATS is expected to be applied to low density airports (where low density is determined as being mostly single operations, rarely exceeding two simultaneous movements of aircrafts[1]) as well as to medium density airports (where more than two simultaneous movements can be expected). In the long-term period the concept may also be applied for larger airports or small airports with occasionally more traffic density.

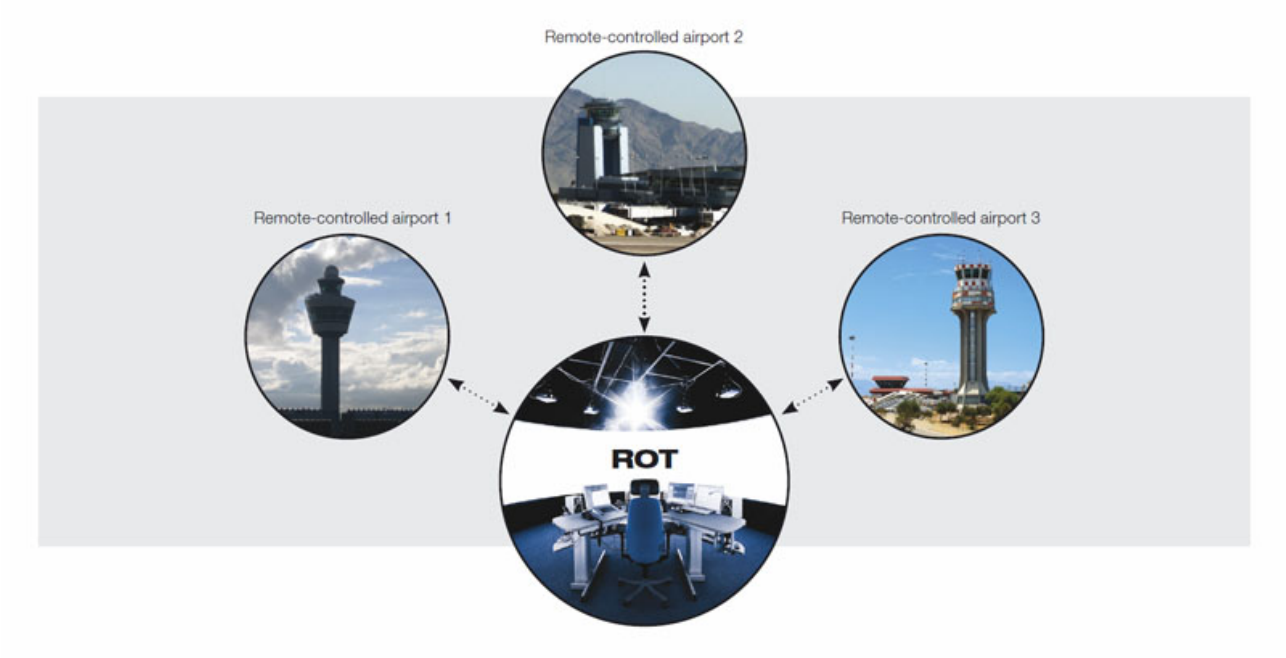

Figure 1: Remotely Operated Virtual Tower concept system overview

For the purposes of this document only the Remote Provision of ATC services to a single airport will be introduced in the following pages.

The main change to today's current operations is that the ATCO will no longer be located at the airport. They will be re-located to a Remotely Operated Virtual Tower Centre far away from the airport. The airport view(s) will be captured and reproduced in the Remotely Operated Virtual Tower Centre. The visual reproduction of the airport view(s) can be overlain with information from additional sources and enhanced through technology for use in all visibility conditions.

[1] Movement means a landing or take-off of an aircraft.

Cameras and sensors are strategically placed at the airport and everything they register is transmitted in real time through a digital network to air traffic control and projected on 360 degree screens. Rather than looking through the window at the aircraft, the ATCO sees them on the screen, apart from the data he/she controls and steers air traffic just like in a real tower.

The main expected benefit for an airport is cost effectiveness. ATS facilities will be cheaper to maintain, able to operate for longer periods and enable lower staffing costs (through centralised resource pools) and training/re-training costs, by large scale effects. It will also significantly reduce the requirement to operate and maintain actual control tower buildings and infrastructure, leading to further cost savings, as well as eliminating the need to build replacement towers.

3 Scenario Description: The Remotely Operated Virtual Tower

In the first part of this section the current operating method for the local Tower is explained, while in the second part the new concept of the Remotely Operated Virtual Tower is introduced.

3.1 Current Operating Method

The ATCO is responsible for assuring safe operations and provision of air traffic control services for the airport manoeuvring area and the vicinity of the airport. This includes responsibility for clearance delivery, ground control, management of inbound and outbound flow and flight data processing.

With a local, physical presence at the airport, the ATCO has the ability to perform local physical tasks such as direct runway inspections, checking local weather stations or basic maintenance if required. In addition, some task sharing can exist where the ATCO or AFISO performs additional local tasks. Other local officers (such as rescue officers) can in turn perform some of those tasks.

Regulation states that an airport control Tower has to fulfil two main operational requirements, in order for an air traffic controller to be able to properly control aircraft operating on and in the vicinity of the airport. Those requirements are:

- the tower must permit the controller to visually survey the portions of the airport over which he exercises control and its vicinities;
- the tower must be equipped to permit the controller to rapidly and reliably communicate with the aircrafts he is concerned with.

The most significant factors contributing to adequate visual surveillance are the siting of the tower and the height of the control tower cab. The optimum tower site will normally be as close as possible to the centre of the manoeuvring part of the airport, provided that at the intended height, the tower structure itself does not become an obstruction or hazard to flights.

The ATCO uses several means and systems to provide the services, but a major information source is the visual “out-the-window” (OTW) view. The OTW view is from a single viewpoint, typically high above the ground from the centre of the airport. Airport sound (e.g. engine noise, birdsong, wind noises) are directly available through ambient noise. Other functions/systems that are needed to provide the service are for example:

- Voice communications;
- Flight Plan and ATS message handling;
- Manoeuvring of airport lights, navigation aids, instrumental landing system, alarm and other airport systems;
- Binoculars, Signal Light Gun;
- Paper Strips.

Paper Strips are physical artefacts which provide details of all arriving/departing aircrafts. Usually different colors are used to distinguish arriving and departing flights. The ATCO will order them according to the arrival/departure time and will annotate them to indicate what instructions/information has been passed. The strips are a key element in maintaining a mental picture of the traffic situation and can act as a backup in low visibility or emergency situations (see Figure 2).

Figure 2: Flight progress strips

Additional tools providing information gathered through specific sensors (e.g. ground radar information, meteo radar and meteo sensor information, ADS-B data, etc.) can be used to facilitate surveillance, subject to coverage.

Figure 3: Ground-radar and paper strips

3.2 New SESAR Operating Method

In the Remotely Operated Virtual Tower Operational Concept, the full range of ATS will be provided remotely by an ATCO. The airspace users must be provided with the same level of services as if the ATS were provided locally.

The main change is that the ATCO will no longer be located at the airport. They will be re-located to a Remotely Operated Virtual Tower Centre (RTC).

The visual surveillance will be provided by a reproduction of the OTW view, by using visual information capture and/or other sensors. The visual reproduction can be overlain with information from additional sources when available, for example, surface movement radar, surveillance radar, ADS-B (Automatic Dependent Surveillance-Broadcast), multi-lateration or other positioning and surveillance implementations providing the positions of moving objects within the airport movement area and vicinity. The collected data, either from a single source or combined, is reproduced for the ATCO on data/monitor screens, projectors or similar technical solutions.

The provision of ATS from a local tower building (as in today's current operations) has some constraints at certain airports due to the single operational viewpoint from a central, high up perspective and is subjected to prevailing weather conditions (e.g. clear, foggy). This can create some minor limitations in capability, which is accepted in 'traditional' air traffic control. With the use of reproduced visual views, these limitations can potentially be eliminated. Visual information capture and reproduction can still be done in order to replicate the operational viewpoint obtained from a traditional tower view and this may ease the transition from current operations to remote operations and also provide some common reference points. Alternatively, several operational viewpoints may be based on information captured from a range of different positions, not necessarily limited to the original tower position. This may provide an enhanced situational awareness and/or a progressive operational viewpoint. In all cases, the visual reproduction shall enable visual surveillance of the airport surface and surrounding area.

The use of technologies to enhance the visual reproduction in all visibility conditions may be introduced. The full set of Advanced Visual Features (AVFs) will be gradually introduced into the concept as they are defined and developed. The AVFs will be tools to improve situational awareness and eventually aid in providing improved use of visual separations applied by ATCOs. To further improve the situational awareness the airport audible background sounds can be captured and relayed in the RTM. Moreover benefits in terms of workload might be gained through other enhancements integrated into the visual representation. For example, the ATCO head-down time may be reduced by integrating certain information into the panorama view. Thus radar data, weather information, the PTZ camera view etc. could be moved from the ATCO work desk onto the panorama representation screen.

Through the use of enhanced technology and digital information, a wider range of information will be available and possible to share with other stakeholders, airport users and other ATS. The concept will also introduce the ability to record visual information; this will create enhanced and unique opportunities to support incident/accident investigators when working at airports.

It is foreseen that the concept will have minimal or zero negative impact on the Instrument Flight Rules (IFR) traffic.

The ATCO will not have the ability to perform any tasks that are external to the control facility e.g. physical runway inspection. Therefore the role of the ATCO as seen under current operations will change, with the focus being almost solely on pure ATS tasks with secondary non ATS tasks performed by non ATS personnel local to the airport.

Although it is not necessary, it will be possible to remove the local control tower as it will no longer be used for the provision of air traffic services. The infrastructure (service, maintenance etc.) that goes along with maintaining such a building will also become redundant. Instead, a local installation consisting of systems/sensors will be maintained by central maintenance teams. The remote facility will also require maintenance, but it is expected that a more 'traditional' building using common systems and components will lead to a reduction in overall maintenance costs. If single airports share RTC's with other airports then overall building costs will also reduce as they become shared.

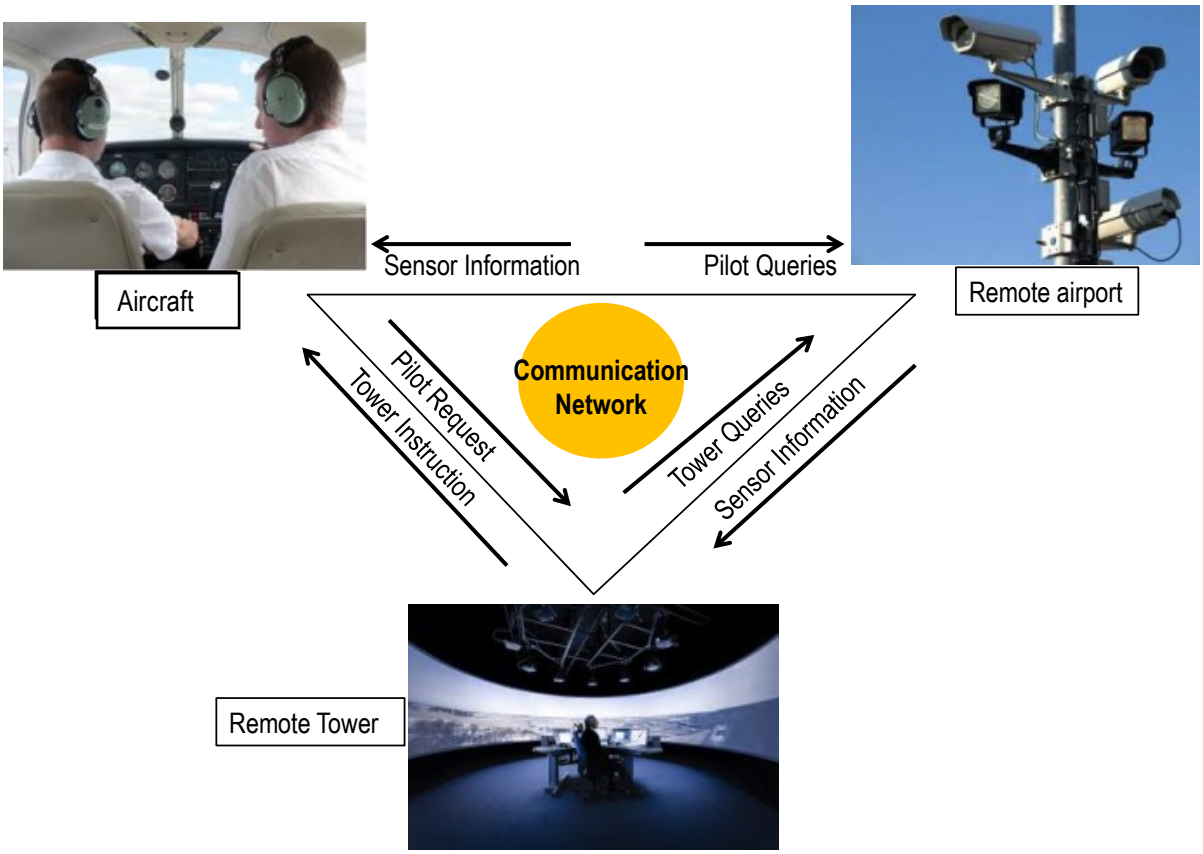

Figure 4: Remotely Operated Virtual Tower concept: domains overview

3.3 Technical Implementation

In order to provide a better understanding of the scenario, in the next sections we present the services, the actors, the communication lines and the physical elements which are involved in the depicted scenario, divided in three main domains: the Remotely Operated Virtual Tower, the Remote Airport and the Aircraft (see Figure 4).

3.3.1 Remotely Operated Virtual Tower

The Remotely Operated Virtual Tower includes controller working positions for remote airport control. They incorporate all necessary control systems, live video presentation and additional Remotely Operated Virtual Tower specific systems.

The OTW vision in Remotely Operated Virtual Tower is based on live video image captured at the remote airport and sent to the Remotely Operated Virtual Tower centre via a digital network. The live video image will provide the ATCO with an out-the-window view similar to an actual ATS tower.

A set of fixed cameras on the dismissed local tower (or other airport structure/building) in the remotely controlled airport sends to the RTC live images of the airport and it surrounding as viewed by a local ATCO.

Each camera could be a multi spectral camera (B&W/RGB/IR) or a set of dedicated single spectral cameras to enhance the vision in cases of low visibility operations. A secondary set of cameras could provide an alternative point of view.

One or more remotely controlled (by ATCO) electro-optical system implements the "binocular" function to achieve a more detailed vision.

A multi display system or a circular video wall reproduces the OTW vision of the remotely controlled airport.

Ground radar, ground sensors data, Advanced Surface Movement Guidance and Control Systems (A-SMGCS) data received from remotely controlled airport are presented on the CWP display.

The ATCO could select a subset of data presented on CWP and display them on a graphic overlay on OTW representation implementing a display function.

- Data recording function will provide video and voice communication recording and playback.
- Sounds and noises of remotely controlled airport are delivered in RTC.

Figure 5 provides an overview of the functional blocks composing the Remotely Operated Virtual Tower architecture in the different domains. Moreover, in the next pages the services, the actors, the communication lines and the physical elements will be explained thoroughly. Figure 6 illustrates the symbols to denote the different architectual components.

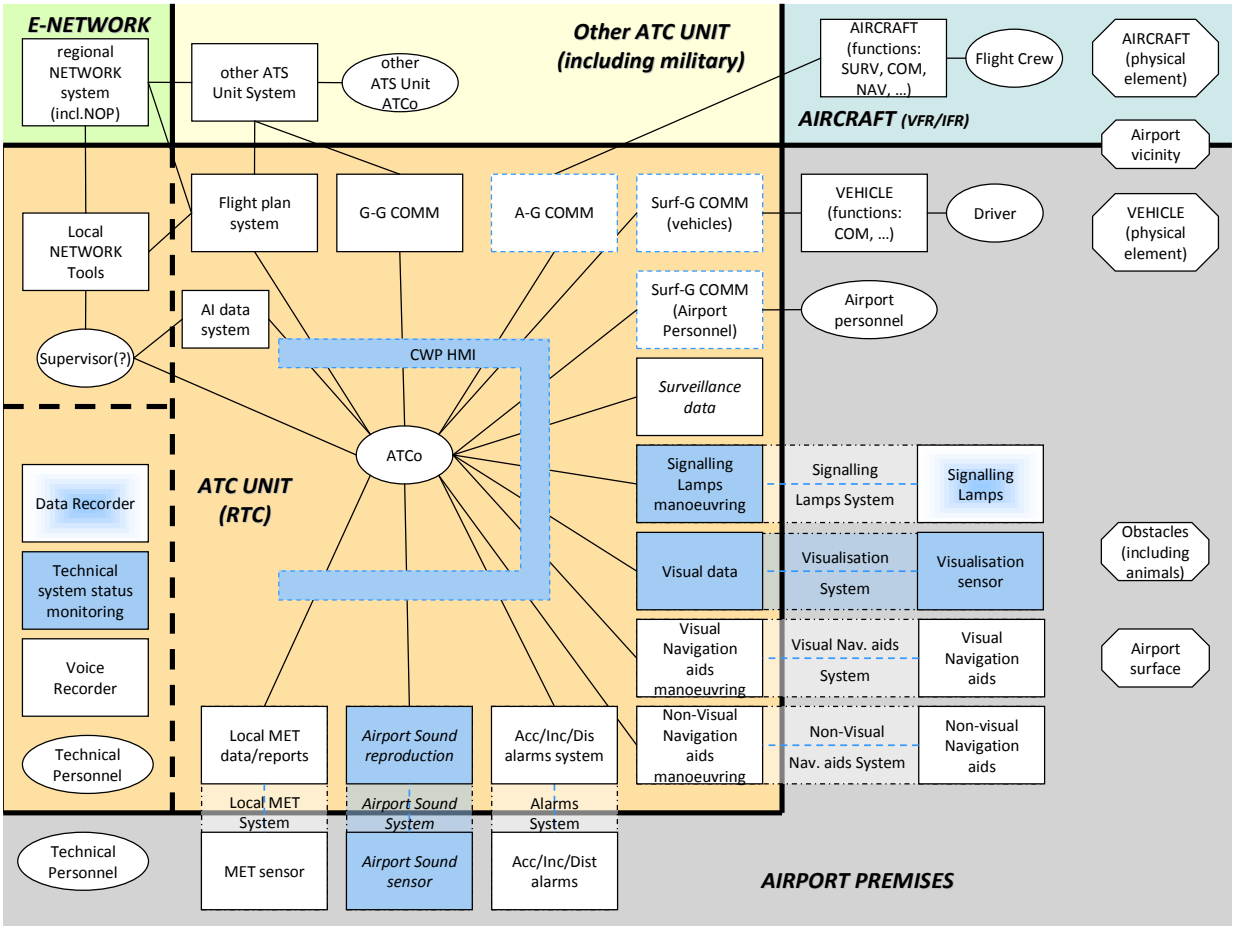

Figure 5: Functional block model Remotely Operated Virtual Tower

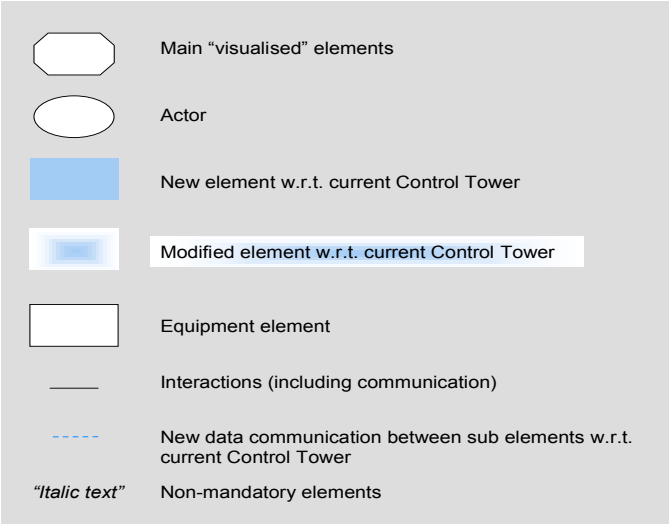

Figure 6: Elements - Functional block model Remotely Operated Virtual Tower

Element Type	Input Services	Ground Elements	Description
Services	Operational Supervision	Local Network Tools	Provides relevant information and tools for supporting the Supervisor's tasks as managing the airport re-staffing resources
	Airport Flight Data Processing	AI data system	Provides Aeronautical Information to the ATCO to be used by supervisor and/or ATCO as necessary
	Airport Flight Data Processing (for more details see Figure 7)	Flight plan system	Provides flight plan information to the ATCO for the aircraft flying/operating in the area of responsibility of the ATCO in form of paper strips or eventually electronic strips
	Airport Surveillance (for more details see Figure 7)	Surveillance Data System	When available, it provides "real-time" surveillance data for the (equipped) aircraft flying/operating in a delimited area of responsibility of the ATCO
	Ground Lighting Management	Signalling Lamps System	Allows the ATCO to remotely manoeuvre the Signaling Lamps located in the airport premises
	OTW Visualization	Visualisation System	Provides "real-time" images of the airport, the airport traffic, as well as any obstacle[2] in this area. A specific function allows a binocular view of particular element/objects

[2] All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that: a) are located on an area intended for the surface movement of aircraft; or b) extend above a defined surface intended to protect aircraft in flight; or c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

	Ground Lighting Management (for more details see Figure 7), Support Functions (for more details see Figure 7)	Visual Nav. aids System	Allows the ATCO to remotely manoeuvre the different "lighting" systems to support aircraft in "finding their way" to the airport, on the vicinity of the runway and on the airport surface
	Support Functions	Non-Visual Nav. Aids System	Allows the ATCO to remotely manoeuvre the different "non-lighting" systems to support aircraft in "finding their way" to the airport/runway
	Support Functions	Accident, incident and distress alarms	Allows the ATCO to monitor and trigger accident, incident and distress alarms as applicable to the airport
	Support Functions	Airport Sound System	When available, it provides "real-time" noise from the airport (aircraft engines, wind sound, …)
	OTW Visualization	CWP HMI	Allows to ATCO to get information from all previous systems and to interact with them as necessary (to have a deeper insight about the systems connected with the CWP HMI see Figure 7)
	Support Functions	Local MET system	Provides to ATCO the relevant weather information on the airport (temperature, pressure/QNH, snow on the runway, wind direction/strength, …)
Communication lines	Airport Communications	G-G COMM	Allows voice/data communication between ATCO and "other ATS unit ATCO"
	Airport Communications	A-G COMM	Allows voice (VHF) / data (CPDLC) communication between ATCO and Flight Crew
	Airport Communications	Surf-G COMM (vehicles)	Allows voice communication (VHF) between ATCO and vehicles drivers on the airport surface
	Airport Communications	Surf-G COMM (Airport personnel)	Allows voice/data communication between ATCO and airport personnel
Actors		Supervisor	The (optional) Supervisor could have main responsibility for staff/CWP allocation in an RTC with several workstations connected to several airports. He/she manages the airport/ATC unit resources/capacity in order to cope with the foreseen traffic (staffing, re-sectorisation, closure of the airport, …). During a shift, a Supervisor role can be used to manage the allocation of staff and CWP at any one time during the shift in order to provide an efficient set up at all times and guarantee a flexible system. The Supervisor role can be performed by a dedicated

			person, or can be handled by one of the shift staff in addition to their ATCO/AFISO role.
		ATCO	Provides ATC services by using the information provided in the CWP HMI. The TWR ATCO is responsible for assuring safe operations and provision of air traffic control services for the airport manoeuvring area and the vicinity of the airport. This includes responsibility for clearance delivery, ground control, arrival management, departure management and flight data processing.
		Technical personnel	In charge of the maintenance of the following "Technical supervision" elements
Physical elements	Technical Supervision	Data Recorder	Allows to record operational data including visualization information
	Technical Supervision	Voice Recorder	Allows to record voice communication on the applicable radio channels
	Technical Supervision	Technical System status monitoring	Allows to monitor and detect any technical failure mode / degraded mode of the system

Table 1: Remotely Operated Virtual Tower components

The Figure below illustrates how the different services defined in Table 1 interact with the CWP HMI.

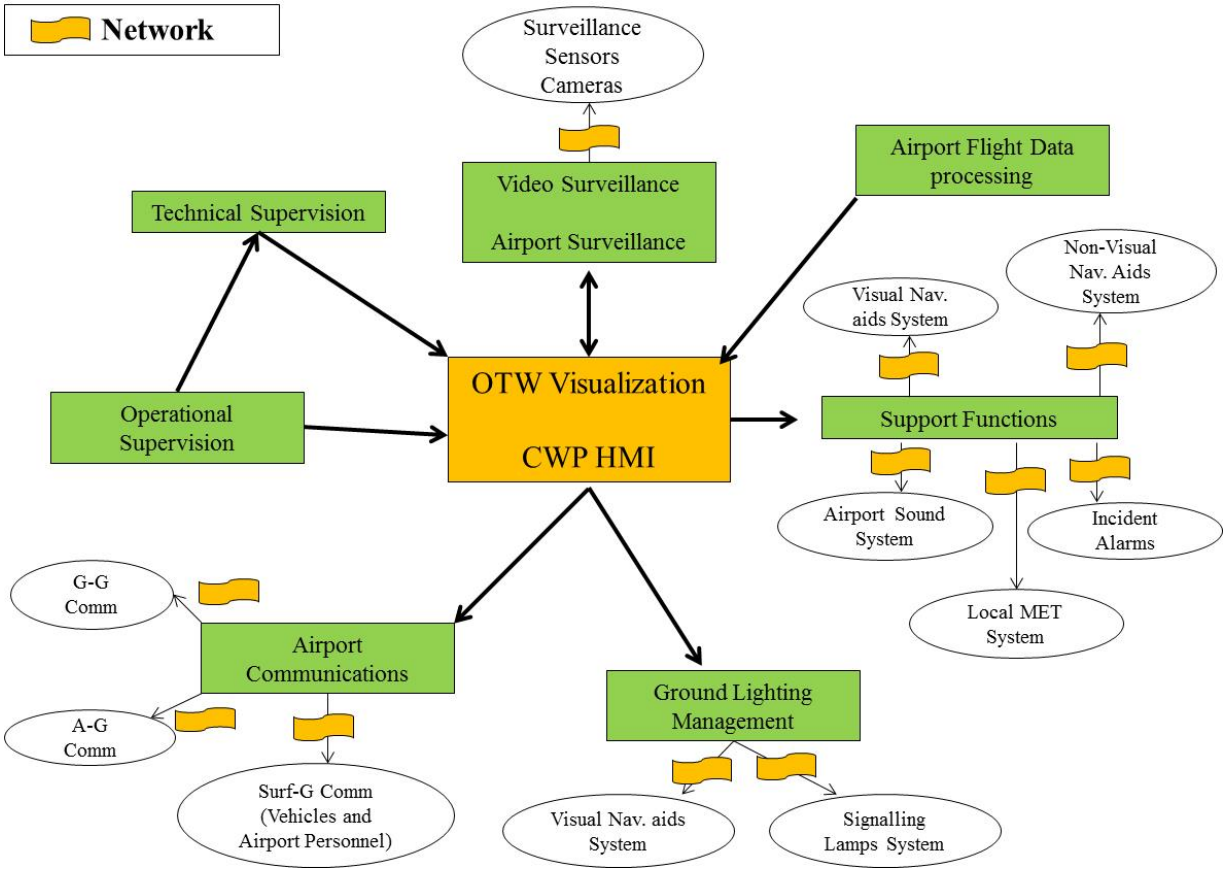

Figure 7: Functional relation flow

In particular, the figure lists all functional components of the Remotely Operated Virtual Tower solutions and their dependencies and relations. Furthermore external systems or sensors, which are related to the Remotely Operated Virtual Tower systems, are shown. The logical information flow of flight data, support information and voice communication is the same as for the standard tower. Main difference is the remote connection to dedicated information sources at the local airport and the acquisition of this information via the WAN infrastructure.

The central element is the Controller HMI, which combines functions from the other components to an integrated controller working position. A Remotely Operated Virtual Tower specific part of the HMI is the OTW Visualization component. It uses mainly the Airport Surveillance functions to replicate the out of the window view. In case of the video based Remotely Operated Virtual Tower implementation the visualization is based on the video surveillance component, which is attached to local camera sensors.

The Airport Surveillance and Video Surveillance block is processing sensor data (radar data / video streams) from the local airport, which are transferred via the network infrastructure. Parts of the processing may be performed locally at the airport or at the RTC. The exact deployment is a matter of detailed design and specific for a dedicated implementation.

Other data such as support information or status and control of airfield light are also integrated in the controller working position. Selected support information might be directly embedded into the visualization component (e.g. as overlay information). The information flow for technical supervision starts at the acquisition of status information of all technical equipment at the local airport or in the Remotely Operated Virtual Tower center. Status information is aggregated and processed for presentation.

Voice Communication is interconnecting local radios and standard phone interfaces. All data are transferred via the common network infrastructure. Voice Communication functions are integrated in the controller HMI.

In what follows we provide a detailed description of all the services interacting with the CWP HMI shown in Figure 7.

Airport Surveillance

This functional block provides controllers with airport situational awareness on the STAR(s), apron(s), taxiway(s), runway(s) and landing/take-off paths by providing position and identification of all surface traffic (aircraft and vehicles). It merges the surveillance information provided by the different surveillance sources providing a unique picture of the actual traffic situation. For each aircraft, vehicle and obstacle a system track is generated.

The airport surveillance component will be extended in a Remotely Operated Virtual Tower system by introducing a dedicated function to gather data for visualization to replace the classical out of the window view of traditional towers. Visualization and surveillance capabilities will be combined to enhance situation awareness for the remote control scenario. Specific issues such special weather conditions, different sun light conditions and replacement of binocular view have to be addressed by this component.

In addition new components are introduced for the video based Remotely Operated Virtual Tower approach:

- Video stream management;
- Camera Control;
- Visual Tracking;
- Video Data Fusion.

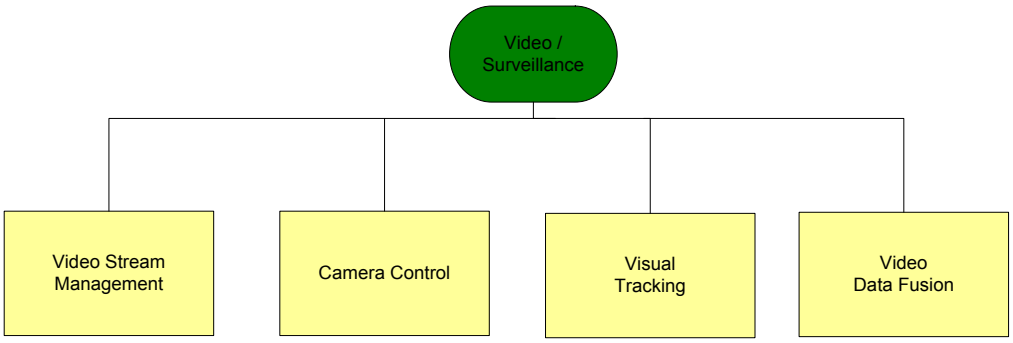

Figure 8: Functional decomposition of Surveillance / Visualization for video based Remotely Operated Virtual Tower

Video Stream Management

This component includes handling of video data from several local cameras and transferring this data to the Remotely Operated Virtual Tower Centre. It includes bandwidth management and compression, monitoring of delay times, frame rate and access control.

Camera Control

The component provides access to control functions of cameras. This functional block includes authentication functions and control function related to image adjustments/optimization and PTZ control.

Visual Tracking

This component performs automatic object tracking functions based on the managed video streams. Output of this component is position information of the identified object or marking of the identified object in the video stream.

Video Data Fusion

Data fusion combines different inputs from surveillance sensors and generates an aggregated system track for a dedicated object.

Airport Flight Data Processing

This functional block manages the creation, update and modification of system flight plans up to/from the moment the aircraft takes-off/lands. In addition, it calculates the predicted trajectory by taking into account applicable constraints and relevant data (e.g. aircraft performance, weather data, airport configuration data, wake vortex characteristics associated to each aircraft). Airport Flight Plan should be updated at the occurrence of identified significant events such as, for example: request and approval clearance for Start-Up, Push Back, Taxi, Line-Up, Take-Off and similarly for landing aircraft.

Support Functions

The Support functions do not affect directly the provision of ATM Services at operational time. They contain at least the following:

- Recording - performing the recording of the ATM System data related to the Airport ATC, and buffering those data on a persistent database;
- Playback - providing support for display and voice recording, display and voice playback, other data recording and reduction, etc;
- Data analysis - providing support for maintenance, investigation etc;
- Automatic Safety Data Gathering Tool - providing support for safety aspects.

In context of a video based Remotely Operated Virtual Tower supporting functions will be extended by recording of video streams and additional audio feed (from the airport environment).

Ground Lighting Management

This function provides the functionalities, for the Airport ATC users, to control and monitoring in real time that the entire "light system" is constantly able to support the operative needs, in order to assure all the airport operations in an appropriate way under all conditions. This system is also the main enabler to support and implement the Surface Guidance.

In context of Remotely Operated Virtual Tower this component will be used in a limited way. Focus is the standard control and status feedback of all airfield light segments via the Remotely Operated Virtual Tower center.

Operational Supervision

This functional block allows the Supervisor to manage the most appropriate operational configuration, according to traffic demand and airport needs, and to react in case of system fault, re-assigning and distributing available resources in order to maintain adequate safety levels and quality of service.

Technical Supervision

This functional block is in charge of the technical supervision of an Airport ATC system (e.g. monitoring the services provided by the system, starting, stopping or re-starting the system or part of it).

The Technical Supervision encompasses the following functions:

- presenting technical and functional systems status: monitor system availability. Acquire, synthesize and display technical and functional status on all the system hardware/software resources;
- providing failure detection and analysis assistance: generate alarm or warning on failure detection. Provide support for analysis of supervision data (enable queries on historic of events);
- providing supervision commands and actions: accept supervision commands/actions (e.g. (Re) start/stop/stand-by/reset/switch-over) from eligible operators and gives the capability to perform maintenance activities.

In context of the Remotely Operated Virtual Tower the technical supervision is deployed in a distributed environment and has to cover equipment hosted at the airport and the Remotely Operated Virtual Tower center.

Airport Communication

The Airport Voice Domain system provides Voice front-end functionalities (Telephone and Radio Voice Communication Switching functionalities, typically).

Air-Ground Voice Communications

This functional block provides the functions performed by a Radio VCS.

In the Remotely Operated Virtual Tower operation scenario the air ground communication is not directly interconnected to the local radio. The located Remotely Operated Virtual Tower Centre needs a dedicated connection to the local radio to access air ground communication. Therefore additional infrastructure and an access gateway for the radio will be required.

Especially for a backup or emergency radio system a dedicated backup connection between the local tower and the Remotely Operated Virtual Tower center will be required. Standard fallback solution such as handheld radios used directly in the tower is not applicable for the Remotely Operated Virtual Tower scenario.

Ground-Ground Voice Communications

This functional block provides the functions performed by a Telephone VCS.

Remotely Operated Virtual Tower specific enhancements for this component are related to management of remote and an optional local VCS position for backup or transition purpose.

3.3.2 Airport Premises

Element Type	Input Services	Ground Elements	Description
Services	Ground Lighting Management	Signalling Lamps System	Signaling Lamp is located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
	Support Functions	Local MET system	Captures the relevant weather information on the airport to be provided to the ATCO in the remote ATC unit (RTC)
	Support	Airport Sound	Captures “real-time” noise from the airport to be provided

	Functions	System	to the ATCO in the remote ATC unit (RTC)
	OTW Visualization	Visualisation System	Captures "real-time" images on the airport premises to be provided to the ATCO in the remote ATC unit (RTC)
		Vehicle (functions: COM, …)	Encompasses all the information/systems needed for driving it and communicate with ATCO and other airport personnel
Actors		Driver	Drives the vehicle in the manoeuvring area as instructed by the ATCO
		Airport Personnel	Management of the airport stands, pushback services, runway inspections, …
		Technical Personnel	Is in charge of the maintenance of the "remote" equipment located in the airport premises
		Airport Rescue Unit	Could utilize by external sharing of the visual reproduction for quick response and localization of the emergency, even during low visibility and without being dependent on information passed on by ATCO personnel
		Airfield security and ground handling	Could be alerted of unauthorized infringements on the manoeuvring area, debris on the runway and other safety and/or security related issues.
Physical elements		Visual Nav. aids System	Visual Navigation aids are located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
		Non-Visual Nav. Aids System	Non-Visual Navigation aids are located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
		Ground Lights System	Ground Lights are located on the airport manoeuvring area, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
		Obstacles	Fixed (temporary or permanent) and mobile objects (including animals) that are captured by the Visualisation system in order to be remotely provided to ATCO
		Vehicle (physical element)	The vehicles are captured by the Visualisation system in order to be remotely provided to ATCO

Table 2: Airport components

3.3.3 Aircraft

Element Type	Ground Elements	Description
Services	Aircraft	Encompasses all the onboard information/systems needed for the flight.
Actors	Flight Crew	Pilots the aircraft using airborne information/systems and ATC instructions/clearances
Physical	Aircraft (physical	The aircraft are captured by the Visualisation system in order to be

elements	element)	remotely provided to ATCO

Table 3: Aircraft components

3.3.4 External Entities: Other ATC Unit elements

Element Type	Ground Elements	Description
Services	Other ATS Unit ATCO	ATCO coordinates with other ATS Unit ATCO for transferring departing/arriving aircraft, (with military) for activating/ deactivating restricted areas, …

Table 4: Other ATC Unit elements

3.3.5 E-Network element

Element Type	Ground Elements	Description
Services	Regional NETWORK system	Provides Regional flight plans for the day of operations (CFMU) to local Network

Table 5: Network elements

4 Example of Use Case

The following use case presents an arriving aircraft scenario, handled by a Remotely Operated Virtual Tower and it is written from a Remotely Operated Virtual Tower ATCO point of view. The starting general conditions are the following:

- The Remotely Operated Virtual Tower ATCO is located away from the airport and/or the local Tower;
- The Remotely Operated Virtual Tower ATCO has at his/her disposal the visual reproduction of the airport view;
- The Remotely Operated Virtual Tower ATCO is providing ATS to a single airport.

The post-condition to be achieved is to provide a safe and efficient provision of ATS for arrival aircraft, with the same or better levels of service as if the ATS had been provided locally.

The standard procedure to handle an arriving aircraft is introduced below in Figure 9, focusing on the communication between the ATCO located in a Remotely Operated Virtual Tower and the Flight Crew needed of support during the landing operations.

Figure 9: Standard procedure for the Arriving Aircraft Operation

The steps of the arriving procedure are better detailed in Table 6.

Step	Remotely Operated Virtual Tower ATCO	Flight Crew	Notes	Phase
1.	a) Establishes contact (R/T) with the inbound IFR flight crew when the aircraft is established on final approach.	b) Acknowledges contact.	Remotely Operated Virtual Tower ATCO may also relay potential updates of the actual MET Report, displayed on the RTM and other relevant information e.g. regarding runway conditions to the Flight Crew (if no ATIS is available).	Final Approach
2.	a) Verifies that the runway is free of obstacles for the landing of the aircraft and issues the landing clearance to the Flight Crew using R/T.	b) Acknowledges the landing clearance.	Remotely Operated Virtual Tower ATCO runway check is performed by visual reference gained from the relayed visual reproduction of the airport.	Final Approach
3.	a) Monitors the aircraft's final approach and landing to ensure safety and intervenes if required.	b) Proceeds with the approach and lands the aircraft.	Remotely Operated Virtual Tower ATCO monitors aircraft on relayed visual reproduction. Advanced Visual Features may overlay additional information onto the visual reproduction to assist the Remotely Operated Virtual Tower ATCO in identifying and monitoring the aircraft on final approach e.g. wind measurements, runway visual range values, runway lights status.	Final Approach and landing
4.	a) Issue a clearance where to exit the runway. Verifies that the aircraft has vacated the runway via the planned exit. Issues a taxi clearance via appropriate taxiway(s) to the allocated stand on apron.	b) Executes the clearance and vacates runway. Acknowledges the taxi clearance.	Remotely Operated Virtual Tower ATCO monitors aircraft on relayed visual reproduction. The Remote TWR ATCO may use an alternative viewpoint at this taxiway in order to be able to get an enhanced view and monitor more closely that the aircraft has left the RWY.	Landing / Runway
5.	a) Monitors the traffic situation for the detection of potential hazardous situations (e.g. converging airport traffic, temporary obstructions, debris). If the Taxi Clearance Limit is an active runway, the Remotely Operated Virtual Tower ATCO verifies that the runway is clear and the aircraft can cross and issues taxi route	b) Acknowledges and accepts the route clearance, updating the aircraft system. Manoeuvre the aircraft assisted by the routing displayed onboard the aircraft and/or using visual navigation aids (e.g. taxiway markings and lighting).	Remotely Operated Virtual Tower ATCO monitors aircraft on relayed visual reproduction and/or Advanced Visual Features	Taxi

	clearance(s) to the stand.			

Table 6: Protocol to handle arriving aircraft

Appendix

Term	Definition
ACC	Area Control Centre
ADD	Architecture Definition Document
ADS-B	Automatic Dependant Surveillance - Broadcast
AFIS	Airport Flight Information Service
AFISO	Airport Flight Information Service Officer
APOC	AirPort Operations Centre
APP	Approach
A-SMGCS	Advanced Surface Movement Guidance & Control System
ART	Advanced Remotely Operated Virtual Tower Research Project
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATCO	Air Traffic COntroller
ATM	Air Traffic Management
ATS	Air Traffic Service
CFMU	Central Flow Management Unit
CPDLC	Controller Pilot Data Link Communications
CWP	Controller Working Position
D-ATIS	Digital Automatic Terminal Information Service
DCL	Departure Clearance
DLIC	Data Link Initiation Capabilities
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrumental Landing System
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
MLAT	Multi-Lateration
OSED	Operational Service and Environment Definition
OTW	Outside The Window

Term	Definition
PTZ	Pan Tilt Zoom Camera
QNH	Barometric pressure adjusted to sea level
ROT	Remotely Operated Tower (proof of concept project)
RTC	Remotely Operated Virtual Tower Centre
RTF	Remotely Operated Virtual Tower Facility
RVT	Remote and Virtual Tower Project
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SMR	Surface Movement Radar
SPR	Safety and Performance Requirements
STAR	Standard Terminal Arrival Route
TAD	Technical Architecture Description
TS	Technical Specification
TWR	Airport Control Service (which is a subset of ATC Service)
VCS	Voice Communication System
VHF	Very High Frequency (radio spectrum band)