European Union Aviation Safety Agency

Guidance Material

on

remote aerodrome air traffic services

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Table of contents

GUIDANCE MATERIAL ON REMOTE AERODROME ATS

1. Introduction

The concept of remote provision of aerodrome air traffic services (ATS) (commonly known as 'remote towers' or 'remote tower operations', sometimes referred to as 'digital towers') enables the provision of aerodrome ATS from locations/facilities without direct visual observation. Instead, the view of the aerodrome and its vicinity is based on means of technology. Throughout this document, the term used to describe this is 'remote aerodrome ATS'.

The various aspects of the provision of ATS at an aerodrome are already governed by provisions at ICAO, EU and national level, including those related to the assessment of changes to functional systems. This document provides support on how to meet these requirements in the case aerodrome ATS is provided remotely.

1.1. Purpose and intended readership

This document provides guidance to support both:

— organisations (e.g. air traffic service providers, aerodrome operators) implementing, or considering the implementation of remote aerodrome ATS; and

— the competent authorities in charge of the approval of remote aerodrome ATS implementation.

This document also describes the general concept of remote aerodrome ATS to the ATM community by establishing a common baseline and understanding thereof. In addition, it provides clarification about and consistency with related terms and definitions.

The document lists areas and issues for consideration when implementing remote aerodrome ATS, in particular those related to change management, safety and human factors. However, it should be noted that every case of implementation is unique and is subject to a local safety assessment, in accordance with applicable regulations and the procedures accepted by the relevant competent authority.

In order to provide a single source of information encompassing all the aspects related to remote aerodrome ATS, EASA has opted for the development of a stand-alone 'Guidance Material' document. In order to ensure regulatory consistency with existing regulatory material, the aspects related to the qualification and training of air traffic controllers (ATCOs) are dealt with through a separate set of AMC and GM to Regulation (EU) 2015/340 [3].

1.2. Scope

The scope of this document is the overall concept of remote aerodrome ATS — covering single and multiple modes of operation (described in Sections 3.2 and 3.3), remote tower centre operations (described in Section 3.4) and the use of technical enablers (some of which have traditionally not been available for aerodrome ATS) (described in Section 5.2.8). As such, the guidance provided in this document can be seen as generic. In addition, the document provides an overview of the operational context and applications that have been validated or that are operational to date (see Chapter 4).

This document covers the technological, procedural and operational aspects of remote aerodrome ATS, in order to facilitate the safe and harmonised implementation throughout the EASA Member States in accordance with the objectives of ATS.

This document focuses primarily on the unique implementation aspects of **remote** aerodrome ATS and therefore does not list all regulations related to aerodrome ATS provision. ATS providers or aerodrome operators considering implementation of remote aerodrome ATS are responsible for ensuring compliance with the international standards and EU/national requirements as may be applicable to individual operations.

This document also provides guidance on pre-decision assessment and post-implementation validation, including socio-economic considerations in Section 6.1.

While the main scope of/focus for this document is remote aerodrome ATS being provided from a remote tower (where aerodrome ATS is provided principally through the use of a visual surveillance system — rather than out-of-the-window views — to visually observe aerodrome traffic), the guidance presented in this document may likewise be used as relevant for the case when visual surveillance system elements (e.g. 'hot spot/gap filler' cameras) are used to support ATS provision in conventional towers.

1.3. Document structure

This document is structured as follows:

— Chapter 1 'Introduction' presents the purpose, scope, intended readership, structure and background of this document as well as the justification for its development.

— Chapter 2 'Definitions' lists the terms and definitions used in this document.

— Chapter 3 'The remote aerodrome ATS concept and modes of operation' provides a general overview of the concept of remote aerodrome ATS with a short historical retrospect and by introducing:

- its main operational modes;
- remote tower centre operations; and
- technical enablers that support remote aerodrome ATS.

  Finally, it also lists possible operational applications.

— Chapter 4 'Operational context/applications and related recommendations' describes the operational context and applications that have been validated or introduced into operation to date and provides related recommendations. In addition, it includes an overview on some ongoing initiatives which could further contribute to the development of the concept.

— Chapter 5 'Operational and system considerations' describes the operational and procedural needs and requirements for remote aerodrome ATS as well as considerations for a remote tower system.

— Chapter 6 'Management of change' provides considerations and guidance related to the change management for the introduction of remote aerodrome ATS, for the fields of safety assessment, human factors assessment, information and cybersecurity, contingency planning, transition/implementation plan and remote tower system constituents.

— Chapter 7 'Aerodrome-related aspects' outlines aspects to take into account for the aerodrome operator. Furthermore, it outlines the coordination needs between the ATS provider and the aerodrome operator.

— Chapter 8 'Possible impact on airspace users' shortly discusses how airspace users could be affected by the implementation of remote aerodrome ATS.

— Chapter 9 'Aeronautical information products and services' gives indications on information that may need to be included in the various aeronautical information products and services.

— Chapter 10 'Qualification, training and licensing considerations' describes qualification and training considerations for air traffic controllers (ATCOs), aerodrome flight information service officers (AFISOs) and air traffic safety electronics personnel (ATSEP).

— Chapter 11 'References' lists the legislation and the documents which have been considered for the development of this document.

— Chapter 12 'Appendices' contains all the appendices to this document.

2. Definitions

For the purpose of this document, the definitions in Article 2 of Regulation (EU) No 923/2012 'SERA' (*) as well as in Article 2 of and Annex I to Regulation (EU) 2017/373 'Common Requirements' (**) apply. Particular consideration should be given to the following definitions:

(*) **'aerodrome control service'** means air traffic control service for aerodrome traffic;

(**) **'aerodrome flight information service (AFIS)'** means flight information service and alerting service for aerodrome traffic at an aerodrome;

(*) **'aerodrome traffic'** means all traffic on the manoeuvring area of an aerodrome and all aircraft flying in the vicinity of an aerodrome. An aircraft operating in the vicinity of an aerodrome includes but is not limited to aircraft entering or leaving an aerodrome traffic circuit;

(*) '**air traffic service (ATS)**' means a generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).

Additionally, the following definitions also apply:

'aerodrome ATS' means air traffic service for aerodrome traffic, in the form of 'aerodrome control service (ATC) or 'aerodrome flight information service' (AFIS);

'conventional tower' means a facility located at an aerodrome from which aerodrome ATS is provided principally through direct out-of-the-window observation of the aerodrome and its vicinity;

'detect/detection' means to visually be able to see that there is something;

'identify/identification' means the ability to correlate a detected or recognised object with a specific individual aircraft/vehicle;

'multiple mode of operation' means the provision of ATS from one remote tower/remote tower module to two or more aerodromes at the same time (i.e. simultaneously)[2][3];

'operational context' means the operational characteristics — such as aerodrome size/layout, traffic volume/density and complexity, related airspace and flight procedures, number of simultaneously served aerodromes, etc. — that should be considered when remote aerodrome ATS is to be implemented;

'out-of-the-window (OTW) view' means a view of the area of responsibility of the aerodrome ATS unit from a conventional tower, obtained via direct visual observation;

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[2] See Section 3.3.

[3] There are examples where — within the control zone (CTR) of an aerodrome or within the airspace where AFIS for an aerodrome is provided — also other aerodromes/heliports are situated but for which no aerodrome ATS (aerodrome control service or AFIS) is provided on ground. A typical example would be a heliport located inside the horizontal limits of a CTR of an aerodrome (but located away from that aerodrome). Although the traffic/helicopters flying in/out of the heliport need a clearance to fly through/in the CTR, the heliport itself is not provided with aerodrome control service as defined by relevant EU legislation (e.g. Regulation (EU) No 923/2012 'SERA'), since the heliport's traffic on the manoeuvring area is not provided with the service. Hence, this example falls outside the scope of the definitions for both single and multiple mode of operation, as they refer to 'provision of aerodrome ATS'.

'recognise/recognition' means to visually be able to determine the class/category/type of an object, e.g.:

— class/category/type of aircraft based on e.g. size/fuselage, engine configuration, wing/stabiliser configuration, painting/colour marking, etc.;

— class/category/type of personnel and obstructions, e.g. person/wildlife/foreign object debris (FOD);

— class/category/type of vehicle, e.g. ambulance/car/fuel truck/baggage trailer;

'remote aerodrome ATS' means (provision of) aerodrome ATS from a remote tower/remote tower module;

'remote tower centre' (RTC) means a facility housing one or more remote tower modules;

'remote tower module' (RTM) means a combination of systems and constituents from where remote aerodrome ATS can be provided, including one or more ATCO/AFISO workstation(s) and the visual presentation. (It can be compared with the tower cabin of an aerodrome conventional tower.);

'remote tower' means a geographically independent facility from which aerodrome ATS is provided principally through indirect observation of the aerodrome and its vicinity, by means of a visual surveillance system. (It is to be seen as a generic term, equivalent in level to a conventional tower);

NOTE: The actual distance to the serviced aerodrome may vary from hundreds of metres to many kilometres.

'single mode of operation' means the provision of ATS from one remote tower/remote tower module to one aerodrome at a time;

'visual presentation' means a view of the area(s) of responsibility and interest of the aerodrome ATS unit, provided by a visual display;

'visual surveillance system'[4] means of a number of integrated elements, normally consisting of optical sensor(s), data transmission links, data processing systems and situation displays providing an electronic visual presentation of traffic and any other information necessary to maintain situational awareness at an aerodrome and its vicinity.

[4] EUROCAE ED-240A Change 1 [12] uses the term 'remote tower optical system' for the same system.

3. The remote aerodrome ATS concept and modes of operation

The concept of remote aerodrome ATS enables provision of aerodrome ATS from locations/facilities without direct visual observation. Instead, provision of aerodrome ATS is based on a view of the aerodrome and its vicinity through means of technology.

The primary change introduced by remote tower operations, compared to conventional tower operations, relates to the manner by which visual observation of the aerodrome and its vicinity is achieved. When operating from a remote tower facility, this is no longer carried out by direct out-of-the-window observation from a conventional tower. Instead, visual observation is achieved utilising a visual surveillance system, enabling situational awareness in accordance with Regulation (EU) 2017/373 [2]and ICAO Documents 4444 [7] and 9426 [8].

A remote tower can be located away from the aerodrome it is providing a service to, or it can be located in a building on or close to the aerodrome but without an adequate direct view of the area of responsibility. System elements of a visual surveillance system could also be introduced in a conventional tower, in order to enhance/complement situational awareness or to provide a visual presentation of parts of the aerodrome or its vicinity which is otherwise either inadequate or non-existent.

The concept was initially introduced and developed within some Member States in the early 2000s, and it has been further developed and refined within the SESAR JU programme. At the time of publication of this document, four so-called SESAR Solutions[5] related to remote tower operations have been published by SESAR JU. (With reference to the European Operational Concept Validation Methodology (E-OCVM) [31], a SESAR Solution indicates that an operational concept has completed phase V3 of the Concept Lifecycle Model, thus being ready and mature for industrialisation (V4) and deployment (V5)).

When it comes to remote aerodrome ATS, Japan has been providing AFIS from remote locations since 1974[6], although in the beginning only with a limited visual presentation of the aerodrome and its vicinity. The first remote tower implementation providing aerodrome ATS based on situational awareness fully in accordance with ICAO Documents 4444 [7] and 9426 [8] was approved and introduced into operations in Sweden in 2015. Since then, several initiatives to provide remote aerodrome ATS have been introduced into operation, with an increasing number of initiatives being undertaken throughout Europe as well as worldwide.

The concept of remote aerodrome ATS is constantly evolving and over time, since the concept was initially defined, the operational framework/target environments as well as new applications have evolved. It is expected that this evolution will continue.

Results from research and development activities (such as the SESAR JU programme) and experience from operations are important inputs to the development of formal specifications, standards and regulatory framework material (such as this document).

[5] Solution #71: ATC and AFIS service in a single low-density aerodrome from a remote CWP,
Solution #12: Single remote tower operations for medium traffic volumes,
Solution #52: Remote tower for two low density aerodromes,
Solution #13: Remotely provided air traffic service for contingency situations at aerodromes.

[6] http://www.icao.int/Meetings/anconf12/WorkingPapers/ANConfWP130.2.1.ENonly.pdf

3.1. Modes of operation

For the purpose of this document, the concept of remote aerodrome ATS is categorised into the following two main modes of operation:

— single mode of operation; and

— multiple mode of operation.

For both modes, ATS may be provided either as aerodrome control service (ATC) or aerodrome flight information service (AFIS).

Irrespectively of single or multiple mode of operation, remote aerodrome ATS could be implemented/provided both for the case when there is already a conventional tower at the aerodrome concerned, or for the case when there currently is no conventional tower. The provision of remote aerodrome ATS could be performed on a permanent basis (fully replacing the conventional tower, if one exists) or it could be performed on a temporary basis; for example, during specific times such as during the night or for specific events, or it could be performed for contingency purposes (e.g. where a remote tower is used as backup facility for a conventional tower).

When providing remote aerodrome ATS, the operational application will vary depending on various factors such as the operational environment and the individual needs of stakeholders (as is the case in any ATS provision).

3.2. Single mode of operation

The single mode of operation refers to the provision of ATS to one aerodrome at a time, from a single remote tower module (RTM).

Operational applications which typically would fall under the remit of the single mode of operation include~~,~~ but are not limited to the provision of ATS:

— to one aerodrome from one RTM;

— during planned or unplanned contingency situations, as a dedicated backup solution for an existing aerodrome ATS; and

— to distant or visually blocked areas of an aerodrome, for which the view from the conventional tower cabin is inadequate or non-existent, by implementing visual surveillance system elements at the conventional tower. This could therefore be in lieu of building a second aerodrome/conventional tower.

__Note:__ With regard to the definitions in Chapter 2, this application is not regarded as a 'remote tower' and therefore it falls within the scope of a 'conventional tower'. However, the guidance in this document may be used as relevant for the visual surveillance system elements, and the relevant parts of GM3 ATCO.D.060(c) to Regulation (EU) 2015/340 [3] may be used for the local unit endorsement course.

3.3. Multiple mode of operation

The multiple mode of operation refers to the provision of ATS to more than one aerodrome at a time, i.e. simultaneous service provision, from a single RTM.

Operational applications include, but are not limited to:

— the provision of ATS to more than one aerodrome simultaneously from one RTM;

— mixed conventional and remote aerodrome ATS operations — the situation when a conventional tower is also providing ATS to another aerodrome remotely (additionally and simultaneously with the ATS provision to the local aerodrome), through the use of a visual surveillance system providing the visual view of the remote aerodrome. (In this particular situation, the conventional tower could at the same time be considered a remote tower.); and

— the simultaneous provision of ATS to a specific area or a specific function to more than one aerodrome, e.g. a clearance delivery position to more than one aerodrome.

Note - Clearance delivery per se would not require a visual presentation/visual surveillance system and would therefore not be considered either a 'remote tower' or an 'RTM' as defined in Chapter 2 of this document.

3.4. Remote tower centre (RTC)

The ATS provider may provide remote aerodrome ATS from a centralised facility known as a remote tower centre (RTC), which could house one or several RTMs.

An RTC could be set up as shown in the example in Figure 1, with multiple RTMs and possibly one or more supervisor positions (depending on the size and requirements of the RTC). The RTMs can have an independent combination of either single-mode-of-operation or multiple-mode-of-operation scenario per each RTM, which may also change over time (i.e. changing from single to multiple mode of operation for one RTM, or vice versa). The allocation of aerodromes between RTMs may also be changed on a flexible basis (similar to the procedures for sector allocation within an area control centre (ACC)) in order to improve efficiency of resources or to respond to operational needs and demands. The ability to switch aerodromes between RTMs will depend on many factors such as ATCO/AFISO qualification and training, technical configuration of the RTMs, traffic schedule and distribution between aerodromes, and how such factors impact safety and human performance.

The required number of available RTMs in an RTC will depend on the number of aerodromes connected to the RTC, the complexity and size of the connected aerodromes as well as the need for additional/spare RTMs, based on contingency and service availability requirements.

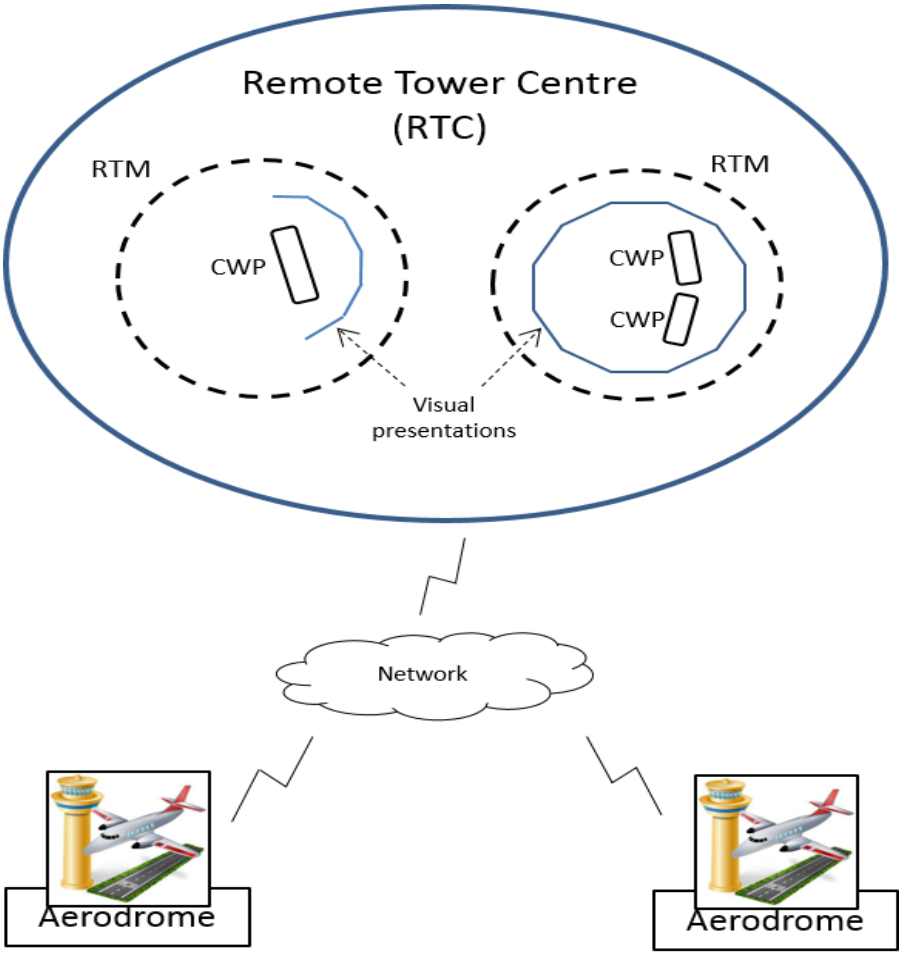

Figure 1: Example of high-level overview of remote aerodrome ATS from an RTC

3.5. Technical enablers for remote aerodrome ATS

The solutions which are available for remote aerodrome ATS are not based on a unique system configuration but on a varied set of technical enablers. The appropriate configuration of technical enablers should be carefully assessed and selected according to the operational needs of each implementation and supported and identified by the safety, security, and human factors assessments.

Below is a (non-exhaustive) list of possible technical enablers. Many of the below listed enablers are also available for conventional towers; however, in the remote tower context they will be affected to various degrees due to the need for data transmission links. Each technical enabler is further described in Chapter 5.

— Visual presentation, replacing, or complementing, the OTW view of a conventional tower (further described in Section 5.2)

— Binocular functionality (e.g. a pan-tilt-zoom (PTZ) camera/function, as defined and described in ED-240A Change 1 [12]), fulfilling/emulating the function of a binocular in a conventional tower (Section 5.2)

— Signalling lamp, remotely controlled (Section 5.3)

— Aerodrome sound reproduction (Section 5.4)

— Communication means to provide aeronautical mobile service, aeronautical fixed service and surface movement control service (Section 5.5)

— Management of navigation aids, aeronautical ground lights and other aerodrome assets (Section 5.7)

— Meteorological information (Section 5.8)

— Other ATS systems/functions, as would typically also be available in a conventional tower, but which are not necessarily affected by the remote provision of ATS (Section 5.9)

— Additional visual 'hot spot/gap filler' cameras (Section 5.2.8)

— The use of infrared or other optical sensors/cameras outside the visible spectrum (Section 5.2.8)

— Dedicated means to facilitate the detection and identification, as well as enabling automatic following, of aircraft or vehicles in the visual presentation (e.g. by overlaid labels based on data from ATS surveillance systems/sensors e.g. ADS-B, PSR, SSR, A-SMGCS, complemented by flight plan correlation when available, commonly referred to as **'radar tracking'**) (Section 5.2.8)

— Dedicated means to facilitate the detection and following of moving objects in the visual presentation (e.g. by highlighting/framing such objects based on image processing techniques, commonly referred to as **'visual tracking'**) (Section 5.2.8)

— System support to help the ATCO/AFISO detect smaller foreign object debris (FOD), highlighting the existence of such small objects in the visual presentation (Section 5.2.8)

— Other overlaid information in the visual presentation such as framing and/or designation of runways, taxiways, etc., compass directions, meteorological information, aeronautical information (NOTAM, SNOWTAM, etc.), other operational information (e.g. runway conditions like water, snow or mud presence, coefficient of friction, etc.) (Section 5.2.8)

— Enhanced functionalities of the binocular functionality, e.g. automatic following of moving objects (Section 5.2.7.2)

4. Operational context/applications and related recommendations

This chapter describes the operational context and applications which have been validated to date (by the SESAR JU programme and approved as SESAR Solutions), as well as operational contexts and applications for which remote aerodrome ATS have been approved for operation, together with related recommendations. This would not rule out the possibility for an expansion into other more challenging operational contexts and applications based on further research and operational experience. Regardless of the operational context, the implementation of remote aerodrome ATS will depend upon a local safety assessment, in accordance with applicable regulations and the procedures accepted by the relevant competent authority.

In this chapter, when discussing the results stemming from the SESAR JU programme, some terms used by SESAR are frequently referred to and they should be understood as follows:

— 'basic and advanced features' is a division of technical enablers used by SESAR to validate different equipage levels (refer to Appendix 4 for a representative division between basic and advanced features);

— 'low-density aerodromes'[7] are described by SESAR as aerodromes with typically a low capacity utilisation, where the prevailing traffic is mostly single aircraft movement operations, rarely reaching or exceeding two simultaneous aircraft movements; and

— 'medium-density aerodromes'[8] are described by SESAR as aerodromes with typically a medium capacity utilisation, where simultaneous aircraft movement operations can be expected, frequently experiencing more than one aircraft movement simultaneously.

4.1. Single mode of operation

Single mode of operation is, in principle, envisaged to have the potential to be implemented for aerodromes of all sizes and conditions. Research (several so-called SESAR Solutions pertaining to the single mode of operation have been published[9]) as well as operational experience support the single mode of operation. The following sections list aspects to be considered for the implementation of single mode of operation.

4.1.1. Traffic volume/density and traffic complexity

The traffic volume/density as well as the traffic complexity — e.g. the characteristics and mix of aircraft (IFR/VFR, aircraft types, performance and equipage, etc.) and vehicle operations — are factors for consideration when implementing remote aerodrome ATS (as is the case when building/upgrading a conventional tower).

The traffic volume/density and traffic complexity will drive the requirements for the visual presentation and the need for enhanced binocular functionality, as well as for other technical

[7] This definition is derived from the SESAR JU programme publications related to remote aerodrome ATS. ICAO Annex 14 [10] defines aerodrome traffic density in a different manner and for different purposes. The definition contained in this document serves exclusively the purposes explained above.

[8] Ibid.

[9] Solution #71: ATC and AFIS service in a single low-density aerodrome from a remote CWP,
Solution #12: Single remote tower operations for medium traffic volumes,
Solution #13: Remotely provided air traffic service for contingency situations at aerodromes.

enablers. For each implementation, the safety assessment should consider the traffic volume/density as well as the traffic complexity related to the aerodrome when establishing the necessary functionalities of the system.

Validation results from the SESAR JU programme ([13], [14], [19], [28] & [30]) indicate that, in the context of low-density aerodromes, the basic features (as described by SESAR, see Appendix 4) are considered to be sufficient. For aerodromes where traffic volume/density exceeds the low-density characteristics (as described by SESAR), validation results indicate that the need for advanced features (as described by SESAR, see Appendix 4) may be increased. However, at the same time it is acknowledged that the quality of the visual presentation is crucial; with a high-quality visual presentation, the basic features (as described by SESAR, see Appendix 4) may still be sufficient.

Depending on the visual performance quality of the visual presentation, the basic features (as described by SESAR, see Appendix 4) may be sufficient for aerodromes where traffic exceeds the low-density or low-complexity characteristics. However, it is recommended that ATS providers consider using the advanced features (as described by SESAR, see Appendix 4), especially for medium-density aerodromes (as described by SESAR) and beyond. However, when implementing such features, caution should be taken with regard to the potential dependency on information intended to maintain or reach a certain level of situational awareness or capacity. Appropriate fall-back and degraded mode procedures should be developed to handle system degradations.

4.1.2. Characteristics of the aerodrome layout

The aerodrome layout is a factor for consideration when implementing remote aerodrome ATS (as is the case when building/upgrading a conventional tower).

The aerodrome layout will drive the requirements for the visual presentation and the binocular functionality and will affect the set-up of the camera installations, e.g. whether a single-camera tower (possibly complemented with visual 'hot spot/gap filler' cameras) or a distributed camera installation should be implemented (See Section 5.2 for further elaboration related to this topic). Also, larger multiple runway aerodromes may negate the need for more than one conventional tower as the aerodrome expands (by introducing cameras and their (visual) presentation into the conventional tower). For each implementation, the safety assessment should consider the characteristics of the aerodrome layout when establishing the necessary functionalities of the system.

The validation exercises conducted in the framework of the SESAR JU programme ([19], [21], [22], [28], [29], [30]) have so far mainly been conducted for aerodromes comprising non-complex layouts (mainly one runway, one to three runway entrances per runway[10], one to four aprons), but also for aerodromes comprising more complex aerodrome layouts (e.g. two runways and complex taxiway layout).

4.1.3. Aerodrome switching under single mode of operation

The single mode of operation also covers potential scenarios where the ATCO/AFISO switches service provision from one aerodrome to another aerodrome, without providing service to both (or more) at

[10] Although this context may appear to describe a complex aerodrome layout, it should be noted that a low number of runway entries/exits can in fact lead to more complex operations. For instance, in case of only one entry/exit per runway, the need for backtracking will increase, leading to longer runway occupancy times.

the same time. Switching of aerodromes should only be done when circumstances so allow, typically in conjunction with opening/closing of ATS (in accordance with the AIP/NOTAM published ATS hours of operation) for the aerodromes concerned.

The ATS provider should establish the procedures and conditions for switching to adequately manage the operational circumstances (e.g. 'when and how') for any such implemented scenario. All mechanisms implemented should be validated, approved by the competent authority as part of the change to the functional system and documented in the operations manual (as specified by Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.035 'Operations manuals').

Furthermore, related human factors considerations are detailed at the end of Section 6.3.1.

4.1.4. Remote tower as backup facility

The remote aerodrome ATS concept could be used to support the ATS contingency arrangements for an aerodrome, as stipulated by Regulation (EU) 2017/373 [2], ATM/ANS.OR.A.070 and ATS.OR.135. A remote tower could be used as a backup facility in case the conventional tower is not available, either for planned reasons such as maintenance, or for unplanned reasons such as emergency outages. The rationale would be ATS continuity with a high level of retained safety, capacity and flexibility during contingency situations.

It should be noted that, in reference to ICAO Annex 11 [9], Attachment C, point 2 referenced to in GM4 ATS.OR.135 to Regulation (EU) 2017/373 [2], any contingency arrangement is supposed to be temporary in nature, i.e. to be used only for limited time periods, until the ordinary services and facilities can be resumed. Meaning that a backup facility is not to be used as the principal means to provide the service unless properly demonstrated and approved by the competent authority.

When implementing a backup facility based on the remote aerodrome ATS concept, it is recommended to define the required level of human-machine interface (HMI) commonality with respect to the conventional tower. Similarity to the ATCO/AFISO workstations and support tools provided in the conventional tower would reduce both the ATCO/AFISO familiarisation time during the transition into contingency phase, as well as the need for recurrent contingency training. The use of new technical enablers should be carefully assessed. Although the introduction of such enablers has the potential to introduce operational benefits, this should be balanced against the disadvantages caused by introducing new tools and equipment which may not be available in the existing conventional tower, as well as by adding complexity to a backup facility (for which robustness would normally be a key factor).

With regard to the visual presentation of RTMs used as a backup facility for a conventional tower, it would be beneficial to maximise the similarities with the OTW view of the conventional tower. On the other hand, the placement of camera(s) feeding the visual surveillance system will need careful consideration. It would not be advisable to install them on the conventional tower structure, as their purpose is to be used during an event which may have impacted the structure and the electrical/data infrastructure of the conventional tower building.

Another important aspect to consider for a backup implementation is the split of infrastructure (such as for communication, uninterruptible power supply (UPS), etc.). Depending on the desired robustness of the backup solution and system, it is recommended to consider and reduce the number of common cause failures as far as practically possible. An appropriate level, depending on a local assessment, should be assessed and defined.

Lastly, it is recommended to define the requirements on traffic complexity (mix of aircraft and vehicles etc.), capacity and duration of service, and switchover time for the backup facility.

Contingency operations based on the remote aerodrome ATS concept have been studied in the framework of the SESAR JU programme ([15], [21], [22], [23], [24], [29]) and one related SESAR Solution has been published (see footnote 9 above).

4.2. Multiple mode of operation

SESAR JU has to date published one SESAR Solution related to the multiple mode of operation[11], with further research to expand the concept ongoing. Yet, at the time of publication of this document, no operational implementation of this concept exists, and subsequently operational experience is so far limited to validation and trial activities (performed within the SESAR JU framework as well as individually by ATS providers). Nevertheless, implementation plans comprising the multiple mode of operation exist among providers within the EASA Members States; EASA considers that there is already sufficient information and data available to provide support and guidance to facilitate its safe implementation, as well as to provide a basis for further development.

The overarching recommendation with regard to multiple mode of operation is that it is to be used only when the operational circumstances so allow and when certainty exists that workload and complexity can be managed. It is the responsibility of the ATS provider to define the suitable operational circumstances, which require careful considerations, as well as to provide sufficient evidence for an acceptable level of safety (as is always the case).

Some further aspects to consider for the implementation of multiple mode of operation are provided in the sections below. In addition, more detailed operational, procedural and technical considerations are outlined in Section 5.13 and change-management-related considerations are outlined throughout Chapter 6 (Section 6.2.1 for safety assessment considerations, Section 6.3 for human factors considerations and Section 6.6 for contingency planning/procedures considerations).

4.2.1. Number and size of aerodromes in multiple mode of operation

The number and size of aerodromes to be combined in multiple mode of operation need to be carefully assessed. Furthermore, not only the number of aerodromes, but also the selection of the appropriate combination of aerodromes considering operational aspects (such as traffic levels and complexity, type of ATS provided on each aerodrome (ATC or AFIS), approach control service provision, meteorological conditions across the aerodromes, geographical locations and the aerodromes' surrounding topography/terrain, runway orientations, etc.) should be thoroughly considered when providing ATS via the multiple mode of operation. Also, a suitable level of equipage to support the operations should be determined. The local safety assessment, taking traffic density, complexity and other local factors into account, should determine the suitable number and combination of simultaneous aerodromes (which may vary over time, depending on e.g. traffic distribution, weather, etc.).

[11] Solution #52: Remote tower for two low density aerodromes.

The results of the validation exercises performed so far (continued research is ongoing within SESAR 2020[12], see Section 4.2.6) in the framework of the SESAR JU programme ([16], [25]) show that the multiple mode of operation can be applied for the simultaneous provision of ATS to two low-density aerodromes (as described by SESAR) by a single ATCO/AFISO. The basic features (as described by SESAR, see Appendix 4) are deemed to be adequate for ATC service and AFIS provision at these low-density aerodromes, even though the level and flexibility of service provision can be improved through the use of advanced features (as described by SESAR, see Appendix 4). The required equipage would be dependent on e.g. traffic level and complexity (including mixture of aircraft and vehicles) as well as aerodrome layout and its complexity, rather than the provision of ATS to multiple aerodromes (as opposed to a single aerodrome). Similar to this, it can be noted that the SESAR validation results have revealed that the total traffic level and complexity generally have a greater impact on ATCO/AFISO workload than the number of aerodromes to which services are being provided.

4.2.2. Simultaneous aircraft movements on different aerodromes

The probability of instances of simultaneous aircraft movements on the different aerodromes, based on the expected traffic, as well as the impact thereof, should be carefully assessed and taken into account in the local safety assessment before implementing multiple mode of operation.

The management of traffic distribution between aerodromes in multiple mode of operation can be handled at different instances, as follows:

— Strategical: forecasting/pre-planning of traffic flows, planning of staffing and allocation of aerodromes across RTMs
— Pre-tactical: when flight plans are available, building a mental traffic sequence and acting if necessary, e.g. delaying traffic at its origin
— Tactical:
  - Normal ATCO working practices, based on existing procedures and own judgement (e.g. delaying start-ups or incoming traffic (by speed reductions, holdings, etc.), while a landing/take-off at the other is handled). It should be noted that AFISOs may not be entitled to use such procedures to the same extent. Although they cannot exercise control of traffic, AFISOs could, under specified circumstances, inform the airspace users of delays or undertake other actions via coordination with other/adjacent ATS units and/or the aerodrome operator/owner.
  - Opening additional operational positions (e.g. ground, air), splitting/merging of aerodromes across RTMs, or requesting the support of another ATCO/AFISO.

The ATS provider should establish procedures to manage capacity peaks or high ATCO/AFISO workload for any other reason, e.g. to address when and how to open an additional position in the RTM or when and how to split aerodromes into separate RTMs. All mechanisms implemented should be validated, approved (by the competent authority as part of the change to the functional system) and documented in the operations manual (as specified by Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.035 'Operations manuals'.

12 SESAR 2020 refers to the second part of the SESAR JU programme, which, building on SESAR 1 (running between 2008-2016), started at the end of 2016 and is planned to last until 2024.

***Note:** Guidance on handling of simultaneous aircraft movements at different aerodromes can be found in the SESAR report from the demonstrations/validations performed in Ireland, see reference [30].*

4.2.3. Aerodrome switching/merging/transferring/closing under multiple mode of operation

The multiple mode of operation may include scenarios where the ATCO/AFISO would change service provision between aerodromes on a flexible basis. This may include the following possibilities:

— switching: changing service provision for one (or several) aerodrome(s) to another aerodrome (e.g. if providing service to aerodromes A & B, change service provision to aerodromes A & C);

— merging: adding aerodromes to be provided with service (e.g. if providing service to aerodromes A & B, change service provision to aerodromes A, B & C); and

— closing or transferring service provision for one or several aerodromes (e.g. if providing service to aerodromes A, B & C, change service to aerodromes A & B).

This may also include the possibility of changing from a single mode of operation to a multiple mode of operation environment, or vice versa, by adding or closing/transferring aerodromes in the RTM (e.g. if providing service to aerodrome A, change service provision to aerodrome A & B, or vice versa).

Switching/merging/transferring/closing of aerodromes should only be done when circumstances so allow. The ATS provider should establish the related procedures and conditions to adequately manage the operational circumstances (e.g. 'when and how') for any such implemented scenario. All mechanisms implemented should be validated, approved by the competent authority as part of the change to the functional system and documented in the operations manual (as specified by Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.035 'Operations manuals'.

Furthermore, human factors considerations related to switching are detailed in the end of Section 6.3.1.

4.2.4. Service provision in multiple mode of operation

Regarding the type of ATS provision, what has been validated for multiple mode of operation is the combination of aerodromes where the same service type is provided (e.g. ATC+ATC or AFIS+AFIS). Hence, no known experience exists, and no related recommendations can be made at this point regarding mixed ATC and AFIS in multiple mode of operation.

4.2.5. Recommended implementation and transition steps

It is likely that multiple mode of operation will be implemented as part of an extension to an already existing single mode of operation implementation. This would facilitate the transition from a one-to-one operating method to a one-to-many operating method by first gaining operational experience of remote aerodrome ATS in a single mode of operation set-up. Therefore, such an approach is recommended. However, depending on the local safety assessment, this may not be a prerequisite for implementation.

4.2.6. Possible developments of multiple mode of operation

Even though, at the time of publication of this document, there is only one SESAR Solution published related to multiple mode of operation, future research and validation activities as well as development of technology may potentially extend the possible operational context of multiple mode of operation.

In this regard, it can be noted that validation activities comprising three simultaneous aerodromes have already been performed in SESAR 1[13] and that continued research, evaluating the multiple mode of operation concept beyond the scope of SESAR Solution #52, i.e. higher traffic volumes and increased number of simultaneous aerodromes, is within SESAR 2020[14]. The number of aerodromes to be simultaneously provided with ATS from one RTM will ultimately be dependent on a number of factors, such as traffic levels and how the traffic schedule at each aerodrome intersects with the others, meteorological conditions at the aerodromes, technical configuration, support functions, etc. (see Section 4.2.1). The foundation for such evolution will, however, be dependent on gained operational experience and trust.

4.3. Common aspects applicable to both single and multiple modes of operation

4.3.1. Airspace and traffic circuit characteristics

As for conventional tower operations, the airspace characteristics should be taken into consideration when implementing remote aerodrome ATS. This includes the airspace classification as well as traffic circuits, departure and arrival paths/sectors, VFR entry/exit points, VFR holding points, etc., as need be for the particular aerodrome.

4.3.2. Aerodrome environment

Since each aerodrome is unique and has its own characteristics regarding the surrounding topography, it is important to take into account the specific aspects that may affect the implementation of the concept, as would be the case also when implementing a new conventional tower at an aerodrome. Furthermore, natural phenomena and the local wildlife characteristics (e.g. the occurrence of animals/birds on and in the vicinity of the aerodrome) are also factors that should be considered for each aerodrome. In addition, the implementation of remote aerodrome ATS should consider and appropriately address the existence of environmental restrictions which could influence the operations of the subject aerodromes.

4.3.3. Local weather characteristics

Local weather/climate factors are other aspects to take into account when assessing the impact that the implementation of the concept may have on the aerodrome operations and/or ATS provision. The location of the aerodrome, such as proximity to sea/lake/river, altitude over (or under) mean sea level, proximity to mountains, etc. and the associated typical meteorological phenomena may affect the ATS provision.

For low-visibility conditions, the use of technical enablers, such as visual hot spot cameras, could be used to support situational awareness and local low-visibility procedures (as would also be a possibility for conventional tower operations).

[13] SESAR 1 refers to the first part of the SESAR JU programme, lasting from 2008 to 2016.

[14] SESAR 2020 refers to the second part of the SESAR JU programme, which, building on SESAR 1, was started at the end of 2016 and is planned to last until 2024.

4.3.4. ATCO's/AFISO's roles and responsibilities

The ATS provider should identify the particular configuration of the RTM and the related operating methods, taking into consideration the operational application and the particular needs of the aerodrome(s), in such a way that the ATCOs/AFISOs are enabled to fulfil their responsibilities as if the service would be provided from a conventional tower.

4.4. Remote tower centre operations

4.4.1. Supervision

When operating an RTC with more than one RTM, organisational and operational issues of more managerial nature may surface, similar to the ones in other larger operational units. In the same way that an ACC/approach/tower operational supervisor is responsible for the supervision of operations, a supervisor role could be introduced in the RTC in order to lead, supervise and assist the operations at the RTC.

The aim is that the supervisor can collaborate during planning, problem-solving and decision-making processes, leading to an optimum performance in the RTC.

The tasks of an RTC supervisor can include, for example:

— planning the allocation and combination of aerodromes and staff to modules in the RTC;

— monitoring the traffic and weather situations to anticipate any potential overload or underload;

— reallocating aerodromes and staff by opening/closing modules or splitting/merging aerodromes as necessary, particularly in case of unexpected situations (e.g. overload at an RTM, abnormal or unusual situation at an aerodrome, technical problem at an RTM, etc.).

— supporting RTM operators in case of unexpected situations;

— coordinating with the technical supervision in case of technical failure occurring at the RTC/RTM or at an aerodrome;

— coordinating with adjacent units supervisor(s), when necessary;

— coordinating in emergency situations with other stakeholders involved.

The supervisor – if employed – should have the appropriate training and certification to fulfill his or her duties in line with AMC1 ATM/ANS.OR.B.005(a)(6) to Regulation (EU) 2017/373 [2].

4.4.2. Holders of multiple endorsements

Whenever licence holders are authorised to hold concurrently more than one unit endorsement[15] or its equivalent for AFISOs, a roster should be set up to allow for the regular exercise of the privileges. Particular attention should be paid to the definition of the number of unit endorsements that ATCOs working at the same RTC should concurrently hold and maintain. This should be determined on the basis of a thorough safety assessment as well as on the need to comply with applicable requirements (e.g. the minimum hours for the maintenance of the unit endorsement for each aerodrome concerned). Based on the information gathered from the implementation feedback and from

[15] According to AMC1 ATCO.B.020(a) to Regulation (EU) 2015/340 [3], each aerodrome for which aerodrome ATC service is provided from an RTC, should constitute its own unit endorsement.

discussions with stakeholders, current experience indicates that three concurrent unit endorsements can be held and maintained safely, in compliance with applicable requirements.

When defining the minimum hours of exercising the privileges in the context of the competence scheme, the holders of more than one unit aerodrome endorsement should not be treated differently unless the level of harmonisation of equipment and/or ATM procedures between RTMs is considered mitigating. A minimum number of hours should be retained for each unit endorsement individually and a number of hours for the overall RTM exercises as well.

Equipment may facilitate the logging of the required hours.

5. Operational and system considerations

This chapter addresses procedural considerations, operational needs and requirements, as well as related system and equipment aspects, to be considered for the implementation of remote aerodrome ATS.

ATCO/AFISO confidence and trust in the system is of vital importance for the implementation of remote aerodrome ATS. The human factors assessment (see Section 6.3) as well as an assessment of social aspects is fundamental to build this confidence and trust.

5.1. Remote aerodrome ATS procedural considerations

This section details recommendations on procedures related to remote aerodrome ATS. Some of these recommendations are of a general nature, whereas some are specifically related to operations from an RTC.

— All formal interfaces with all stakeholders (as specified by Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.005(f)) and contracted activities (as specified by Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.015) should be re-evaluated to include items that are unique to remote aerodrome ATS, especially with regard to the communication between the remote ATS unit and the aerodrome. Such formal interfaces should be documented in local agreements. The need for coordination between the ATS unit and the respective aerodrome — and related aspects — is specifically covered in Chapter 7.

— There might be cases where the ATS provider performs tasks which fall under the responsibility of the aerodrome operator. In case such tasks are to be continued to be performed by the ATS provider, following the introduction of remote aerodrome ATS, specific agreements between the ATS unit and the aerodrome operator should be in place[16]. Particular considerations regarding these tasks and contingency procedures should be included in the service level agreement / contract between ATS provider and aerodrome operator to achieve adequate redundancy measures in case of partial or single or multiple failures at the RTC.

— Before initiating service provision, or before assuming responsibility for service provision, the ATCO/AFISO should be able to verify the status of the aerodrome (in terms of traffic, weather situation, etc.) and its related systems and a coordination and transfer of control of operational systems should take place when needed.

— In today's conventional tower operations, operating methods and procedures can sometimes differ between aerodromes due to local variations and practices. When providing service to several aerodromes from an RTC, there may be an opportunity to streamline and unify the operating methods and procedures for the aerodromes connected to the same RTC.

— In today's conventional tower operations there is often a lack of standardisation of systems and equipment between different aerodromes. ATCO/AFISO workstations and HMI are often different from one conventional tower to another. In order to support flexibility within an RTC regarding aerodrome and RTM allocation as well as to reduce ATCO/AFISO training needs and to contribute to the overall improvement of uniformity of ATM services — when providing

[16] For further details, see Chapter 7.

service to several aerodromes from an RTC — it is recommended to unify the RTMs within the RTC in terms of HMI and equipment to the extent possible taking into account the different aerodromes to which services are provided.

— When providing service to several aerodromes from an RTC, to support the flexibility of staff and RTM allocation between aerodromes, it is recommended that the RTC enables the transfer of responsibility of ATS for aerodromes between the RTMs within the RTC. If implemented, appropriate procedures for the transferring/merging/splitting of aerodromes between RTMs should be developed and documented. If the transferring/merging/splitting of aerodromes between RTMs is performed during ATS hours of operation, service provision should be uninterrupted.

— When service can be provided to one aerodrome from different locations (RTC, conventional tower, stand-alone RTM), appropriate procedures for the transferring and assuming of responsibility of ATS between these locations should be developed and documented. Regulation (EU) 2017/373 [2] ATS.TR.225 'Responsibility for control' applies. If the transfer of responsibility is performed during ATS hours of operation, service provision should be uninterrupted.

5.2. Visual surveillance system

A visual surveillance system constitutes the core element of remote provision of ATS to aerodromes and typically consists of two main operational parts: the 'visual presentation' replacing the OTW view of a conventional tower and the 'binocular functionality' emulating traditional binoculars, both further described below. A visual surveillance system includes a number of integrated elements, including sensors, data transmission links, data processing systems and situation displays.

Regardless of the technical solution/design, it is crucial that the visual surveillance system fulfils the regulatory requirements and the operational needs that exist on the service provision. These regulatory requirements and operational needs as well as some functional requirements/considerations are described and discussed in Sections 5.2.3, 5.2.4, 5.2.5 and 5.2.7 below. It is acknowledged that the human vision sensing system is very sophisticated and that it may not be feasible to precisely replicate the ATCO/AFISO visual performance that could be obtained via direct OTW visual observation[17].

Note: The visual performance obtained by the means of a visual surveillance system may in some circumstances and to some extent improve the OTW visual observation.

Fully replicating the visual performance obtained via direct OTW visual observation is also not key to the implementation of remote aerodrome ATS. Instead, it is fundamental to define operational visual performance requirements — corresponding to the specific operational context — and ensuring that they can be supported by the visual surveillance system. A process for the definition and the

[17] In this context, it is worth to note that sometimes there is a misconception concerning depth perception and the ability to judge distances in the context of (remote) aerodrome ATS. Human depth perception based on eye distance is effective only at near distances (typically up to 6 metres). At longer distances, depth perception is based on references such as relative size, location of objects used as references, motion, etc. Hence, depth perception based on eye distance is not relevant for the provision of aerodrome ATS. The ability for depth perception and distance judgement is therefore not affected by providing aerodrome ATS based on a visual presentation view instead of the OTW view from a conventional tower.

verification of requirements is described in the EUROCAE 'ED-240A Change 1' MASPS document [12]. Based on the discussion in Sections 5.2.3, 5.2.4 and 5.2.5 below, the ATS provider may use the process described by 'ED-240A Change 1', or equivalent, to define the local operational visual performance requirements (termed 'Area-of-Interest and Object-of Interest Requirements' (AOREQ) and 'Tracking-of-Interest Requirements' (ToIREQ) by ED-240A Change 1). An extensive work to define a set of baseline operational visual performance requirements has been performed in the framework of the SESAR JU programme. As a support to remote aerodrome implementers, these requirements are presented in Appendix 5. They can be seen as example requirements and may be used by an ATS provider/implementer as a starting point when defining their own local operational visual requirements, tailored to the specific operational needs and the specific operational context of the particular implementation.

It is recommended that the visual surveillance system is operationally validated against the perceived total image quality, and not only against individual system parameters. The general operator's acceptance process described in EUROCAE 'ED-240A Change 1' MASPS document serves as the first verification of the performance of the visual surveillance system under reference (i.e. optimal) conditions. However, it is furthermore recommended that the performance of the visual surveillance system is operationally validated in various visual conditions (e.g. dawn, daylight, dusk, darkness and different visibility conditions), not only as a variation in time but also as a variation in the presented view of the aerodrome and its vicinity at one point in time — as light conditions are likely to differ across the view. It may be beneficial to apply a 'scenario/use case' approach when both defining and validating operational visual performance requirements. For instance, a scenario could be: '**Detect** an aircraft of a certain type/size at 5 NM final, **recognise** the aircraft at some stage to be able to give a landing clearance, be able to see/follow the aircraft during its complete landing from detection to landing, roll-out, taxiing off the runway and until taxiing to apron (leaving the manoeuvring area)'. Adopting such validation approach will help to understand the operational benefits and shortcomings of a specific implementation case. If shortcomings are identified, they could be managed either by improving the technical system or by implementing appropriate operational procedures and mitigation means.

It is assumed that the visual surveillance system is primarily based on a visible spectrum camera/sensor solution where cameras capture the image at the aerodrome and the image is relayed to the ATCO's/AFISO's screens, possibly enhanced by cameras/sensors from the non-visible spectrum, such as thermal, infrared etc.

As regards differentiation between ATC and AFIS provision with respect to visual surveillance systems, no significant differences affecting the implementation of remote aerodrome ATS at a certain aerodrome have been identified. Instead, it is rather the traffic volume/density and operational complexity (as opposed to the type of service, ATC/AFIS, provided) that should be considered when defining the exact operational and functional/technical requirements on the visual presentation and the binocular functionality.

For recommendations related to interoperability, integrity and system availability regarding a visual surveillance system, refer to EUROCAE ED-240A Change 1 [12].

5.2.1. Visual presentation

The visual presentation replaces the OTW view of a conventional tower, with the purpose of providing a view of the aerodrome and its vicinity (i.e. area of responsibility). It may take different forms and designs depending on the specific technical solution.

A common design used for implementation to date comprises a display that presents a wide field-of-view image (similar to the OTW view obtained from a conventional tower) derived from a central location on the aerodrome, typically a 'camera tower' comprising one or several cameras. This design is commonly known as a 'panorama' or 'panoramic' view. The 'panorama'/'panoramic' view may also be supported by additional 'hot spot/gap filler' cameras (i.e. cameras situated in other locations around the aerodrome), as need be.

Another design that has emerged is the so-called video wall view, where several sensors from various locations around the aerodrome are presented/stitched together in a combined view, hence presenting different view images from different locations around the aerodrome in a combined manner on this video wall. This set-up using a distributed camera system may e.g. be fit for use at larger multiple runway aerodromes, to support situational awareness also when distances are large.

5.2.2. Binocular functionality

The binocular functionality (e.g. a Pan-Tilt-Zoom camera/function, as defined and described in ED-240A Change 1 [12]) emulates the function of a binocular in a conventional tower, by allowing the ATCO/AFISO to have a close-up view of a specific location or object. As such, it fulfils the part of ICAO Doc 9426 ATS Planning Manual [8] (PART III, Section 2, Chapter 2 'Specific Requirements for an Aerodrome Control Tower') that lists binoculars as recommended equipment in an aerodrome control tower.

This functionality is considered additional to the overall visual presentation, enabling the ATCO/AFISO whenever necessary to look at certain objects/occurrences in the area of interest more closely (e.g. engine on fire, landing gear extended, RWY condition/objects on RWY, etc.). The view from the binocular functionality may be presented within the visual presentation display (e.g. as 'picture-in-picture') or on separate screens/displays.

5.2.3. Primary/direct regulatory requirements affecting a visual surveillance system

Point (b) of AMC1 ATS.TR.205(c) to Regulation (EU) 2017/373 [2] states that:

'(b) Control of all flight operations on and in the vicinity of an aerodrome, as well as of vehicles and personnel on the manoeuvring area, should be continuously maintained by:

(1) visual observation, which can be achieved directly by out-of-the-window observation or through the use of a visual surveillance system; and

(2) an ATS surveillance system where available, in accordance with ATS.TR.245.'

In addition, Part III, Section 2, Chapter 2.1.1 a) of ICAO Doc 9426 (ATS Planning Manual) [8] states that 'the tower must permit the controller to survey those portions of the aerodrome and its vicinity over which he exercises control'.

At the same time, Chapter 2.1.2 of ICAO Doc 9426 (ATS Planning Manual) [8] states: '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 aerodrome, provided that at the intended height, the tower structure itself does not become an obstruction or hazard to flight.' and Chapter 2.1.3 states that 'The height of the tower should be such that the controller is provided with the visual surveillance previously described. The higher the tower, the more easily this optimum surveillance is attained, but at greater financial cost and with a greater likelihood of penetrating the obstacle limitation surfaces.' As these guidelines provided by ICAO Doc 9426 [8] may be valid in the case of a single centrally located camera tower installation at an aerodrome, they may on the other hand not be relevant in the case of a visual surveillance system comprising several camera installations on various locations around the aerodrome.

This promotes understanding of the overarching regulatory requirements directly affecting the visual surveillance system and can be formulated as follows:

The visual surveillance system — subject to the visibility conditions at the aerodrome and its vicinity as well as the topography of the surrounding terrain and tailored to the ATCO/AFISO roles — **should enable the ATCO/AFISO to survey those portions of the aerodrome and its vicinity over which they exercise ATS and should enable them within their area of responsibility, to see:**

— **flight operations (aircraft[18]) in the vicinity of the aerodrome[19];**

— **flight operations (aircraft[18]) on the aerodrome;**

— **vehicles and personnel on the manoeuvring area[20].**

***Note:** Different tasks performed by ATCO/AFISO (e.g. ground, air, apron management (if applicable)) may affect the area of interest; therefore thorough consideration should be given to the tailoring of the visual presentation in support of each specific task.*

The above should be seen as applicable in both daylight and darkness conditions (subject to the hours of operation of the ATS unit); however, during darkness it is acknowledged that it may be difficult to see objects without their own light source.

5.2.4. Indirect regulatory requirements affecting a visual surveillance system

In addition to the above-mentioned primary/direct regulatory requirements, there are some regulatory requirements on the service provision that may be indirectly applicable to the visual surveillance system. For conventional tower operations, they are fulfilled as per the principle 'you see what you see'[21]. However, for the remote aerodrome ATS context, these requirements need to be considered. This section lists such relevant provisions of Regulation (EU) 2017/373 [2] and ICAO Doc 9426 [8]. It is important to note that Regulation (EU) 2017/373 [2] and ICAO Doc 9426 [8] only address aerodrome ATC service in details, and not AFIS. However, this guidance extends the association of the

18 'Aircraft' is defined in Annex I to Regulation (EU) 2017/373 [2] as 'Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface'.

19 A description of the term 'aircraft operating in the vicinity of an aerodrome' is provided with the definition of 'aerodrome traffic' included in Regulation (EU) No 923/2012 [4] as 'includes but is not limited to aircraft entering or leaving an aerodrome traffic circuit'.

20 The manoeuvring area is defined in Regulation (EU) No 923/2012 [4] as 'that part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons'.

21 According to Class 3 ATCO medical requirements (see Regulation (EU) 2015/340 [3]).

relevant provisions to AFIS as well, where appropriate, and not in contradiction with the objectives and the principles of Flight Information Services.

Point (a) of AMC1 ATS.TR.305(a)(7) to Regulation (EU) 2017/373 [2] states: 'Whenever an abnormal configuration or condition of an aircraft, including conditions such as landing gear not extended or only partly extended, or unusual smoke emissions from any part of the aircraft, is observed by or reported to the aerodrome air traffic controller or the AFIS officer, the aircraft concerned should be advised without delay.' Also, Regulation (EU) 2017/373 [2], ATS.TR.400 details the aerodrome control tower's responsibility and the circumstances for when to alert rescue and firefighting services. Hence, it should be considered, as part of the local safety assessment, whether the visual surveillance system needs to enable the ATCO/AFISO to visually detect and recognise aircraft abnormal configurations or conditions, such as landing gear not or only partly extended or unusual smoke emissions from any part of the aircraft. As the Regulation states that this could likewise be reported to the aerodrome controller, this needs to be defined at the local implementation level.

Point (a) of AMC1 ATS.TR.205(c) to Regulation (EU) 2017/373 [2] states: 'Aerodrome control towers should issue information, instructions and clearances to aircraft under their control to achieve a safe, orderly and expeditious flow of air traffic on and in the vicinity of an aerodrome with the objective of preventing collision(s) between: (…) (5) aircraft on the manoeuvring area and obstructions on that area.'

Although the Regulation does not explicitly state that an ATCO needs to visually see/detect obstructions (the existence of an obstruction could likewise be reported to the ATCO/AFISO), there is an expectation on the service that obstructions (of a certain size, up to a certain distance and subject to the visibility and daylight conditions) can be visually observed/detected by the ATCO/AFISO. Therefore, as part of the local implementation and safety assessment, it should be considered whether and to what extent the visual surveillance system needs to enable the ATCO/AFISO to visually detect and recognise obstructions on the manoeuvring area. Local operational requirements should be defined, taking into account size and distance of obstructions, as well as under which daylight and meteorological conditions the requirements are to be valid.

As concerns obstructions, GM1 to AMC16 ATS.TR.210(a)(3) to Regulation (EU) 2017/373 [2] states: 'Animals and flocks of birds may constitute an obstruction with regard to runway operations.', and point (b) of GM1 to AMC1 ATS.TR.305(a)(5) to Regulation (EU) 2017/373 [2] states: 'Essential information on aerodrome conditions shall include information relating to the following: (…) (5) other temporary hazards, including parked aircraft and birds on the ground or in the air;'.

Note: *The SESAR JU validations has shown 'visual tracking' (refer to Section 5.2.8) to be a useful tool to support the detection of the occurrence of birds/flocks of birds.*

Point (b) of AMC12 ATS.TR.210(a)(3) to Regulation (EU) 2017/373 [2] states: 'Prior to take-off, the aerodrome control tower should advise aircraft of: (…) **(2) significant meteorological conditions**[22] in the take-off and climb-out area, except when it is known that the information has already been received by the aircraft.' Therefore, it should be considered whether the visual surveillance system

[22] GM1 to AMC12 ATS.TR.210(a)(3) to Regulation (EU) 2017/373 [2] states 'Significant meteorological conditions include the occurrence or expected occurrence of cumulonimbus or thunderstorm, moderate or severe turbulence, wind shear, hail, moderate or severe icing, severe squall line, freezing precipitation, severe mountain waves, sandstorm, dust storm, blowing snow, tornado or waterspout in the take-off and climb-out area.'

needs to enable the ATCO/AFISO to visually observe some significant meteorological conditions in the take-off and climb-out area (subject the type of and distance to the significant weather, the daylight/darkness conditions as well as the meteorological visibility).

Although the responsibility for the monitoring of the condition of the movement area and reporting on matters of operational significance to the ATS provider lies with the aerodrome operator (ADR.OPS.B.015 of Regulation (EU) No 139/2014 [5]), the ATS provider may want to consider whether and to what extent the visual surveillance system should support the ATCO/AFISO to visually observe/detect runway surface states and their changes, such as those conditions listed in points (b)(2) to (b)(5) of GM1 to AMC1 ATS.TR.305(a)(5) to Regulation (EU) 2017/373 [2].

Paragraph 1.4 of Appendix 1 to AMC1 SERA.14001 to Regulation (EU) No 923/2012 [4] 'Phraseologies for use on and in the vicinity of the aerodrome' defines the following means of visual communication with aircraft:

— showing landing lights as a possible means for 'identification of aircraft' (1.4.1);

— moving ailerons (or rudder), rocking wings or flashing landing lights as a possible means for 'acknowledgement by visual means' (1.4.2).

As a consequence, the implementation of remote provision of aerodrome ATS should consider, as part of the local safety assessment, whether and to what extent these indirect regulatory requirements should form operational requirements driving the technical requirements for the implementation. As for a conventional tower, the fulfilment of such requirements will be dependent on the distance from the aircraft and on meteorological and daylight/darkness conditions.

5.2.5. Other operational needs affecting a visual surveillance system

In case the ATS unit is also responsible for the provision of apron management services, refer to Section 7.2.6. Even if the ATS unit is **not** providing apron management services, there could be an operational need/benefit for the ATCO(s)/AFISO(s) to have access to a view of the apron(s).

Furthermore, as recommended by laid down in CS ADR-DSN.G.380 to Regulation (EU) No 139/2014 [5], any remote (i.e. located at specified remote areas along the taxiway leading to the runway meant for take-off) de-icing/anti-icing facility should be visible from the air traffic control tower, i.e. this should be supported by the visual surveillance system.

Although not explicitly stated in regulations, there would be an expectation on the service provision that the ATCO/AFISO should be able to observe and follow up on changes in weather conditions (e.g. precipitation, showers, fog patches, clouds and the build-up of cumulonimbus) or weather occurrences (e.g. flooding, snowbanks) as would be feasible from a conventional tower. Therefore, the ATS provider should consider, as part of the local implementation and safety assessment, whether and to what extent the visual surveillance system should support the ATCO/AFISO to observe such weather condition observations.

5.2.6. Camera siting aspects

The determination of the number of cameras to be used, the locations and the height at which they are to be installed, in order to meet the regulatory requirements and the operational needs described above, may be influenced by parameters such as:

— dimensions of the aerodrome;

— design characteristics and complexity of the aerodrome layout;

— location of the communication, navigation and surveillance equipment (both existing and planned) to prevent any potential interference;

— types of activities and operations that take place at the aerodrome;

— prevailing weather phenomena;

— functionalities and capabilities of the cameras employed;

— existing buildings and constructions (e.g. terminal buildings);

— existing conventional tower (if any);

— desired line of sight and angle of incidence;

— considerations of obstacle limitation surfaces and avoidance of creation of new obstacles;

— direct or indirect sun glare;

— lighting glare at night;

— external light sources;

— ease of access for maintenance purposes; and

— aeronautical easements.

A dedicated, comprehensive and coordinated assessment should be conducted by the ATS provider and the aerodrome operator in order to demonstrate that the number, location, height and characteristics of the cameras fulfil all the objectives for each individual case.

For related information regarding the camera siting aspect, see also Section 7.1.4.

5.2.7. Functional considerations for a visual surveillance system

In addition to the regulatory requirements and the operational needs described above, factors related more directly to system performance should be considered when moving to a ‘remote’ environment, as they will affect the performance of the visual surveillance system and subsequently also the operational capabilities of the ATS unit.

The performance and usability of the visual surveillance system is a complex combination of many such system performance factors. Some of them found to be particularly critical for the ATCO/AFISO ability to perform the ATS are discussed below, but as indicated under Section 5.2.7.6 ‘Other image quality factors’, they are not the only which may be affecting remote aerodrome ATS provision. Because of this complexity, as already mentioned under Section 5.2, it is essential that the visual surveillance system is operationally validated against the perceived total image quality, rather than against specific image quality factors.

5.2.7.1 Visual presentation set-up and layout

The visual presentation should be designed to avoid unnecessary discontinuities or non-uniformities of the presented view. Existing discontinuities and non-uniformities should be clearly indicated so as to avoid misleading impressions of the observed area. For the case of seams/joints in the visual presentation, they should, as far as possible, be avoided at operational 'hot spot' areas such as holding positions, runway entrance/exits, etc. When this would not be achievable, mitigation measures should be considered, such as a hot spot camera providing an unobscured/unbroken view (or a predefined 'quick access' position for the binocular functionality).

This recommendation can be seen as related to the guidelines provided in Chapter 2.1.4 of ICAO Doc 9426 [8], stating: 'Vertical supports for the cab roof should be kept to the smallest feasible diameter so as to minimize their obstruction of the controller's view. The supports should also be as few as possible…'. A difference with regard to the 'vertical supports for the cab roof' of a conventional tower compared to the frames/joints between cameras/screens in a visual presentation, is that the vertical supports are actually blocking the view, whereas the frames/joints in a visual presentation are probably not blocking any part of the view, but rather just separating the images. Even so, it is recommended to minimise the number of seams/joints (e.g. between screens) in the visual presentation, and if existing, to keep them to the smallest feasible width (e.g. by using screens with narrow frames/borders).

Also, the risk of potential loss of information between images (e.g. when combining images from different sensors) should be thoroughly assessed as part of the implementation, and if such information loss can be detected, appropriate mitigation means should be introduced. A factor to take into account in this regard is the natural system degradation that may occur over time. For instance, even if there is no occurrence of information loss when the system is new and recently installed, weather and natural wear may affect the equipment and its configuration, resulting in a potential loss of information over time. If this is regarded as a potential risk factor for a particular implementation case, it is recommended that regular checks are introduced as part of the overall maintenance programme.

In case a partial or full loss of visual presentation is expected to be mitigated utilising the binocular functionality, see considerations in the second to last paragraph in Section 5.2.7.2 below.

5.2.7.2 Binocular-functionality-related functional requirements

The binocular functionality should be simple, quick, and easy to use, not considerably increasing the time needed to perform the same/similar tasks as when performed with manually operated binoculars in a conventional tower. As a recommended minimum, the binocular functionality should include a fixed optical magnification feature with a visual indication of the direction of bore sight, but may also include a moveable/adjustable optical zoom feature.

In order to increase its usability, the binocular functionality may also include functionalities such as:

— predefined and user-definable positions (automatic functions including zoom, pan-and-tilt and focus) enabling the ATCO/AFISO to quickly jump to frequently recurring areas of interest (e.g. waypoints, thresholds, etc.);

— predefined and user-definable automatic scanning patterns, such as runway sweeps (including the option to pause or stop the scan to be able to check detected objects), supporting the ATCO/AFISO to perform tasks such as scanning the runway;

— automatic following of moving objects (e.g. aircraft, vehicles, personnel, animals), assisting the ATCO/AFISO to follow relevant moving objects of interest (commonly referred to as 'PTZ tracking');

__Note:__ Technical standards/recommendations related to binocular functionality automatic following of moving objects (termed 'PTZ object following' within ED-240A Change 1) are contained in EUROCAE ED-240A Change 1 [12].

— optical sensor(s) from the non-visual spectrum, such as infrared.

When the RTM comprises several separate roles/workstations (typically for larger aerodromes), the use of independent binocular functionalities and their independent presentation for each role/workstation should be considered (to avoid distraction amongst the ATCOs/AFISOs). In the case that more than one independent PTZ is available, operational, technical and human factors related to the assignment, transfer and locking of each PTZ should be assessed.

If the binocular functionality is planned to be utilised as a mitigation means for (partial or full) loss of visual presentation, this added dependency should be accounted for when developing availability requirements on the binocular functionality.

For recommended requirements on control latency and camera movement speed performances, refer to EUROCAE ED-240A Change 1 [12] (PTZ REQ 1 to 5)].

5.2.7.3 Video latency

One critical parameter is the time delay between the occurrence of an event in the real world and its presentation to the ATCO/AFISO on the visual presentation/binocular functionality, referred to as video latency**.** The maximum allowable video latency, including its variation in time, should be determined by the local safety assessment, with the aim of not negatively affecting the ATCO's/AFISO's ability to safely provide ATS. It is recommended that this value is as low and constant as possible, as long delays will undoubtedly negatively affect the ATCO's/AFISO's situational awareness, with a direct safety impact. The exact figure should be derived from operational needs, taking into account the local conditions of the operational context.

Recommendations for maximum video latency are presented in the notes below; however, subject to the outcome of the local safety assessment and the acceptance by the competent authority, an alternative maximum video latency may be applied.

__Note:__ EUROCAE ED-240A Change 1 [12] (VC REQ 01) stipulates a maximum video latency of 1 second, as this 'is related to existing ground surveillance sensor standards and is considered as reasonable in a Remote Tower environment'.

__Note:__ Validation activities performed in the framework of SESAR JU programme have indicated a recommended maximum video latency of 1 second (refer to SESAR OSED [17] (REQ-06.09.03-OSED-VC03.1105) & SESAR Technical Specification [18] (REQ-12.04.07-TS-0110.0007)); however, this should be seen in the context of the specific conditions (operational and technical) that were validated and hence may not be universally fit for purpose.

5.2.7.4 Video update rate

The fidelity of the image presented to the ATCO/AFISO also depends on the video update rate (also known as 'frame rate'), defined as the number of times per second the video is updated. The video update rate primarily affects the following operational aspects of the presented image:

— the appearance of moving objects (such as aircraft or vehicles), i.e. if a smooth and regular impression to the human eye is provided;

— the capability to perceive and monitor flashing/rotating objects (such as runway guard lights (RGL), aircraft strobe lights, emergency vehicle lights or rotating propellers/rotors); and

— the ability to perceive acceleration/deceleration/direction changes (i.e. turns) of moving objects.

The appropriate video update rate, including its variation in time, should be determined by the local safety assessment, taking into account the operational context, in order to ensure an adequate presentation of moving objects to the ATCO/AFISO, as well as an adequate presentation of flashing/rotating objects, e.g. flashing lights.

It is acknowledged that defining a recommended video update rate is complex due to the capabilities and nature of the human eye, the influence of motion blur and due to inherent dependency of many system parameters (e.g. jitter, contrast, video compression, bandwidth and codex). It is further acknowledged that the video update will likely be a compromise against image resolution in order to optimise bandwidth consumption; where the image resolution will influence the capability to detect and recognise objects, the video update rate will influence the factors listed above (appearance of moving objects, ability to perceive acceleration/deceleration/direction changes of moving objects, capability to perceive and monitor flashing/rotating objects). The video update rate is therefore recommended to be evaluated and defined for each implementation, taking into account the specificities of the local operational needs and conditions.

Note: *For further considerations related to video update rate, refer to EUROCAE ED-240A Change 1 [12] (Section 4.2.2).*

Note: *Recommendations on minimum video update rates can be found in SESAR publications [16] (REQ-06.09.03-OSED-VC03.1104) & [17]] (REQ-12.04.07-TS-0110.0006). Further to this, an empirical study published in 2018 on video update rate [33] is publicly available.*

5.2.7.5 Difference in daylight/darkness perception

A visual surveillance system, including the camera sensors and display units, can produce an image that may result in the user having a different perception and capability to see objects/weather in varying light conditions. As part of the implementation and validation of the visual surveillance system, it will be necessary to understand the performance and any limitations of how the cameras perform in differing light conditions and will require the configuration to be optimised for the environment and tasks required.

Validation activities have shown that the presented image in some technical platforms may appear brighter compared to the real-world conditions during dusk and dawn, prolonging the experience of daylight and enabling the ATCO/AFISO to see occurrences which are not possible to be seen in real life due to darkness conditions.

Although this can be considered as a benefit from the situational awareness perspective, it could also pose new operational risks. It may be difficult for the ATCO/AFISO to judge when darkness has occurred, potentially leading to incorrect service provision or incorrect selection of airfield lighting.

Equally, the image in true darkness may be optimised for a less noisy image to compensate for artificial light, but this could mean that meteorological elements may be harder to detect.

The understanding of these differences should be part of the SAT test, the local safety assessment and conversion training; therefore, where appropriate, technical or procedural mitigations should be put in place. Technical improvements may include the provision of sunrise/sunset times and separate camera configurations that allow a user to view areas easier under certain light conditions.

5.2.7.6 Other image quality factors

In addition to the aforementioned factors, there are also other image quality factors which could affect the quality of the visual surveillance system, potentially impacting the ATCO/AFISO ability to effectively provide ATS. A non-exhaustive list includes sensor resolution, display resolution, image uniformity, sharpness, contrast, colour depth, video compression, bandwidth and network related issues, etc. For a further elaborated description of such aspects, refer to EUROCAE ED-240A Change 1 [12].

5.2.7.7 Protection against natural external influences

Local weather and climate conditions at the aerodrome where the services are provided, lighting conditions, animal interference on cameras/sensors (e.g. insects, birds), etc. may affect and degrade the performance of the visual presentation and the binocular functionality. In order to avoid negative effects on the ATCO's/AFISO's ability to provide the ATS, the visual surveillance system should include (as applicable, depending on the selected technical solution) means to reduce the impact caused by animals (e.g. insects, birds), variable light conditions across the field of view, counter-light effects (e.g. glare from direct sunlight/low standing sun), precipitation (e.g. rain, snow, hail), condensation, icing, winds, or any other weather phenomena as applicable to the local conditions at the aerodrome.

In case the means of technical protection against the impact of external influences (e.g. bird droppings, precipitation, condensation, dust/dirt build up, etc.) are not sufficient, maintenance procedures should be set up as to ensure that camera installations can be cleaned regularly and on short notice, as needed for service provision.

5.2.7.8 Failure detection

In order to fulfil Regulation (EU) 2017/373 [2], ATS.OR.140 'Failure or irregularity of systems and equipment' as well as ICAO Doc 4444 [7] Chapter 7.1.3[23] 'Failure or irregularity of aids and equipment', the remote tower system should enable the ATCO/AFISO to detect any failure or irregularity which could adversely affect the safety or efficiency of flight operations and/or the provision of ATS, such as corrupt, delayed (beyond the defined maximum latency value) or frozen image of the visual surveillance system.

Note: *Technical standards for maximum video failure notification time can be found in EUROCAE ED-240A Change 1 [12] (VC REQ 4).*

5.2.8. Technical enablers for increased situational awareness

The visual presentation may include tools and functionalities aiming at increasing the ATCO/AFISO situational awareness and enabling the ATCO/AFISO to increase the time spent on 'looking out the windows', i.e. scanning the area of responsibility.

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[23] ICAO Doc 4444 [7] Chapter 7.1.3 has not been transposed into the EU regulatory framework.

Such tools/functionalities could typically consist of two different types/categories:

— Additional sensors at the aerodrome (and presented to the ATCO/AFISO), that may improve the visual range:

  - Additional visual 'hot spot/gap filler' cameras, enabling the ATCO/AFISO to get a closer view of specific areas of interest as well as improving visual range in low-visibility conditions – covering distant or obscured parts of the aerodrome or particularly operational critical areas such as holding points for determination of runway clearance.

  - Optical cameras of the non-visible spectrum, such as thermal or infrared, improving visibility primarily during hours of darkness.

— Digitally overlaid information in the visual presentation, such as:

  - Overlaid symbols and/or labels associated with and highlighting objects capable of movement and relevant for the service provision, such as aircraft, vehicles, personnel, obstructions or animals/birds on the manoeuvring area and in the vicinity of the aerodrome. Objects not relevant for the service provision would include e.g. vehicles outside the aerodrome premises. Such symbols and labels can be based on:

    o information from optical sensors, i.e. system detection of moving objects by image processing techniques (including also non-cooperative targets) in the visual field of view (commonly referred to as **'visual tracking'**);

      Note: *Technical standards/recommendations related to 'visual tracking' are contained in EUROCAE ED-240A Change 1 [12].*

    o information from ATS surveillance systems/sensors e.g. ADS-B, PSR, SSR, A-SMGCS, targeting primarily cooperative targets (commonly referred to as **'radar tracking'**); AMC1 ATS.TR.155(a) to Regulation (EU) 2017/373 [2] applies;

    o or a combination of the two above.

  - Overlaid framings/symbols to indicate/highlight specific parts of the aerodrome, such as framing of runways, taxiways etc. in order to enhance the ATCO/AFISO situational awareness, especially in darkness and during low-visibility conditions.

  - Overlaid added information relevant to the service provision. Instances of element classes may include:

    o geographic: cardinal/compass directions;

    o meteorological: e.g. wind direction and speed (e.g. instant, 2 min average, 10 min average), QNH, temperature, visibility (e.g. RVR values), object markings to support distance judgement, MET REPORT, METAR, TAF;

    o operational/AIP- and service-related: runway/taxiway/apron designators, visual reminders such as 'RWY blocked' markings to aid with runway incursion prevention, aerodrome assets/systems status such as lighting, clock, checklists, aeronautical information (NOTAM, SNOWTAM, etc.), other operational information (e.g. RCR, RWYCC, etc.).

- System support using a video data processing system to help the ATCO/AFISO detect smaller FOD, highlighting the existence of such small objects in the visual presentation to attract attention (objects which else would be difficult to detect).

5.2.8.1 Considerations when implementing visual presentation technical enablers

When found beneficial (as described in Sections 4.1.1, 4.1.4 and 4.2.1), the ATS provider may evaluate the possibility of complementing the visual presentation with tools and functionalities such as the ones described in Section 5.2.8. The ATS provider should conduct an in-depth evaluation of such technical enablers, including the necessary validation activities and human factors assessment, as part of the corresponding safety assessment of the local implementation.

When implementing additional sensors intended to improve the visual range, care should be taken to mitigate the potential risk induced by ATCOs/AFISOs having a different perception of visibility compared to pilots (e.g. the ATCO/AFISO might 'forget' that the pilot operates in a reduced horizontal visibility if they see the aerodrome clearly).

When implementing overlaid information in the visual presentation, care should be taken about the potential unintended loss of such information and the associated risks that may arise as a consequence. For instance, one risk may arise from introducing a dependency on certain functions/tools to achieve a certain level of situational awareness or capacity. Appropriate degraded mode procedures should be developed to handle such situations.

Furthermore, if any digitally overlaid information is implemented in the visual presentation, it is strongly recommended that all such overlaid information is possible to toggle on/off as well as to adjust in light intensity by the ATCO/AFISO. This way the following could be avoided:

— potential blocking of important visual information,

— ATCO/AFISO information overload,

— ATCO/AFISO distraction/dazzling during darkness/night-time operations due to the possibility to adapt to the light conditions at the aerodrome.

5.3. Signalling lamp

In accordance with CS ADR-DSN.K.500 to Regulation (EU) No 139/2014 [5], ICAO Circular 211-AN/128 [11] paragraphs 26 and 29, and in line with EUROCONTROL Manual for AFIS [32] Sections 3.6.7 and 4.2.2.3, the remote tower infrastructure should allow the ATCO/AFISO to communicate via a signalling lamp (e.g. in the case of radiotelephony or data link communication failure).

In order to enable the ATCO/AFISO to communicate via the signalling lamp, remote command capabilities of the signalling lamp from the remote tower should be in place. For this purpose, the means of directing the signalling lamp towards the applicable aircraft/vehicle/personnel may be combined with the binocular functionality. The remote tower system should have the means to ensure that the remote command of the signalling lamp is effectively performed and the means for the ATCO/AFISO to detect any potential failure in its functionality. The location of the signalling lamp at the aerodrome concerned should also be published in the AIP, so that pilots know from where to expect the signals.

The remote operation of the signalling lamp might be subject to delays due to communication latency from the remote facility to the aerodrome infrastructure. The maximum allowable delay should be determined by the local safety assessment taking into account the operational context in order to ensure the ATCO's/AFISO's ability to act timely.

5.4. Aerodrome sound

When providing remote aerodrome ATS from a location/facility where the ATCO/AFISO is unable to detect the naturally occurring sounds of the aerodrome, a function that captures and relays aerodrome sound may be introduced. The implementation of such an aerodrome sound reproduction functionality should be assessed as part of the local safety assessment, taking into account the particularities of the operational context. Particular care should be taken when selecting the aerodrome sound detection devices site. Nearby noise or impact of wind on the microphones could shield the aerodrome sound.

Aerodrome sound reproduction functionality would be an enabler for increased situational awareness and could create a greater sense of presence. Such a functionality has shown to be particularly valuable for smaller aerodromes where sound could play an important role for the ATCO/AFISO, attracting their attention to arising occurrences. Aerodrome sound can increase situational awareness during e.g. low-visibility conditions and emergency situations, and it may also support weather perception. Furthermore, it could raise awareness of potential traffic outside the visual field of view provided by the visual presentation/visual surveillance system.

On the other hand, today's practice at many conventional towers is to minimise or even suppress surrounding aerodrome sound by insulating the tower cab/building. This may be the case for larger aerodromes with a high traffic volume/density or for aerodromes where the traffic involves particularly loud aircraft operations such as military jet fighters.

If implemented, the volume of the aerodrome sound reproduction should be adjustable. This possibility would support the needs of individual ATCOs/AFISOs to minimise disturbing background noise when/if needed. Also, the use of aerodrome sound in an RTC set-up would need to be carefully assessed.

A maximum allowable latency for the aerodrome sound should be determined, taking into account the corresponding video latency of the visual surveillance system and a possible synchronisation with it.

For further considerations regarding multiple mode of operation, refer to Section 5.13.4.

5.5. Communications

A remote tower facility used for the provision of aerodrome ATS, like a conventional tower facility, is required to enable ATCOs and AFISOs to perform voice/data link communication, as detailed below:

— **Aeronautical mobile service** (air-ground communications) in the area of responsibility, in accordance with relevant provisions of Regulation (EU) 2017/373 [2], Annex IV, Section 4.

— **Aeronautical fixed service** (ground-ground communications) in the area of responsibility, in accordance with relevant provisions of Regulation (EU) 2017/373 [2], Annex IV, Section 4.

In addition to the communication with the units and entities prescribed by Regulation (EU) 2017/373 [2] Annex IV Section 4 (as listed above), the remote tower infrastructure should also enable the ATCOs and the AFISOs to establish voice/data link communication with aerodrome personnel and/or any other entities as need be for the coordination and communication between the remote ATS unit and the aerodrome (and as documented in local agreements, see Section 5.1 and Chapter 7).

— **Surface movement service** (communications for the control of vehicles on manoeuvring areas at controlled[24] aerodromes or for the management of vehicles and persons on the manoeuvring area at AFIS aerodromes) in the area of responsibility, in accordance with Regulation (EU) 2017/373 [2], ATS.OR.445.

'Aeronautical mobile service' and 'surface movement service' are typically established through the local radio equipment at the aerodrome. For remote aerodrome ATS, the RTC/RTM might need a dedicated connection (e.g. through WAN) to the local radio equipment at the aerodrome. This remote command of the aerodrome radio equipment might be subject to delays due to communication link latency. The maximum allowable delay should be determined by the local safety assessment, taking into account applicable standards and recommended practises (ICAO/EUROCAE[25]) as well as the operational context, in order to ensure a timely communication between the ATCO/AFISO and aircraft and vehicles.

Also, for backup or emergency radio systems (refer to GM1 ATS.OR.400(a) to Regulation (EU) 2017/373 [2]), a dedicated and independent backup connection between the aerodrome and the remote facility should be required. Standard fall-back solutions, such as handheld radios used in a conventional tower, may not be applicable in the remote tower scenario due to coverage limitations. Backup/emergency radios should also be installed in a different location than main radios.

5.6. Voice and data recording

Regulation (EU) 2017/373 [2] specifies recording requirements for aeronautical mobile service (air-ground communications) (ATS.OR.400 (b) and ATS.OR.455 (a)), aeronautical fixed service (ground-ground communications) (ATS.OR.435(c) and ATS.OR.455(a)(2)), surface movement control service (ATS.OR.445) and aeronautical radio navigation service (ATS.OR.450 and ATS.OR.455). Furthermore, '*Note 1.*' to ICAO Doc 4444 [7] Chapter 7.1.1.2.1 (introduced by 'Amendment No. 8' applicable as of 8 November 2018) clarifies that 'For the purposes of automatic recording of visual surveillance system data, Annex 11, 6.4.1 applies'.

The philosophy of the EU provisions is to record and retain all data used to support the provision of ATS — and in a way that the recorded data is the same as or at least similar to the information presented to the ATCO/AFISO. For the particular case of remote aerodrome ATS, the recording and retention of data should therefore be extended to include constituents specific to remote aerodrome ATS, including the visual presentation, the binocular functionality and other technical support systems such as aerodrome sound reproduction (if implemented). The data recorded should be normally recorded from two sources:

— data obtained from the sensors directly or through the network (through the wall),

[24] This could also be applicable for AFIS aerodromes.

[25] For instance, ICAO Annex 10 Volume III, ICAO Doc 9896, EUROCAE ED136, ED -137B, ED-138 standards.

— data recorded as seen by the ATCO/AFISO on the screen, captured by a screen capture device(at the glass).

With reference to the above, it is recommended that the image presented to the ATCO/AFISO (i.e. the processed data presented to and used by the ATCO/AFISO as support in their decision-making, including both the view of the aerodrome and its vicinity as well as any overlaid data/information/decision support; sometimes referred to as 'screen recording'), is recorded and retained to support an effective accident and incident investigation[26].

When recording the image as presented to the ATCO/AFISO, it is implicit that the image is recorded with the same picture quality as presented/used in the system (number of pixels, frame rate, etc.).

Additionally, the recording and retention of the aerodrome sound reproduction data (as presented/reproduced to the ATCO/AFISO) should also be considered, if such functionality has been implemented (refer to Section 5.4.). Note that Regulation (EU) 2017/373 [2], ATS.OR.460 stipulates recording of background communication and aural environment at ATCO/AFISO workstations (and retention of the last 24 hours of operation), unless otherwise prescribed by the competent authority. Meeting the requirement under ATS.OR.460, it is likely that the aerodrome sound reproduction will be recorded/captured inherently.

It should be noted that integrity issues may result from the recording and retention of optical/video/sound data from public spaces (which could be the case for an aerodrome, depending on the national legislation). Such integrity and privacy issues are different from state to state depending on national integrity and surveillance legislation and would need to be taken into account.

5.7. Management of aerodrome assets

5.7.1. Aeronautical ground lights and navigation aids

The remote tower infrastructure should enable the ATCO/AFISO to operate and monitor all assets which are necessary to fulfil the tasks assigned to the ATS unit. The following requirements/specifications provide examples of assets/tasks that the remote tower infrastructure should support:

— Regulation (EU) 2017/373 [2], ATS.TR.150 'Aeronautical ground lights' and associated AMC and GM;

— Regulation (EU) No 139/2014 [5] CS ADR-DSN.S.890 'Monitoring';

— Regulation (EU) 2017/373 [2], ATS.OR.525 'Information on the operational status of navigation services'.

5.7.2. Management of other aerodrome assets

Even though not regulated as ATS tasks, the remote tower infrastructure may need to consider the monitoring and manoeuvring of (other) aerodrome-related assets such as accident/incident/distress alarms, vehicle traffic lights, gates or bars, arresting cables/barriers or runoff nets, activation of anti-bird guns/systems, etc. according to the specific needs of the particular aerodrome. The monitoring,

[26] In accordance with Regulation (EU) 2017/373 [2], the responsibility for data recording and retention of 'aeronautical mobile service', 'aeronautical fixed service', 'surface movement control service' and 'aeronautical radio navigation service' lies within the ATS provider.

operation, and cost bearing of such assets, their implementation and related procedures should be specified in local agreements between the aerodrome and the ATS unit. If the aerodrome concerned is part of a multiple mode remote aerodrome ATS installation, particular attention should be paid to interdependencies that may exist between different locations and systems.

5.8. Meteorological information

The presentation of meteorological information to the ATCO/AFISO may in the remote tower context be affected by the need for additional data transmission links.

The remote tower infrastructure is required to support and provide:

— presentation of meteorological information in accordance with Regulation (EU) 2017/373 [2], ATS.OR.515 and AMC12 ATS.TR.210(a)(3) to Regulation (EU) 2017/373 [2]; and

— access to relevant meteorological information in accordance with the requirement under Regulation (EU) 2017/373 [2], ATS.OR.242(a).

5.8.1. Remote aerodrome ATS equipment used for MET observation purposes

Meteorological service is not an ATS task; it falls, therefore, outside the scope of remote aerodrome ATS. Whether remote tower equipment is usable for MET observation purposes depends on local legislation, requirements and actual implemented system configuration. Local requirements apply also to the MET observer role of ATCO/AFISO.

However, if local legislation allows the use of remote aerodrome ATS equipment for MET observation purposes, then the requirements stemming from this intended utilisation mode shall be included in the specification, set-up, verification and certification of the implemented system.

The remote aerodrome ATS equipment that is primarily affected by this utilisation mode is the visual surveillance system detailed in Section 5.2. All aspects listed in that section should be considered for MET observation as well if the system is intended for such use.

5.9. Other ATS systems/functions

This section lists systems/functions which are needed for the ATS provision, but which are not necessarily affected or changed due to the service being provided remotely.

Such systems/functions include:

— presentation of ATS surveillance system(s), (e.g. air situation display(s) or surface movement control display(s)), when available for the particular aerodrome (in accordance with AMC1 ATS.TR.205(c) to Regulation (EU) 2017/373 [2]);

— handling of air traffic service messages (in accordance with ICAO Doc 4444 [7] Chapter 11)[27];

— presentation and updating of flight plan and control data (in accordance with Regulation (EU) 2017/373 [2], ATS.OR.145 and associated AMC and GM)*;*

[27] With regard to the use of ICAO aerodrome location indicators in the case of remote aerodrome ATS, each aerodrome/ATS unit will keep its designated location indicator and the relevant ATS messages should be rerouted accordingly.

***Note**: When an RTC enables the transfer of responsibility of ATS for aerodromes between RTMs within the RTC, it is recommended that an electronic system is used for the presentation and updating of flight plan and control data.*

— presentation of the correct time in the format of hours, minutes and seconds in UTC (Regulation (EU) No 923/2012 [4], SERA.3401(a));

The ATCO/AFISO needs to have access to all relevant operational data (e.g. AIP information, NOTAMs, manual of operations, etc.) required for conducting the ATS tasks.

5.10. Technical architecture, interdependencies and redundancy aspects

Service continuity requirements as well as interdependency aspects should be considered when designing the overall technical architecture of the complete system, i.e. all the facilities, installations and equipment enabling and supporting the remote aerodrome ATS, including the identification of **redundancy needs**.

This would include the data transmission links between the aerodrome and the remote tower/facility, the number of cameras at the aerodrome (considering both the camera(s) used to provide the visual presentation image as well as the camera(s) used to provide the binocular functionality), the number of screens for the visual presentation, power supply needs, etc.

Particularly the data transmission links would constitute a critical enabler as the visual surveillance system, aeronautical mobile service and surface movement control service voice communication, as well as monitoring and manoeuvring of systems/equipment on the aerodrome (e.g. camera management, aerodrome lights and navigation/landing systems) would rely on this communication link. Based on current best practices, it is recommended that the connection between the aerodrome and the remote facility is doubled and physically separated and that a third independent connection is used for backup/emergency radio purposes (unless the remote tower is situated close enough to the aerodrome so that this could be solved via standard fall-back solutions such as handheld radios with the sufficient radio coverage). When the ATS provider relies on third-party providers (e.g. network or telecom service providers), the requirements in Regulation (EU) 2017/373 [2] apply.

As regards power supply needs, in case the remote tower facility is located away from the aerodrome (not located at an aerodrome), the power supply measures listed in Section 7.2.5.1 should be applied in an analogous manner.

When ATS is provided to several aerodromes from one RTC/facility, the system architecture should be so designed to avoid interdependencies between the aerodromes/ATS units as far as practically possible. (Refer also to Sections 6.1.1 and 6.5.2, and Chapters 8 and 9.)

As operations from an RTC brings interdependencies between the ATS provision to several aerodromes, Member States and competent authorities are advised to assess the acceptability of the level of interdependencies generated and take measures as deemed suitable. Those measures may include, but are not limited to:

— a requirement to have an aerodrome with independent ATS provision within a certain distance,

— an action on requirements for hours of service.

5.11. Technical supervision

Remote aerodrome ATS is based on a distributed infrastructure comprising system components on the aerodrome as well as in the remote tower facility, which may be located away from the aerodrome. The infrastructure also includes data communication connecting the sites involved. The ATS provision is dependent on a high level of availability of the technical system.

The system and its constituents should include monitoring functions that continuously monitor the technical status and provide:

— **Presentation of the technical status:** Indicate system availability by acquiring, synthesising and displaying the technical and functional status of the system and its constituents.

— **Failure detection:** Generate alarms and warnings when failures have been detected.

— **Support for analysis of the detected failure:** Classify the severity of the failure and make available the recorded technical data related to the failure.

— **Proposed actions and help function:** Propose appropriate failure correction actions based on the available data.

— **Log technical data:** Record data related to the failures for post-processing in support of safety procedures, system development and history of events.

The requirements and need for a technical supervision role should be based upon the local needs and the local safety assessment. The technical supervision role can be implemented in different ways depending on the local situation. The role can be:

— part of the normal maintenance organisation at the aerodrome; or

— a dedicated function at the remote facility; or

— a mixture of both as long as one function has responsibility for the total system functionality.

The system monitoring function should automatically analyse the failures, classify them and, based on the severity, present information to the technical supervisory function. The technical supervisory function should have access to all information. The information presented related to the failure can be on different detailed levels. In the ATCO/AFISO positions, only information directly related to the operational function should be presented. Advice and 'help information' could be generated by the system automatically or be provided through other means like 'checklists', etc. In case of severe failures impacting the operational service provided when the ATCO/AFISO is monitoring the system, the solution could be for the ATCO/AFISO to call for the technical supervisory specialist, close down the service or implement pre-arranged contingency plans.

5.12. Working environment

A dedicated analysis of the working environment and ergonomics of the facilities used for remote aerodromes ATS should be conducted by the ATS provider, as this would be an essential aspect for a successful implementation and an enabler for ATCO/AFISO overall system trust. A good working environment will help to reduce the risks for fatigue, stress, mental strain, etc. A poor working environment on the other hand will negatively affect the ATCO/AFISO ability to perform their job, and might, in the long run, negatively affect the safety of ATS provision.

The physical working environment (noise, temperature, lighting, etc.) would be required to be in accordance with national regulations for normal office establishments.

It is recommended that the working environment permits daylight conditions equal/similar to ordinary office establishments. A comparison can be made to modern ACCs which typically are designed to allow for daylight conditions. Furthermore, it should be possible to adjust the lighting conditions in the RTC/RTM in order to adapt to the daylight/darkness conditions at the (possibly remote) aerodrome(s). For instance, if several RTMs are co-located in an RTC, there may be a need to control/adjust the light conditions individually for each RTM (as the light conditions may differ between the aerodromes connected to different RTMs). Within the RTM, care should be taken to the difference and transition in light between the visual presentation (e.g. display screens) and its background (e.g. wall). If this aspect is not well treated, it may create eye strain and reduce the usefulness of the visual presentation.

The ATCO/AFISO workstation should be designed according to state-of-the-art ergonomic design principles and should allow for a degree of flexibility for user adaption. Aspects to consider may be: limiting the number of input and output devices to a minimum, adaption for left-/right-handed persons, height adjustable worktables, etc. including applicable ISO standards[28].

5.13. Additional considerations for multiple mode of operation

5.13.1. Procedural considerations in multiple mode of operation

5.13.1.1 Handling of abnormal and emergency situations in multiple mode of operation

The ATS provider should put in place procedures and contingency plans that clearly define how to deal with unexpected or unusual events, such as an emergency at one of the aerodromes significantly increasing ATCO/AFISO workload and affecting their ability to continue to provide ATS to all aerodromes under their responsibility. Such procedures and situations require adequate and recurrent training. Each application for multiple mode of operation will require careful consideration for potentially exacerbated emergency situations and therefore the potential exists for enhanced training and mitigations.

Accordingly, the following is a non-exhaustive list of actions the ATCO/AFISO could undertake to support the best possible management of an abnormal or emergency situation:

[28] ISO 6385, Ergonomic principles of the design of work systems
ISO 9241 Ergonomics of human-system interaction
ISO 9241, Ergonomics of human-system interaction
ISO 7730, Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria
ISO 8995-1, Lighting of work places
ISO 7250-1, Basic human body measurements for technological design
ISO 4871, Acoustics - Declaration and verification of noise emission values of machinery and equipment
ISO 7000, Graphical symbols for use on equipment — Registered symbols
ISO 9995, Information technology — Keyboard layouts for test and office systems
ISO 2813, Paints and varnishes
ISO 11064 Ergonomic design of control centres

— Temporarily delay or stop traffic at the other aerodrome(s). Although AFISOs cannot exercise control of traffic, an AFISO could impose delays or other actions via coordination with other/adjacent ATS units and/or the aerodrome operator.

— Split aerodromes in order to isolate the aerodrome with the abnormal/emergency situation on an RTM dealing with only this issue.

— Request well-timed support of another qualified ATCO/AFISO, in order to be able to continue the provision of ATS for all aerodromes under the responsibility of the same RTM.

5.13.1.2 Communication aspects in multiple mode of operation

The ATS provider should conduct an in-depth evaluation of the communication aspects of any multiple mode of operation implementation, as part of the local safety assessment. The related operational procedures should be designed and established, and the necessary system support should be defined accordingly.

The validation activities performed in the framework of the SESAR JU programme ([25], [28], [30]) have examined different ways of handling communication in a multiple mode of operation context, i.e. in dealing with frequencies/radio traffic for several aerodromes at the same time as well as dealing with an increased number of telephone lines to other ATS units and entities (compared to single mode of operation). With regard to the radio communication aspect, based on the validation results, some preferences can be noted, as discussed below.

<u>For aeronautical mobile service (air-ground communications)</u>, two obvious possibilities exist. Either the respective aerodrome frequencies are handled **separately** or **cross-coupled** (as e.g. commonly used when combining sectors in an ACC).

If treated **separately**, the ATCO/AFISO would be able to hear all transmissions for all aerodromes; however, the pilots would only hear the aircraft transmissions related to their 'own' aerodrome. The ATCO/AFISO may respond/transmit to aerodromes separately, or may choose to respond/transmit to all aerodromes under their responsibility. One benefit of this method would be a reduced risk for pilot confusion, as a result of lowered risk to misinterpret transmissions on frequencies of other aerodromes. On the other hand, pilots may try to transmit on the frequency when the ATCO/AFISO is occupied with radio traffic at another aerodrome, as they will not necessarily hear transmissions of the other aerodrome(s). In addition, the ATCO/AFISO would need to select the correct transmitter/frequency, which could lead to the possibility of a mix-up of transmitters/frequencies (transmitting on the wrong aerodrome frequency).

If the different aerodrome frequencies are **cross-coupled**, pilots (as well as the ATCO/AFISO) would hear all transmissions related to all aerodromes under the responsibility of the ATCO/AFISO. The benefit of this method would be that pilots at all times would be aware of the ATCO/AFISO occupancy and the risk for simultaneous transmissions (affecting the ATCO/AFISO) would be reduced. Also, the risk for ATCO transmitter/frequency mix-up (transmitting on the wrong aerodrome frequency) will be eliminated. On the other hand, confusion may arise from pilots hearing transmission(s) at other aerodromes. Based on the SESAR JU programme validation results ([25], [28], [30]), the preferred method seems to be frequency cross-coupling across the aerodromes.

Some specific recommendations can be given with regard to aeronautical mobile service:

— When performing multiple mode of operation and when there is a possibility of confusion due to aerodromes having the same or similar runway designators, and if transmissions are not performed to individual aerodromes, the inclusion of aerodrome names in clearances/radio transmissions should be considered as a standard procedure.

— In addition, the ATS provider may also consider, as part of the local safety assessment, the inclusion of aerodrome names/ATS unit call sign for all transmissions (i.e. not only for the first contact) between pilots and ATCOs/AFISOs in multiple mode of operation. If this procedure is to be implemented, it should be published in the AIP for the particular aerodrome, together with any other specific communication methods as deemed necessary.

For surface movement control service (communications for the control of vehicles other than aircraft on manoeuvring areas at controlled[29] aerodromes), based on the SESAR JU programme validation results ([25], [28], [30]), the preference seems to be to keep the frequencies of different aerodromes separate. A recommendation in this regard can also be made:

— For aerodromes provided with (or to potentially be provided with) multiple mode of operation, it is recommended to consider the introduction of different call sign/number series for the vehicles at the respective aerodrome. For instance, vehicles at aerodrome A to use a call sign/number series starting with 'A' or '1', vehicles at aerodrome B to use a call sign/number series starting with 'B' or '2', etc.). This could be a simple way to support and facilitate the ATCO/AFISO recognition of vehicle radio calls from different aerodromes, as well as to avoid misinterpretations of clearances/transmissions. Another possibility could be to include the aerodrome name or its shortened form into the call sign/number of the ground vehicles. Using different position symbols for different aerodromes might be also an option. For further guidance on interdependencies, see Section 5.10.

5.13.2. RTM design considerations in multiple mode of operation

When performing multiple mode of operation, the ATCO/AFISO should be provided with all systems and data/information required to perform the ATS for all aerodromes under responsibility, in one single workstation. This set-up should enable the ATCO/AFISO to operate/monitor all equipment at all aerodromes as required. There is likely a level of technical complexity to the management of different equipment, which may vary in design and interface from site to site. This needs to be considered and managed in any multiple mode operation implementation case.

The technical system should support and reduce ATCO/AFISO workload by system integration to the level where the ATCO/AFISO can focus on task performance in the new working environment.

Furthermore, the system design should support the ATCO/AFSIO to distinguish to which aerodrome any single set of displays and functionalities are linked.

5.13.3. Visual presentation in multiple mode of operation

The provision of ATS to more than one aerodrome simultaneously would be made possible by (a) visual presentation(s) that allow(s) for the monitoring of each aerodrome, enabling ATCOs to maintain 'control of all flight operations on and in the vicinity of an aerodrome, as well as of vehicles and personnel on the manoeuvring area' and AFISOs to 'maintain a continuous watch on all flight

[29] This could also be applicable for AFIS aerodromes.

operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area'[30]. In this regard, it needs to be understood that the spirit of the provisions is not to visually observe/survey all parts of the aerodrome and its vicinity (and all flight operations, vehicles and personnel) at every single point in time. This is virtually impossible also from a conventional tower (e.g. it is impossible for the human vision to survey 360 degrees at any given point in time) and likely also in a single mode of operation set-up. Instead, the 'continuous watch' here is to be interpreted as keeping continuous awareness of all flight operations, vehicles and personnel, by visually scanning the area of responsibility (i.e. the aerodrome(s) and its vicinity).

The visual presentation(s) should be accessible for each aerodrome at all times. To allow ATCO/AFISO to fulfil the duty of continuous watch, the delay to see any part of the area of interest on any aerodrome being under the responsibility of the ATCO/AFISO should not be higher than the delay it would take in a conventional tower (e.g. by turning around to see behind, or to use binoculars), or indeed not higher than the delay experienced in a single mode of operation set-up.

The placement of cameras/sensors at an aerodrome in order to obtain the most suitable view of the aerodrome and its vicinity is dependent on various factors such as aerodrome layout and runway orientation(s), layout of aerodrome traffic circuit(s), the sun's position on the horizon, availability of technical infrastructure, etc. as is the case also when determining the placement of a new conventional tower.

In the case of multiple mode of operation, the ATS provider may want to also consider an additional aspect, not related to the local conditions of the aerodrome, but related to the interdependencies between the aerodromes to be combined in multiple mode of operation. For instance, a generic placement of camera towers (if applicable) relative to the runway directions and relative to cardinal/compass directions on all aerodromes may be beneficial for the ATCO/AFISO situational awareness when providing ATS to several aerodromes simultaneously.

It is essential that the ATCO/AFISO is, at all times, able to distinguish between the aerodromes at which ATS are simultaneously provided remotely.

Note 1: *Validation activities and human factors assessments performed in the framework of the SESAR JU programme (refer to [25] & [27]) indicates that the distinction between aerodromes would be supported by introducing overlaid (digital) information in the visual presentation, marking and identifying the respective aerodrome. This may be particularly helpful during darkness, low-visibility conditions and when the daylight/meteorological conditions are similar at different aerodromes.*

Note 2: *Validation activities and human factors assessments performed in the framework of the SESAR JU programme further indicate that the introduction of other overlaid (digital) information in the visual presentation, such as compass directions (e.g. indicating the 'north' or the main compass directions (i.e. 'N, E, S, W') for each aerodrome), runway/taxiway/apron markings and denominations, 'visual' and/or 'radar tracking', meteorological information, aerodrome assets/systems status, would support the ATCO/AFISO situational awareness in the multiple mode of operation environment and may also increase heads-up time. When implementing any such overlaid information, care needs to be taken with regard to the possible added dependency on such digital information for the service provision and the potential risks induced by its malfunctioning (see more in Section 5.2.8).*

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30 AMC1 ATS.TR.205(c) and GM2 ATS.TR.305(c)(1) to Regulation (EU) 2017/373 [2].

5.13.4. Aerodrome sound in multiple mode of operation

The validation activities and the human factors assessment performed in the framework of the SESAR JU programme have indicated that aerodrome sound may be particularly useful in a multiple mode of operation set-up, aiding ATCOs/AFISOs attention to occurrences at the different aerodromes.

If implemented, it is recommended that the aerodrome sound playbacks are linked in a directional manner according to the visual presentation of aerodromes, as this was found to be a contributing factor to optimal situational awareness.

For multiple mode of operation, if aerodrome sound is implemented, the volume should be adjustable and possible to turn off by the ATCO/AFISO individually for each aerodrome. This would support the needs of individual ATCOs/AFISOs and would enable to minimise disturbing background noise when/if needed. The implementation of aerodrome sound in multiple mode of operation should be carefully assessed in the local safety and human factors assessments, taking into account the particularities of the operational context.

5.13.5. Other ATS systems/functions in multiple mode of operation

In multiple mode of operation, in order to help reduce the ATCO/AFISO overall workload, it is recommended that coordination and transfer of control (the latter only applicable for ATC) of a flight to/from other ATS units (in accordance with Regulation (EU) 2017/373 [2], ATS.TR.320 and associated AMC and GM) is supported by system means enabling automated coordination.

5.13.6. Work environment in multiple mode of operation

It is recommended that the number of input devices to control the same functions for different aerodromes are as few as possible, as this would support the efficient fulfilment of tasks in a multiple mode of operation environment.

The lighting conditions in the RTM should support the possibility of different daylight/darkness conditions at the different aerodromes connected to an RTM in a multiple-mode-of-operation environment.

6. Management of change

6.1. Addressing socio-economic factors

6.1.1. Prior to making the decision: assessing the impact

Within the process of deciding to implement a remote aerodrome ATS operation, usually an impact assessment of various options is performed considering four areas: safety (including human performance), environment, economic (including a cost-benefit analysis) and social impacts, and the interdependencies between those areas. This section acknowledges these interdependencies and considers all factors affecting safety both in the short term (at implementation) and in the long term (once in operation), as well as those related to the longer-term economic costs for operations.

Economy is often a main driver for the introduction of remote aerodrome ATS, especially when it comes to the multiple mode operations (reference SESAR PJ05 documentation). This is usually achieved by an increase of ATCO/AFISO productivity, consolidation of systems, reduced operating costs, and savings or release of land for facilities, which brings the necessity to assess the social field as well.

The social impact of the implementation can be positive or negative. ATCOs/AFISOs are usually the most affected, but other workers can also be affected, such as maintenance staff (including ATSEP) and support staff.

The implementation of the technology may not always result in relocation, and so may not be factored in as a social impact; however, the below areas may still need to be considered when deciding the introduction of remote aerodrome ATS operations:

— Relocation of a group of staff from their conventional tower to the place from which aerodrome ATS will be provided (potentially crossing borders to places with different labour standards)

— Impact on the number and types of jobs

— Change of employer

— Change of employment terms and conditions

— Impact on the hours of service with a strong link to safety level

— Impact on relatives of relocated staff

— Impact on the cost of living for relocated staff

— Staff turnover related to the implementation

— Increase requirement for off-site work (during transition & over time for maintenance service)

— Issues around staff competence (additional training, cross-validation on multiple aerodromes, reduced scope for maintenance services)

— Consequences of failure to achieve the new competence expectations

— Definition of an achievable and realistic timeline for implementation, including milestones

Social consequences of the introduction of remote aerodrome ATS operations usually also go beyond the remit of ATM/ANS. When performing the assessment, the impact beyond ATM should also be taken into consideration. Here is a list of examples of such impact:

— Impact on local and often remote communities

— Impact on aerodrome operations

— Impact on integrated aerodrome security with, for example, the difficulty triggered by the accessibility issues of the various stakeholders

Therefore, all aspects of the change should be considered, such as:

— Assessing the expected social impact before deciding to implement

— Involving affected staff and their representatives at all steps of the project (refer to the change management declaration of the ATM Social Partners; see Sections 6.3 and 6.4)

— Considering the consequences outside the field of ATM

— Defining mitigating measures as appropriate

In the social dialogue, affected parties could identify additional mitigating measures of financial and logistic nature to facilitate a socially smooth transition.

6.1.2. After making the decision: checking the relevance of the initial assessment

The impact assessment made prior to making the decision to implement remote aerodrome ATS operations might need to be revised successively, as various aspects of the assessment initially made or a change of context of operations, etc. could introduce new elements for consideration, including from the social perspective.

One of the main factors of success for remote aerodrome ATS implementation, both for transition and longer-term safety and economic performance, is to make the right choice of location for the new remote aerodrome ATS operation. To inform this decision, here are some examples of criteria to consider, which again may have both positive and negative impacts.

— Difference and desirability of new location (rural/city, facilities, housing, connectivity)

— Change in cost of living or higher cost of living versus other operations, but no increase in remuneration for affected staff as still providing same role — this could affect staff willing to transition and affect longer-term retention of staff.

  - Loss of experienced staff
  - Change in demographics of the unit
  - A continual high churn rate could result in increased/continual training costs for the ANSP.
  - Challenges in both recruitment needed at transition due to staff who choose not to relocate and future recruitment.

— Connectivity to aerodromes covered — not only the distance, but how easy it is to access from other locations (rail/air/road)

- Transition costs (travel for training/familiarisation whilst existing operation continues)
- Stakeholder interfaces — aerodrome operator, airspace users-ATS interfaces meetings (where in-person meetings are required)

— Career development for people affected

— Change in task allocation (multiple validations)

It is important that the decision on the location is based not on just short-term assessments, but also considers the longer-term impacts that could undo the economic savings/benefits. The selection of an appropriate location could even resolve existing challenges with the current conventional location. Also the specific location might imply changes to the service provision;, therefore, a local validation is recommended.

On the involvement of users, see Section 6.4.

6.1.3. Social aspects to consider during transition to remote aerodrome ATS

There are social aspects that arise during the transition phase to remote aerodrome ATS when ATCOs/AFISOs are needed in both conventional and remote aerodrome ATS concurrently. In case the RTC is not located at or in the vicinity of the same premises as the conventional tower, such personnel would be required to commute between two different places for the period of the transition.

In addition to technical, human factors and other nature elements listed in Sections 6.3.1 and 6.3.2, particular attention should be paid to the following social aspects peculiar to the transition phase:

— Considering the possible need for personnel to commute and to be apart from their family and home for increased periods of time.

— When implementing a remote aerodrome ATS centre, a mid- to long-term plan for staff scheduling/rostering should be determined. The plan should include methods to mitigate the social impact on the personal life of staff during transition.

— For training during the transition phase, e-learning might be considered, as appropriate.

— The preparation of the schedule for the necessary on-site activities should involve the staff to minimise commute between units.

— Overall, the implementation schedule should be realistic, and if any delays occur, the staff should be informed, and support measures should be taken accordingly.

To ensure smooth implementation of the change, all aspects of the change should be considered including but not limited to:

— checking the accuracy of the assessment of the expected social impact;

— involving affected staff and their representatives at all steps of the project (refer to the change management declaration of the ATM Social Partners);

— seeking acceptance of the change;

— adaptable transition training durations;

— managing to the extent possible the consequences outside the field of ATM; and

— defining and implementing mitigating measures as suitable.

6.2. Safety assessment

Implementation of remote aerodrome ATS is to be managed as a change to the functional system. The applicable safety assessment requirements are laid down in Regulation (EU) 2017/373 [2], complemented by associated Acceptable Means of Compliance and Guidance Material. Nevertheless, the particularities of the concept of remote aerodrome ATS require some specific considerations in the safety assessment.

In order to facilitate the safety assessment, Appendix 1 to this document summarises (in a non-exhaustive list) the main elements for consideration when implementing remote aerodrome ATS. The list in Appendix 1 may be used as a checklist by the ATS provider and the competent authority, but should be adjusted as necessary taking into account the local implementation aspects of the operational context and the particularities of the selected technical solution. When initiating the safety review process, it could be beneficial and useful to agree on a tailored checklist in coordination between the ATS provider and the competent authority.

In addition to the guidance provided in the other sections of this document, the following sections (6.2.1, 6.2.2 and 6.2.3) provide some additional considerations and guidance related more directly to the safety assessment. It is also highlighted that the results of the human factors and security assessments (see Sections 6.3 and 6.6) form important inputs to the safety assessment (whether performed separately or in conjunction with the safety assessment).

6.2.1. Scope of the safety assessment

The safety assessment should cover every aerodrome, every operational mode and — in the case of multiple mode of operation — every aerodrome configuration/combination. For instance, aerodrome A, aerodrome B and aerodrome C should be subject to separate safety assessments, and in the case of their operation in multiple mode, any intended combination of them should additionally be subject to separate safety assessments.

6.2.2. Dependencies and interfaces

In the case of ATS provision to several aerodromes from one RTC, the safety assessment should additionally cover interdependency aspects between the different aerodromes/ATS units. The recommendations in Sections 5.10 and 6.5.2, and Chapters 8 and 9 should also be considered.

The implementation of remote aerodrome ATS is a change to the functional system that may impact one or several entities, persons or organisations (e.g. communication navigation surveillance (CNS) providers, adjacent ATS providers). Those entities, persons or organisations affected by the introduction of the remote tower concept would be, at least, the aerodrome operator(s) and the airspace users.

In accordance with Regulation (EU) 2017/373 [2], ATS.OR.205 and ATM/ANS.OR.A.045 (and associated AMC1 ATM/ANS.OR.A.045(a)(3), GM1 ATM/ANS.OR.A.045(a)(3), AMC1 ATM/ANS.OR.A.045(e), GM1 to GM4 ATM/ANS.OR.A.045(e), GM1 ATM/ANS.OR.A.045(e)(2) and GM1 ATM/ANS.OR.A.045(f)), an ATS provider is required to address dependencies, interfaces and interactions with such entities, persons or organisations when conducting the safety assessment.

The way in which the technical systems of a remote tower implementation will interact may be different from that of a conventional tower. For example, as discussed in Chapters 3 and 4, technical systems may be located at different distant geographical locations (such as at the aerodrome and at the remote location/facility), interacting with each other as well as with external entities on both sides. Such an interaction would require consideration during the safety assessment.

6.2.3. Identification of hazards

As stipulated in Regulation (EU) 2017/373 [2], ATS.OR.200(2) and ATS.OR.205(b)(1), complemented by EASA ED Decision 2017/001/R [6], AMC1 and AMC2 ATS.OR.205(b)(1) and GM1 ATS.OR.205(b)(1), an ATS provider is required to perform a hazard identification for any changes to those parts of the ATM functional system and supporting arrangements within its managerial control.

The generic safety assessments performed in the framework of the SESAR JU programme ([20], [23], [26]) have yielded a list of operational hazards in relation to the provision of aerodrome ATS. As such, they may not be related to remote aerodrome ATS only, but also to the provision of ATS from a conventional tower. Nevertheless, the implementation of remote aerodrome ATS may affect the causes or the probability of occurrence of those hazards. In order to facilitate performing the safety assessment for the introduction of remote aerodrome ATS, the identified operational hazards from the SESAR safety work are presented in Table 2, Appendix 2 for ATC provision and in Table 3, Appendix 3 for AFIS provision. These hazards may be considered as an initial input by the ATS provider, but need to be adapted appropriately taking into account the local conditions and the operational application and context of the particular implementation and the addition of potential hazards *stemming from the specific implemented system*. The adapted list of hazards can then be used by the ATS provider for the development of safety requirements, by using its own safety assessment methodology as accepted by the corresponding competent authority.

6.3. Human factors assessment

The introduction into service of the remote aerodrome ATS has direct human factors implications. Furthermore, the implementation of mitigation measures to counter such human factors implications may also impact the humans operating the systems.

Some sections in this document already indicate the need for a human factors assessment. This section addresses in more detail human factors aspects that should be considered for the implementation of remote aerodrome ATS. The human factors assessment should be based on a state-of-the-art process and is required to fulfil the requirements of Regulation (EU) 2017/373 [2], ATS.OR.205. It is recommended that such assessment should be performed independently.

Human factors assessment is not about assessing the technical performance itself, but the suitability of technical components in an ATCO/AFISO's task context, allowing the ATCO/AFISO to successfully accomplish the ATS task. In addition, and related to the human factors assessment, social aspects concerning the introduction of remote aerodrome ATS should be considered.

The human factors assessment should cover the relevant human factors areas affected by the change. It concerns:

— HMI and system;

— working environment (see also Section 5.12);

— procedures and working methods;

— organisation and human-human interaction;

— transition factors (competencies, training, acceptance of the new working environment).

It also should cover and involve, in a proportionate manner, those actors (ATCO, AFISO, ATSEP, etc.) affected by the change. The human factors assessment should also support decisions on safety nets and functionalities to safely achieve the level of service intended and in an acceptable manner for the actors involved.

The assessment of human factors aspects should be carried out through various means, such as workshops, simulations[31], passive and active shadow mode validations[32], as appropriate for the proposed implementation, using the final functional system to ensure that human performance is not negatively impacted. Simulations as well as shadow mode validations are considered to be useful to find inconsistencies in the equipment and procedures, while workshops can have multiple purposes, depending on the timing of their use. Workshops should include the operational experts that are impacted by the change, which ensures not only that the human factors issues are captured accurately but also that the purpose and scope of the change is fully transparent to the operational experts. Workshops can therefore not only be used to identify human factors issues that have not been identified before and mitigations to those issues, but also to define the content of trainings, and to disseminate information. The human factors assessment should be led by a human factors specialist. The human factors specialist will be aware of human factors/human performance assessment processes and be able to adapt those processes to their needs. Commonly used human factors/human performance assessment processes are for example the ECTRL HF case or the SESAR HP assessment process. These processes provide examples of methods that can be used to collect data. The human factors assessment has to be clearly indicated as such and not to be merged with a safety assessment; however, it can be included in the same document.

6.3.1. Remote-aerodrome-ATS-related human factors elements/aspects

The aspects listed in this section are applicable when implementing remote aerodrome ATS, regardless of single or multiple mode of operation. Particular care and considerations should be taken with regard to the interaction between aerodromes and the increased complexity when providing multiple mode of operation.

The concept includes existing standards and anticipates the introduction of future standards and applications of the technology associated with image presentation, which encompasses several aspects. Before implementing the technology, the ATS provider should perform human factors assessments, including the following technical elements:

[31] In this context the term simulation should be understood as familiarisation with the new equipment and the tools. The simulations could also be used to develop the procedures for using the equipment and tools.

[32] Shadow mode validations are referred to the validation technique in which the new system is given live feeds in the operational environment and runs in parallel to the operational system. In passive shadow mode, the new system will be non-interfering and will not play an active part in the ATM system. In active shadow mode, the new system will be put in active operation with the old system running in parallel as a fall back. Hence — in the context of remote aerodrome ATS validations — for passive shadow mode, the ATS will still be provided from the conventional tower (shadowed from the remote tower to various degrees), whereas for active shadow mode, the ATS will be provided from the remote tower (shadowed from the conventional tower.)

— screen layout;

— field of view (vertical and horizontal degree angle, speed and smoothness of panning);

— use and impact of colours;

— image quality factors (contrast, brightness, sharpness, focus, dynamic range, resolution, jitter and motion blur, etc.) for the area of interest;

— compression and distortion of reality;

— availability and usability of binocular function;

— avoidance of blind areas and, if unavoidable, their location and their mitigation;

— preliminary assessment of acceptability of and trust in reliability of the visual presentation;

— preliminary assessment of acceptability of and trust in the availability of the visual presentation;

— preliminary assessment of acceptability of and trust in the integrity of the visual presentation;

— preliminary assessment of acceptability of and trust in the accuracy of the visual presentation;

— end-to-end delays between image and sound (if implemented) capture and their presentation;

— discrepancy or synchronisation between visual presentation, aerodrome sound (if implemented) and voice communication;

— appearance and mitigation of image freezing issues;

— physical and mental fatigue induction (e.g. eye fatigue, noise induced fatigue);

— capability of the system to provide smooth, regular and operationally acceptable visual presentation of moving/flashing/rotating objects to the human eye;

— quality of the visual presentation to allow the ATCO/AFISO to judge the distance between objects;

— functions to manage and avoid overlapping information; and

— system monitoring capabilities.

Other technical elements specific to local implementation

At least, the following human factors elements should be taken into consideration as a consequence of the replacement of direct visual observation with visual surveillance systems:

— ATCO/AFISO ability to maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area'[33];

— ATCO/AFISO situational awareness;

— ATCO/AFISO perception;

— ATCO/AFISO workload;

— ATCO/AFISO fatigue and boredom;

[33] AMC1 ATS.TR.205(c) to Regulation EU) 2017/373 [2].

- impact of augmented reality;
- usability of input devices;
- effect of time delays on visual presentation in all situations, with special attention to emergency situations (e.g. runway incursions);
- potential confusion over the different views that an ATCO/AFISO could suffer from having images originated from different cameras with different locations and angles of view on the manoeuvring area (e.g. positioning cameras on both sides of a runway);
- differences in brightness between ground and sky in the screen views;
- differences in brightness between reality and the presented view;
- partial limitation of view in the visual presentation caused by glare, e.g. during low-standing sun;
- contrast of screens with the background;
- colour balance with different daylight configurations;
- combining video images from different source types such as visual cameras, infrared cameras, etc.;
- screens arrangement (e.g. number of screens, angles of screens, edges of screens, multiple views);
- ATCO/AFISO workspace ergonomics (e.g. seated versus standing, distance from desk to screens);
- capability of the cameras to capture and transmit blinking beacon images;
- specific local conditions affecting the visibility (e.g. deficiencies in image capture due to seawater splash);
- if made available, aerodrome ambient sound;
- acoustic characteristics of the control room (RTM/RTC);
- camera angles and screen orientation in relation to aerodrome layouts and in relation to the different legs of the aerodrome traffic circuit, as well as emergency and missed approach procedures;
- integrated flight data label information (if available), both with static information and with dynamic information, and measures to prevent the label from shadowing visual information as well as measures to prevent frequent and sudden moves of those labels;
- binocular functionality and the possibility to follow moving objects, either automatically (rotation, tilt to the desired elevation angle and focus at the indicated distance, if available) or through a manual pan-and-tilt/zoom function;
- visual tracking functionality (if available).

Additionally, the human factors assessment needs to consider some aspects of procedural and other nature, not necessarily related to the replacement of direct visual observation. At least the following aspects should be taken into account:

— local procedures to manage movement of vehicles, aircraft and persons on the manoeuvring area;

— local procedures on the coordination of aerodrome ATS unit and approach control (APP) unit, and/or area control centre and flight information centre (ACC/FIC) as applicable, whether merged or not in the same location;

— local procedures for the coordination between the ATS unit and ATSEP;

— local procedures for the coordination between the ATS unit and aerodrome ground personnel;

— local procedures related to aircraft emergency and abnormal situations;

— local procedures for operations during low-cloud situations, low visibility or similar;

— local procedures to handle limitations and conditions (e.g. number of simultaneous aircraft and/or vehicle movements at one aerodrome for a specific time), if applicable;

— local procedures related to the contingency plans in case of partial, single and or multiple failure at the RTC;

— specific training elements related to local aerodrome characteristics (e.g. unit endorsement requirements);

— effect of limitations on operation (if any) and prioritisation of traffic;

— effect of the types of airspace surrounding the aerodrome concerned, particularly when establishing a new ATS unit;

— effect on the possibility to detect and recognise aircraft, their equipment, flight patterns and behaviour of flights;

— specific local requirements needed for safety reasons, such as:

  - extended spacing (if used e.g. during a transition/start-up phase following implementation);
  - ground equipment (e.g. radar);
  - on-board equipment (e.g. transponder, ADS-B);
  - specific camera configuration (e.g. hot spot coverage);
  - specific additional camera equipment e.g. adaptable housing and ancillary equipment (e.g. automatic cleaning system for the windows, sun filters) to protect and mitigate effects caused by sunshine, weather and animal activities);
  - specific screen requirements (e.g. automatic adjustable contrast to mitigate daylight variations); and

— for the case when ATCOs/AFISOs will switch service provision between aerodromes under the same shift (may be applicable both to the single mode of operation as well as to the multiple mode of operation, see Sections 4.1.3 and 4.2.3), it is recommended that ATS providers consider the consequences on fatigue and mental availability and define mitigation measures as suitable;

— procedures in case of image integrity failure;

— maintenance procedures; and

— fall-back and system degradation procedures and operational contingency procedures in case of significant degradation or interruption of its operations.

6.3.2. Additional human factors elements/aspects related to multiple mode of operation

In reference to the introductory paragraph of Section 6.3.1, when considering the implementation of the multiple mode of operation, the elements listed in this section should be assessed with particular care.

Technology elements

— availability of the visual presentations for all aerodromes under the responsibility of the AFISO/ATCO;

— screen layouts;

— field of view (vertical and horizontal degree angle, speed and smoothness of panning) of each aerodrome;

— image quality factors (contrast, brightness, sharpness, focus, dynamic range, resolution, etc.) for the areas of interest in relation to the different aerodromes;

— supervisory and maintenance tools for ATSEP for handling multiple mode of operation; and

— input commands for each aerodrome (binocular functionalities, signalling lamps, equipment control, etc.).

Human factors elements

— ATCO/AFISO ability to 'maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area'[34] for all aerodromes under their responsibility;

— distributed attention;

— potential confusion and spatial disorientation from the different views of the different aerodromes;

— potential confusion of voice communication (for pilots, vehicle drivers, ATCOs/AFISOs, e.g. origination of call, frequency of voice communication transmission and retransmissions, simultaneous calls, voice station denominator (remote or conventional), interface design);

— differentiation between the different aerodromes (meteorological conditions);

— arrangement of screens for the visual presentation and screens for other ATS systems/functions (e.g. number of screens and their functions, angles of screens); and

— if applicable, aerodrome sound origin.

Procedural and other aspects

— increase in complexity of procedures due to multiple mode of operation, particularly with simultaneous aircraft movements and events (abnormal situations, emergencies, degradations,

[34] AMC1 ATS.TR.205(c) to Regulation (EU) 2017/373 [2].

spacing between aircraft movements at different aerodromes, different interface arrangements with aerodromes);

— operational procedures related to the multiple mode of operation such as splitting, merging and prioritising;

— specific training elements related to multiple operations (unit endorsement requirements, individual human factors limitations);

— potential impact on simultaneous operations on the ground or in the air;

— specific requirements needed for safety reasons, such as extended spacing (if used e.g. during a transition/start-up phase following implementation) and other operational and contingency procedures;

— ATS supervisory function;

— coordination processes with ATSEP in charge of the ATCOs'/AFISOs' tools;

— procedures in case of image integrity failure;

— maintenance procedures; and

— fall-back and system degradation procedures and operational contingency procedures in case of significant degradation or interruption of its operations.

6.4. Involvement of users

During implementation of remote aerodrome ATS operations, it is important to ensure a continuous interaction with the affected stakeholders and users.

Affected stakeholders and users include, inter alia, aerodrome operators, airspace users, other ANSPs, ANSP personnel affected by the change (ATCO/AFISO, ATSEP, MET, etc.) and their representatives. As involvement of aerodrome operators and airspace users is covered in Chapter 8 of this guidance material, this section focuses more on the affected personnel but is still valid for other stakeholders also.

In this context, the ANSP should involve the stakeholders in the different phases of the life cycle of the remote aerodrome ATS implementation, as follows:

— Before taking the decision to implement remote aerodrome ATS operations, the ANSP should collect comments and concerns from the users to be addressed in the development phase. At this stage, the involvement can be carried out through different means (written consultation, open meetings with all stakeholders, one-to-one meetings, etc.);

— During the development phase, the ANSP should consult with the users to make sure that the system under development matches the expectations of users, especially those who will start operating the system daily.

— During the implementation phase, as part of the management of change, the ANSP should ensure the coordination with its personnel, to keep them informed on the relevant technical and operational solutions and to get their feedback for consideration. For this purpose, a dedicated group with ANSP's affected personnel involved could be set up. The training syllabus for future operators of the system should also be developed in cooperation with the personnel to make sure it suits their needs to fully grasp the new operations.

— After the implementation of the remote aerodrome ATS operations, the ANSP should maintain the interactions with the affected personnel and stakeholders for monitoring purposes. This can be part of the regular consultation with the users of its services required by the Regulation (ATM/ANS.OR.A.075).

For further information on how to involve airspace users, see Chapter 8.

6.5. Transition/implementation plan

The ATS provider should, in coordination with the aerodrome operator and other affected stakeholders, establish a transition/implementation plan, as appropriate, for the introduction into service of remote aerodrome ATS, regardless of whether migrating service from a conventional tower or setting up a new ATS unit. The transition/implementation plan should be documented and included in the safety assessment and should cover those tasks, steps, resources (human and equipment) as well as coordination activities with stakeholders as deemed necessary for a successful transition/implementation.

6.5.1. Transitioning from a conventional tower to a remote tower

For the case when the service is migrated from a conventional tower to a remote tower, a transition plan should be developed and should define the different phases to be followed and the associated transition criteria, including fall-back procedures for how to revert the ATS to the conventional tower in case of unexpected events or problems. The capability of providing ATS from the conventional tower should be maintained during all transition phases, plus an additional period (to be defined by the ATS provider) following the successful migration, for contingency reasons. The transition plan should consider the following phase, as appropriate:

— Conventional tower control: While in this phase, ATS will be provided from the conventional tower.

— Transferring control: In this phase, ATS will still be provided from the conventional tower, but the necessary data will also be re-routed to the remote tower for shadow mode operations/transfer of control initiation.

— Remote tower control: In this phase, the responsibility for providing ATS will lie with the remote tower personnel.

The transition between phases may be performed through a handover process between the conventional tower and the remote tower. This handover process should only start once the remote tower is ready to assume responsibility for the ATS. The handover protocol may be split as follows:

— While maintaining the provision of ATS from the conventional tower (conventional tower control phase), the remote tower ATCO/AFISO calls the conventional tower in order to declare their ability to assume responsibility for ATS.

— The acknowledgement of this request by the conventional tower will trigger the transition to the ‘transferring control’ phase.

— When all the necessary information is transferred and when all the required technical operations are completed in order to allow the remote tower system to work properly, the remote ATCO's/AFISO's acceptance of the responsibility will trigger the transition to the 'remote tower control' phases. The conventional tower unit will then inform all the other actors involved (i.e. local emergency personnel, aerodrome services, adjacent and relevant ATS units, etc.) of the successful completion of transfer of responsibility.

The remote tower functional system should be designed in such a way that these phase (or equivalent ones) and the associated transitions are feasible. Additionally, the possibility to return to the 'conventional tower control' phase from the 'remote tower control' phase should be maintained throughout the transition process, and should be also maintained for some time after the successful transition for contingency reasons.

6.5.2. Migration from a conventional tower to a remote contingency tower

When the remote aerodrome ATS have been implemented for contingency purposes as a backup for the conventional tower services, all operational site requirements evaluated for the specific remote contingency tower shall be met; in addition, Sections 4.1.4, 6.3.1 and 6.5 should be taken into account.

The local contingency plan determines the circumstances when the degradation of aerodrome services interrupts the operation of the conventional tower and when services have to be migrated to the remote contingency tower.

Migration from a conventional tower to a remote contingency tower may happen for different reasons. The contingency plan should define procedures for the below-listed situations:

— Unplanned remote contingency operation in case of unexpected events or problems e.g. equipment failure, fire, security threat, etc.

— Planned remote contingency operation e.g. software or hardware changes of ATM system elements, competence maintenance training, on-the-job training

— Reverting the provision of ATS back from the remote contingency facility to the conventional tower

Due to its nature, the remote contingency tower is not in constant operation. In order to be able to maintain its capability of providing ATS backup for a conventional tower whenever it is required:

— in addition to Section 7.2.3, on appropriate technical maintenance, procedures should be developed and implemented to ensure continuous availability. The ATS provider should ensure that all hardware and software modifications made to the conventional tower system, whenever is applicable, are also made to the remote contingency tower system components as well;

— in addition to Section 6.4, security measures should be established to eliminate the risk of impact on the operation due to unauthorised human action; and

— based on the local competence scheme, regular trainings should be provided to maintain the competence of operational personnel.

6.5.3. Setting up a new ATS unit

When the introduction into service of remote aerodrome ATS is performed at an aerodrome where no conventional tower exists (and therefore no associated ATS is provided), an implementation plan for the introduction of the new ATS unit should be developed, taking into consideration the different elements contained in this document and the specific conditions of the target aerodrome.

6.5.4. Common aspects for a transition/implementation plan

Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors), and respective aerodrome operators should be notified without undue delay when ATS is provided from the remote tower, or when ATS from the remote tower is planned to be terminated. This notification process should be applied through the aeronautical information products and services (e.g. NOTAM), see Chapter 9.

6.6. Information and cybersecurity

As stipulated in Regulation (EU) 2017/373 [2], ATM/ANS.OR.D.010, ANSPs — and therefore also ATS providers — shall 'establish a security management system to ensure: (a) the security of their facilities and personnel so as to prevent unlawful interference with the provision of services; and (b) the security of operational data they receive, or produce, or otherwise employ, so that access to it is restricted only to those authorised.'

Remote aerodrome ATS relies on IT infrastructure for data exchange to support, amongst others visual surveillance system, communications (in particular aeronautical mobile service and surface movement service) and management of aerodrome equipment/systems/assets, which may render it vulnerable to potential security threats to computer systems or the data exchanged.

Risks may be posed due to unavailability of such data (denial of service) or unauthorised modification (data tampering) with limited ATCO/AFISO capability to detect potential integrity problems in the information presented at the RTM.

Consequently, the introduction of remote aerodrome ATS may affect the security risk assessment and these security vulnerabilities may have an impact on safety. For this reason, these security vulnerabilities may add new causes to the existing safety hazards (e.g. possible corruption of navigation aids information, loss of visual presentation data) or may add new hazards (e.g. complete loss of the provision of ATS). Based on these considerations, the ATS provider is required (in accordance with Regulation (EU) 2017/373 [2], see above) to conduct a dedicated security risk assessment and take the necessary measures to protect its systems and constituents against information and cybersecurity threats. The results of this security risk assessment should be considered as input to the safety assessment.

In this context, security threat is defined as any circumstance or event with the potential to adversely impact on the operation, systems and/or constituents due to human action (accidental, casual, or intentionally or unintentionally mistaken) resulting from unauthorised access, use, disclosure, denial, disruption, modification, or destruction of information and/or information system interfaces. It should be noted that this may also include malware and the effects of external systems on dependent systems.

6.7. Contingency planning and degraded mode procedures

As stipulated by point 5.1. recital (f) in Annex VIII to Regulation (EU) 2018/1139 [1], an ATS provider — 'shall establish and implement a contingency plan covering emergency and abnormal situations that may occur in relation to its services, including in the case of events which result in significant degradation or interruption of its operations'. Furthermore, Regulation (EU) 2017/373 [2], ATM/ANS.OR.A.070 complemented by GM1 ATM/ANS.OR.A.070 in Annex III to EASA ED Decision 2017/001/R [6], stipulates that a service provider 'shall have in place contingency plans for all the services it provides in the case of events which result in significant degradation or interruption of its operations.'

In addition, degraded mode procedures for events which would not necessarily lead to a significant degradation or interruption of the operation should be properly assessed and developed, as part of the assessment of the change to the ATM functional system (refer to Regulation (EU) 2017/373 [2]), in order to ensure a continued safe service provision in case of e.g. partial system failure/degradation.

Also note that — in reference to ICAO Annex 11 [9], Attachment C, point 2 — any contingency arrangement is supposed to be temporary in nature, i.e. to be used only for limited time periods, until the ordinary services and facilities can be resumed.

With regard to remote aerodrome ATS, the contingency and degraded mode procedures should be adapted/designed to the specific local conditions and the specific technical architecture/design, taking into consideration elements such as:

— the use of light signals and emergency flares;

— alerting in case of failure conditions;

— impact on the service provision in case of major failure; and

— the management of existing traffic in the scenario of major or complete failure of an RTM or RTC.

The following items represent examples of situations for which contingency or degraded mode procedures may need to be applied:

— Events related to visual presentation and binocular functionality, including:

  - unreliable visual presentation, e.g. 'blank screen', frozen presentation, or video latency delay above the maximum value allowed;
  - partial or full loss/degradation of visual presentation, loss/degradation of binocular functionality;
  - technical enablers intended to increase ATCO/AFISO situational awareness (refer to Section 5.2.8.1).

— Events related to other system aspects, including loss/degradation of:

  - communication (i.e. aeronautical mobile service, aeronautical fixed service and surface movement service);
  - signalling lamp;
  - meteorological information;

- information and/or management of aeronautical ground lights;
- information and/or management of navigation aids;
- alarm management;
- aerodrome sound reproduction (if available); and
- other systems such as ATS surveillance information, flight plan and control data, etc.

For the events listed above, each specific element should be considered in isolation, but also in combination with other possible failures and how they interact.

In addition, special consideration of the need to have a spare RTM and associated staff, if suitable, should be taken to reduce the likelihood of service interruption due to the failure of the RTM.

6.7.1. Contingency and degraded mode procedures for multiple mode of operations

In the case of multiple mode of operation, contingency and degraded mode procedures should take into account the effect of any event on all aerodromes connected to one RTM as well as how failures may interfere between the aerodromes. The following cases would need to be considered in the case of multiple mode of operation from an RTM:

— failure of one or several systems for one aerodrome;

— failure of one or several systems for more than one aerodrome but less than all connected aerodromes (this use case is only applicable in the case of more than two connected aerodromes); and

— failure of one or several systems for all connected aerodromes.

6.7.2. Contingency and degraded mode procedures for RTC operations

In the case of operations to several aerodromes from one RTC, appropriate contingency plans for the RTC need to be developed, including, for example, contingency procedures for full RTC failure (see also Sections 5.10 and 6.1.1).

Particular care should be taken about the risk of an RTC becoming a single point of failure for aerodromes which would otherwise be independent, as it could be the case of aerodromes which could be expected to be used by airspace users as ‘alternate aerodromes’ for each other. Despite all measures to reduce its likelihood, the event of total unavailability of an RTC should be considered to enable airspace users to select a suitable alternate. It is expected that this alternate selection can guarantee the availability of an aerodrome with the expected level of ATS. Therefore all remotely controlled aerodromes should have operational contingency procedures for use by the airspace users in place in case of single or multiple failures at the RTC.

To allow suitable selection by airspace users, ATS providers should provide the appropriate information to airspace users. Chapter 9 indicates which information to publish. This information can also take other forms, such as workshops with airspace users to present relevant information for selection of alternate(s) aerodrome(s).

6.8. Remote tower system constituents

In relation to the demonstration of compliance with the applicable articles of and annexes to Regulation (EU) 2018/1139 [1], the split of the technical system into constituents falls under the responsibility of the ATM/ANS service provider, in agreement with the respective competent authority. The split may depend on several factors, such as the availability of community specifications for certain parts of the system and even how the contractual arrangements between the service provider and the constituent manufacturers are established.

Based on the considerations above, some recommendations are put forward on how the remote aerodrome ATS system may be split into constituents.

Based on the high-level remote aerodrome ATS functionalities presented in Chapter 5, the remote tower system constituents may be grouped as follows:

— Visual-presentation-, binocular-functionality- and aerodrome-sound-related functionalities;

— voice/data-communication-related functionalities (i.e. aeronautical mobile service, aeronautical fixed service and surface movement control service);

— manoeuvring- and monitoring-related functionalities (e.g. signal light gun, management of aerodrome equipment/systems such as aeronautical ground lights and navigation aids, alarm management, technical supervision).

The aforementioned functional grouping has been selected as the basis for the proposed split, identifying a constituent as responsible for the implementation of each of these categories. Nevertheless, these recommendations are based on two main assumptions that:

— the system (physical) architecture ensures independence of each of the constituents; and

— the interface specification among them is based on existing standards.

For a particular technical solution, the validity of these assumptions should be assessed by the ATS provider. It is also important to analyse the ATM/ANS service for which a constituent should be considered, as this may also affect the possible split of the system into constituents.

The main question would be whether the visual surveillance system and aerodrome sound are to be considered as constituents in the ATS domain or as a combination of ATS constituents and CNS (surveillance) constituents, or, in other words, if the visualisation means (cameras) and aerodrome sound means (microphones) can be considered as ATS surveillance equipment. With regard to that, the definition of 'ATS surveillance system' of Regulation (EU) 2017/373 [2] is recalled:

'ATS surveillance system' means a generic term meaning variously, ADS-B, PSR, SSR or any comparable ground-based system that enables the identification of aircraft.

GM1 141.ATS states: 'A comparable ground-based system is one that has been demonstrated, by comparative assessment or other methodology, to have a level of safety and performance equal to or better than monopulse SSR.'

The image captured by the cameras/optical sensors is used to replace the 'out-of-the-window view' with a 'visual presentation' and to replace the use of a traditional binocular with a 'binocular functionality'. It is not intended for provision of ATS surveillance services, nor does it provide the necessary means and information for that purpose. (For instance, the precise distance between two aircraft in flight cannot be provided.) It is to be used primarily for the ‘detection’ and ‘recognition’ of aircraft (as well as for other objects and purposes, e.g. vehicles, personnel, obstructions, animals, occurrences at the aerodrome, weather follow up, etc.) and normally not used for the ‘identification’ of aircraft for the purpose of ATS surveillance services provision.

The aerodrome surrounding sound captured by the microphones is used as a means to increase the general ATCO/AFISO situational awareness, but is not used for the ‘identification’ of aircraft for the purpose of ATS surveillance services provision.

Following this analysis, it has been concluded that the ground infrastructure at the aerodrome for capturing images and surrounding sound should be considered as ATS constituents (or part of ANS constituents).

The following table summarises the results of both analyses that constitute the recommended way of organising the allocation of the system’s constituents.

Table 1: Remote tower system constituents

Constituent	Allocated functions	ATM/ANS service
Visual surveillance system & aerodrome sound	Visual presentation Binocular functionality Aerodrome sound reproduction Data recording of the associated data	ATS
Voice/data communication	Aeronautical mobile service (air-ground communications) Aeronautical fixed service (ground-ground communications) Surface movement control service (communications for the control of vehicles other than aircraft on manoeuvring areas at controlled[35] aerodromes) Voice and data recording of the associated communication frequencies/data.	CNS
Manoeuvring and monitoring	Management of signal light gun Management of aerodrome lights Management of alarms Management of navigation aids Technical supervision	ATS

The following is noted:

[35] This could also be applicable for AFIS aerodromes.

- EUROCAE has published ED-240A Change 1 [12], a Minimum Aviation System Performance Standard (MASPS) for Remote Tower Optical Systems.
- The denominations of the constituents are included for illustrative purposes only.
- The ATS provider may split further these constituents (e.g. splitting between equipment at the aerodrome and at the remote tower/RTC), which would require the definition of the interface specifications (standards) among the identified new constituents.
- The ATS provider may consider the possibility of including additional constituents or additional functionalities to the identified ones.
- The ATS provider may consider adding other functions to the identified constituents, provided that they are consistent with the ATM/ANS service (ATS or CNS) provided.
- The ATS provider may consider merging visual surveillance system, aerodrome sound reproduction and manoeuvring and monitoring, as they belong to the same domain.

7. Aerodrome-related aspects

According to ICAO Annex 14 [10], certain aerodromes need to be certified~~,~~ in accordance with an appropriate regulatory framework. At EU level, Regulation (EU) No 139/2014 [5] applies to the aerodromes that meet the criteria prescribed in Regulation (EU) 2018/1139 [1]. EASA Member States are also expected to adopt an appropriate regulatory framework that applies to the aerodromes that fall outside the scope of Regulation (EU) No 139/2014 [5].

During aerodrome planning, design and certification activities, it is imperative that, among others, ATS aspects are properly and adequately identified and addressed.

Remote aerodrome ATS enables the possibility to provide aerodrome ATS from locations other than the aerodrome itself.

An advantage of providing the aerodrome ATS from the aerodrome itself (be it either from a 'conventional tower' or from a 'remote tower') is the possibility of direct personal contact with the aerodrome operator, which can be beneficial, particularly during special events/accidents or incidents.

For remote aerodrome ATS, and specifically if the remote tower is located away from the aerodrome, it is particularly important to ensure appropriate coordination between the competent authorities, the ATS provider, and the aerodrome operator, throughout the implementation phase as well as during the actual ATS provision. Changes necessary for the implementation should be carried out by the aerodrome operator according to ADR.OR.B.040 of Regulation (EU) No 139/2014 [5].

With regard to aerodromes, and irrespective of the regulatory framework that an aerodrome falls under, the following aspects should be taken into consideration to meet this objective.

7.1. Certification

7.1.1. Documentation to be provided by the applicant for the initial aerodrome certification

The documentation for the initial certification of the aerodrome should include information regarding the provision of ATM/ANS at the aerodrome, including:

— the type of ATS provided (ATC services and/or AFIS);

— the way ATS is provided:

- from a conventional tower (ATS unit established at the aerodrome); or
- from a remote tower (ATS unit established at the aerodrome or off-site (away from) the aerodrome); or
- a combination of the above (in alternation from a conventional tower and a remote tower);

— CNS; and

— MET.

When remote aerodrome ATS is provided, the submitted documentation (apart from the necessary arrangements between the aerodrome operator and the ATS provider) should clearly identify:

- the location of the ATS unit;
- communication means to be used between the ATS unit and all relevant aerodrome units;
- the tasks that will be needed to be carried out locally at the aerodrome in order to enable and support the remote aerodrome ATS;
- the organisation that will carry out these tasks locally; and
- the communication procedures established for special occurrences/events, emergency landings or diversions, including reporting procedures.

The submitted drawings showing the design of the aerodrome should contain information regarding:

- the kind of facilities, installations and equipment to be established at the aerodrome or in its vicinity (e.g. cameras, sensors, etc.) to enable and support the remote aerodrome ATS; and
- their location.

Information concerning the planned overall height of the above-mentioned facilities, installations and equipment should also be provided.

Moreover, information should be provided regarding the technical solutions employed for:

- the operation/control/monitoring of the aerodrome's lighting systems and their individual elements, as appropriate;
- the communication systems between the ATS unit and the relevant aerodrome units (e.g. rescue and firefighting services (RFFS) station, apron management services unit as appropriate, persons or vehicles operating on the manoeuvring or movement area (if apron management services are also provided by the ATS unit);
- the operation of the alerting system for RFFS purposes;
- the operation of the signalling lamp;
- the provision of light and pyrotechnic signals to aerodrome traffic[36]; and
- any other aerodrome equipment/system which would have to be used by the ATS personnel.

7.1.2. Aerodrome manual

In the case of remote aerodrome ATS, the aerodrome manual should additionally contain relevant information, including but not limited to:

- provision of relevant information to the aeronautical information service (AIS) for publication in the AIP;
- procedures for the transition of ATS provided from a conventional tower to ATS provided from a remote tower, and vice versa, if applicable;
- procedures for the day-to-day coordination (day- and night-time) between the aerodrome operator and the ATS provider, including wildlife management, airside work interaction, etc. as appropriate;

[36] In EASA Member States, see Commission Implementing Regulation (EU) No 923/2012 [4] (SERA.3301, Appendix 1).

- procedures for the participation of ATS personnel in the aerodrome's safety committees, including the Local Runway Safety Team, and the implementation of the local safety programmes, including joint training and aerodrome familiarisation with other relevant personnel;
- procedures to facilitate site awareness of remote aerodrome ATS personnel (ATCOs/AFISOs), including e.g. the frequency and the agenda for on-site familiarisation visits;
- procedures for low-visibility/extreme weather situations;
- information about the location of facilities (maps, charts), installations and equipment enabling and supporting the remote aerodrome ATS, within and, if applicable, outside the aerodrome's boundaries;
- operating, maintenance (including emergency maintenance) repair and service instructions, troubleshooting and inspection procedures of facilities, installations and equipment enabling and supporting the remote aerodrome ATS;
- procedures for meteorological observation and provision;
- procedures for apron management services provision;
- procedures and measures for the protection of facilities, installations and equipment enabling and supporting the remote aerodrome ATS, control of activities, and ground maintenance in the vicinity of these installations;
- procedures for safeguarding such facilities, installations and equipment against acts of unlawful interference;
- contingency procedures for technical degradation and operational procedures for airspace users in the event of a single point of failure at the RTC;
- procedures for the use of light and pyrotechnic signals to aerodrome traffic; and
- procedures for initiating a NOTAM declaring the aerodrome closed in the event of failure of facilities, installations and equipment enabling and supporting the remote aerodrome ATS.

7.1.3. Local agreement between aerodrome and ATM/ANS providers

In accordance with Regulation (EU) 2017/373 [2], ATS.OR.110, 'An ATS provider shall establish arrangements with the operator of the aerodrome at which it provides ATS to ensure adequate coordination of activities and services provided, as well as exchange of relevant data and information'. This requirement is supported by a set of AMC and GM which address specific aspects of such coordination. A corresponding requirement (point (b)(1) of ADR.OR.C.005) is stipulated in Regulation (EU) No 139/2014 [5] addressing the aerodrome operator. In the case of remote aerodrome ATS, these arrangements should additionally cover the elements contained in Section 7.1.2.

Once the system is in place and operational, the arrangements should also cover all measures relevant to operation, including but not limited to:

- prevention of any new electrical equipment interference with the system elements (EMC compatibility);

— detailed planning of maintenance activities that might have an effect on the system elements; and

— access rights and procedures for equipment rooms and shelters that house more than one item of suppliers' equipment.

7.1.4. Equipment placement constraints

System design may require placing remote tower elements, especially cameras and their holding fixtures at the runway strip, taxiway strip, RESA or near the strip of a precision approach runway. For further details on camera placement, see Section 5.2.6. Placing objects inside the runway strip and its corresponding obstacle surfaces is generally prohibited, but Annex 14 [10], Volume 1, Chapter 9.9, on equipment siting, clearly allows equipment inside the runway safety areas if it is needed for air navigation purposes. According to the Chicago Convention[37] nomenclature, the term 'air navigation' is equivalent to ATM, and not restrictive to navigation as part of CNS; hence, cameras or other CNS equipment required for air navigation purposes are allowed inside the runway safety areas as well.

The applicable EU regulatory framework on aerodromes (CS ADR-DSN.J.480) also allows objects above the inner approach surface, the inner transitional surface or the balked landing surface, provided that they are frangible and because of their function, they should be located on the strip. Furthermore CS ADR-DSN.T.915 stipulating restrictions regarding equipment siting on operational areas allows such installations provided 'its function requires it to be there for air navigation or for aircraft safety purposes'. Also, GM1 ADR-DSN.B.150 repeats the provisions of Annex 14 [10], permitting placement.

Equipment placement should be done taking into account applicable safety and security rules and procedures. When deciding on the most appropriate location, due consideration should be paid to leave the ILS critical/sensitive areas clear. If camera sites are easily accessible to the general public (i.e. outside the aerodrome security area), it should be protected with special care. This should be taken into consideration when developing the physical protection specification, and during implementation and operation. Also Annex 14 [10], Volume I, Chapter 6.1.1 as well as CS ADR-DSN.Q.840, regarding aerodromes that fall within the scope of Regulation (EU) 2018/1139 [1], require objects within the lateral boundaries of the obstacle limitation surfaces to be marked and/or lighted.

7.2. Operational aspects

7.2.1. Coordination between the aerodrome operator and the ATM/ANS providers in the event of system failure

In the event of failure of any of the facilities, installations and equipment enabling and supporting remote aerodrome ATS (locally or remotely), timely coordination between the aerodrome operator and the ATS provider should take place to identify the cause and impact of the failure on the operations, according to the agreed technical and operational contingency procedures between the aerodrome operator and the ATS service provider, and to timely notify this information via NOTAMs, as necessary.

[37] ICAO Document 7300.

7.2.2. Aerodrome safeguarding

In the case of remote aerodrome ATS, although no additional impacts on aerodrome safeguarding procedures (as prescribed by ADR.OPS.B.075 of Regulation (EU) No 139/2014 [5]) is in general anticipated, the aerodrome operator should ensure that:

— the risk of sources of non-visible radiation, or the presence of moving (or fixed) objects, or any other activity, which may interfere with, or adversely affect, the performance of applicable facilities, installations and equipment enabling and supporting the remote aerodrome ATS is assessed and mitigated;

— appropriate security procedures are established and implemented for the protection of such facilities, installations and equipment;

— appropriate security and/or preventive actions according to cyberthreats during the transition of aeronautical data and information are in place (including the provision of redundancy measures);

— only authorised people have access to the facility and/or related equipment and data.

7.2.3. Maintenance of the remote tower system facilities

Where remote aerodrome ATS is provided, the maintenance programme of the remote tower systems at the aerodrome should cover the maintenance needs of the facilities, installations and equipment, including electrical systems, which enable and support the remote aerodrome ATS. Such arrangements should also specify the maintenance responsibilities of the involved organisations.

A preventive maintenance programme should be established and implemented. Such a programme should contain information related to scheduled maintenance work in order to prevent a failure or degradation of such facilities, installations and equipment.

The preventive maintenance programme should be based on the maintenance instructions of the manufacturer of the respective facility, installation and equipment, as appropriate, and should contain all the necessary information for its timely and correct implementation, including but not limited to:

— the type of inspections/checks to be carried out (e.g. visual inspection, cleaning of equipment, equipment stability/alignment, calibration, etc.) for each facility, installation and equipment, taking also into account factors such as their location and meteorological phenomena;

— the frequency of inspections/checks for each facility, installation and equipment;

— the tools and equipment required for each type of inspection/check; and

— the periodic replacement of parts of equipment that may be required.

Arrangements should be in place to ensure that timely corrective maintenance action is taken to ensure safety and regularity of services. Such arrangements should cover the cases of maintenance needs that are:

— identified either during preventive maintenance activities; or

— raised at any other time (e.g. due to equipment malfunction or failure).

7.2.4. Management of the change to remote aerodrome ATS — aerodrome operator[38]

At aerodromes where ATS is provided from a conventional tower and the introduction of remote aerodrome ATS is planned, or at aerodromes where no ATS is provided but is planned to be introduced via the introduction of remote aerodromes ATS, due care and time should be taken for the adequate preparation of the transition/implementation plan before the change/introduction is introduced.

Due to the significance of the change, a competent authority approval may be required. Therefore, the aerodrome operator and the ATS provider should communicate intentions and plans to the appropriate competent authority in due time before the planned introduction of the new operating concept in order to avoid unnecessary delays.

As part of the aerodrome operator's processes and procedures for managing safety, including changes, a safety assessment accompanied with the updated relevant documentation required for initial certification, including human factors aspects, should be submitted by the aerodrome operator to its competent authority prior to the introduction of the change. This assessment should be properly coordinated with the ATS provider and all other interfacing organisations that may be affected by the change.

Although each aerodrome's unique characteristics (based on its complexity, types of operations, organisational arrangements, etc.) may have an effect on both the content and the outcome of the safety assessment, it is expected that this process should at least include the following areas:

— Tasks that are currently performed by the ATS provider and which may need to be performed by the aerodrome operator. This may include:
  - tasks that fall under the responsibility of the aerodrome operator but had been performed by the ATS provider based on existing local arrangements (e.g. runway surface condition assessment or apron management service) and which may need to be performed by the aerodrome operator; and
  - tasks which fall under the responsibility of the ATS provider and which are planned to be performed by the aerodrome operator, based on existing or new local arrangements. Such tasks may include, but are not limited to:
    - maintenance of facilities, installations and equipment necessary for the remote aerodrome ATS;
    - meteorological observations; and
    - provision of pyrotechnic signals to aerodrome traffic.
  - tasks which were, and will continue to be, performed by the aerodrome operator, but which may be affected by the introduction of the change in that they may need to be enhanced in order to cover additional areas. Such tasks may include, but are not limited to:
    - regular inspections conducted by the aerodrome operator;

[38] Refer to Regulation (EU) No 139/2014 [5], ADR.OR.B.040 Changes.

  - safeguarding and protection of facilities, installations and equipment necessary for the remote aerodrome ATS (e.g. obstacles, interference from various sources, etc.); and
  - security procedures for the protection of facilities, installations and equipment necessary for the remote aerodrome ATS.

— Need for review, update and timely implementation of the training requirements for aerodrome personnel, as a result of task reassignment/enhancement, but also amendment of the aerodrome procedures.

— Technical solutions applied:

- remotely for the implementation of the remote aerodrome ATS, such as:
  - operation/control of the aerodrome's lighting systems and their individual elements, as appropriate;
  - operation/control of the visual surveillance system elements located at the aerodrome, as appropriate;
  - communication systems between the remote ATS unit and the relevant aerodrome units (e.g. RFFS station, apron management services unit), persons or vehicles operating on the manoeuvring or movement area (if apron management services are also provided by the remote ATS unit); and
  - operation of the alerting system for RFFS purposes;
- at the aerodrome in order to support the implementation of the remote aerodrome ATS, such as:
  - provision of power supply to the facilities, installations and equipment for providing and supporting ATS remotely;
  - location/installation of cameras and, if applicable, sound microphones; and
  - any other data processing equipment (servers, computers, etc.).

7.2.5. Power supply at aerodromes

Apart from the applicable power supply infrastructure requirements, aerodromes provided with remote aerodromes ATS should also meet the power supply measures listed below.

7.2.5.1 Electrical power supply systems for the remote aerodrome ATS

— Cameras and related facilities enabling and supporting the remote aerodrome ATS and located at an aerodrome should be provided with adequate primary power supply.

— Cameras and related facilities enabling and supporting the remote aerodrome ATS and located at an aerodrome should be provided with a secondary power supply capable of supplying power when there is a failure of the primary power supply. Electric power supply connections to such cameras and related facilities should be so arranged that they are automatically connected to the secondary power supply when the primary power supply fails.

— The power supply for cameras and related facilities mentioned above should be continuous/uninterrupted.

7.2.6. Cameras at aerodromes when apron management services is provided by the ATS unit

For aerodromes (provided) with remote aerodrome ATS and where the respective ATS unit is also responsible for the provision of apron management services, cameras should be in place and so located as to provide the ATS unit with an unobstructed view of the apron(s) (under the responsibility of that ATS unit).

8. Possible impact on airspace users

In principle, and as confirmed by recent operational experience and validation activities, remote aerodrome ATS should not negatively impact airspace users. With reference to Regulation (EU) 2017/373 [2], ATM/ANS.OR.A.075 complemented by AMC1 ATM/ANS.OR.A.075(a) in Annex III to EASA ED Decision 2017/001/R [6], an ATS provider is required to 'provide its services in an open and transparent manner'. This would include the introduction and operation of remote aerodrome ATS. The ATS provider should ensure that relevant aeronautical information is included in the appropriate products and services (see Chapter 9 below). Furthermore, the ATS provider is required to establish a consultation process with the users of its services on a regular basis or as needed for specific changes in service provision, either individually or collectively[39]. Part of this consultation could include the contingency planning for the services provided.

In any case, the ATS provider should analyse any possible impacts on airspace users when conducting the safety assessment and propose appropriate mitigation measures as part of the operations manual. Particular care needs to be taken in the case of multiple mode of operation, where the operations at different aerodromes may become interdependent (see also Sections 5.10, 6.5.1 and 6.5.2). The impacts and mitigation measures should be coordinated by the ATS provider and by the aerodrome operator with airspace users as specified in Regulation (EU) 2017/373 [2], ATM/ANS.OR.A.045 and in GM1 ADR.OR.D.027 to Regulation (EU) No 139/2014 [5] respectively.

Airspace users are informed through the aeronautical information products and services — see Chapter 9, and through other means according to Regulation (EU) 2017/373 [2]. Selecting alternate aerodromes remains a responsibility of airspace users. The objective of the ATS provider should be to allow availability of a suitable level of aerodrome ATS at an alternate.

ATS providers are recommended to disseminate information in other and more interactive forms, such as regular workshops with airspace users to present amongst other things relevant information for selection of alternate aerodrome(s).

As remote tower operations from an RTC generate interdependencies between the ATS provision to several aerodromes, Member States and competent authorities are advised to assess the acceptability of the level of interdependence generated and take measures as deemed suitable. Those measures may include but are not limited to the selection of aerodromes to be served by the same RTC in a given geographical area and/or to the distribution of aerodrome opening hours to ensure adequate availability of a suitable aerodrome.

[39] The requirement stems from Regulation (EU) 2017/373 [2], ATM/ANS.OR.A.075.

9. Aeronautical information products and services

The ATS provider should, together with the aerodrome operator, perform an analysis of the aeronautical information affected by the introduction of remote aerodrome ATS and ensure that relevant aeronautical information is included in the appropriate products and services, as stipulated in the relevant requirements in Annex IV 'Part-ATS' and Annex VI 'Part-AIS' to Regulation 2017/373 [2].

With regard to the publication of the aeronautical information, general requirements are laid down in AIS.TR.305, while the AIP content and structure are established in Appendix 1 to Annex VI 'Part-AIS'.

Section AD 2.23 of the AIP structure determines the elements of information to be published for each of the aerodromes at which ATS is provided remotely. They include:

— indication that remote aerodrome ATS is provided;

— location of the signalling lamp by e.g. the phrase 'signalling lamp positioned at [geographical fix]' as well as a clear indication of the signalling lamp location in the aerodrome chart for each relevant aerodrome;

— description of any specific communication methods as deemed necessary in the case of multiple mode of operation, such as e.g. the inclusion of airport names/ATS unit call sign for all transmissions (i.e. not only for the first contact) between pilots and ATCOs/AFISOs;

— description of any relevant actions required by the airspace users following an emergency/abnormal situation and possible contingency measures by the ATS provider in case of disruptions, if applicable (see AD 2.22 'Flight procedures' of the AIP structure); and

— description of the interdependencies of service availability or indication of aerodromes not suitable for diversion from the aerodrome […] if deemed applicable.

Furthermore, indication that ATS is remotely provided should be included in all approach charts of aerodromes where ATS is remotely provided, with reference to the information listed above. To facilitate this, the provisions of ICAO Annex 4 apply. Annex 4 does not foresee the inclusion of similar information in the approach charts, but it does allow the inclusion of additional symbols on the chart: 'Symbols used shall conform to those shown in Appendix 2 — ICAO Chart Symbols, except that where it is desired to show on an aeronautical chart special features or items of importance to civil aviation for which no ICAO symbol is at present provided, any appropriate symbol may be chosen for this purpose, provided that it does not cause confusion with any existing ICAO chart symbol or impair the legibility of the chart.' Also in 2.3.3 of Annex 4 it is stipulated that 'A legend to the symbols and abbreviations used shall be provided. The legend shall be on the face or reverse of each chart except that, where it is impracticable for reasons of space, a legend may be published separately.' Another solution could be to use an abbreviation as they are allowed to be used — see '2.9.1 Abbreviations shall be used on aeronautical charts whenever they are appropriate.'

This information should not only be provided in the AIP. Other flight preparation sources should be used, as appropriate.

This information should be provided in the AIP. Other flight preparation sources may be used, as appropriate.

Information on implementation plans and milestones may be published in the aeronautical information circular (AIC). For instance, dates and scope of validation exercises, and planned date of operation.

10. Qualification, training and licensing considerations

Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.001 stipulates: 'A service provider shall ensure that it is able to provide its services in a safe, efficient, continuous and sustainable manner, consistent with any foreseen level of overall demand for a given airspace. To this end, it shall maintain adequate technical and operational capacity and expertise.' Furthermore, Regulation (EU) 2017/373 [2], ATM/ANS.OR.B.005(a)(6) stipulates that '(a) A service provider shall implement and maintain a management system that includes: (…) (6) a process to ensure that the personnel of the service provider are trained and competent to perform their duties in a safe, efficient, continuous and sustainable manner. In this context, the service provider shall establish policies for the recruitments and training of its personnel;'.

With reference to the above, all personnel involved in the operation and maintenance of facilities, installations and equipment enabling and supporting the remote aerodrome ATS are to be adequately trained, qualified and competent.

For considerations on multiple endorsements, see Section 4.4.2.

10.1. Qualification and training of ATCOs

The specificities concerning the qualification and training of ATCOs providing remote aerodrome ATS are presented in the AMC and GM to Regulation (EU) 2015/340 [3]; such Regulation establishes the general framework for the licencing of ATCOs [3].

10.2. Qualification and training of AFISOs

Although, at the time of publication of this document, the EU legislation does not include a detailed regulatory framework with regard to the qualification and training of personnel providing aerodrome flight information service (AFISO), the rules presented under Chapter 10 above apply as well for AFIS providers. It is left to the Member States to define the appropriate regulatory means to meet these requirements in accordance with the local AFIS provision.

10.3. Qualification and training of ATSEP

ATSEP involved in the operation and maintenance of equipment, facilities and installations enabling and supporting the remote aerodrome ATS, are to be adequately trained, qualified and competent to perform their duties in accordance with the requirements laid down in Regulation (EU) 2017/373 [2] (Part-PERS) and in Regulation (EU) No 139/2014 [5] (ADR.OR.D.015 and ADR.OR.D.017), as appropriate.

With ED Decision 2020/020/R, AMC & GM to Part-PERS — Amendment 1, AMC and GM to Part-PERS were introduced. This Decision defines qualification streams related to the different ATSEP fields of expertise. Detailed training material is presented in Attachment A to ED Decision 2020/020/R. Remote aerodrome ATS operators are advised to consider combining qualification streams and any additional needed knowledge or competence based on the unique set of competencies required for ATSEP operating and maintaining remote aerodrome ATS equipment.

11. References

11.1. EU Regulations

[1] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91

[2] Commission Implementing Regulation (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011

[3] Commission Regulation (EU) 2015/340 of 20 February 2015 laying down technical requirements and administrative procedures relating to air traffic controllers' licences and certificates pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council, amending Commission Implementing Regulation (EU) No 923/2012 and repealing Commission Regulation (EU) No 805/2011

[4] Commission Implementing Regulation (EU) No 923/2012 of 26 September 2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation and amending Implementing Regulation (EU) No 1035/2011 and Regulations (EC) No 1265/2007, (EC) No 1794/2006, (EC) No 730/2006, (EC) No 1033/2006 and (EU) No 255/2010

[5] Commission Regulation (EU) No 139/2014 of 12 February 2014 laying down requirements and administrative procedures related to aerodromes pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council

11.2. EASA ED Decisions

[6] Executive Director Decision 2017/001/R of 8 March 2017 issuing Acceptable Means of Compliance and Guidance Material to Commission Implementing Regulation (EU) 2017/373

11.3. ICAO provisions/publications

[7] ICAO Doc 4444 ‘Procedures for Air Navigation Services — Air Traffic Management’ (PANS-ATM), Sixteenth Edition, 2016, Amendment 11 of 3 November 2022

[8] ICAO Doc 9426 ‘Air Traffic Services Planning Manual’, First (provisional) edition, 1984

[9] ICAO Annex 11 ‘Air Traffic Services’, Fourteenth Edition, July 2016

[10] ICAO Annex 14 ‘Aerodromes – Volume I, Aerodrome Design and Operations’, Eighth Edition, July 2018

[11] AO Circular 211-AN/128, 1988

11.4. Technical standards

[12] EUROCAE ED-240A Change 1, ‘Minimum Aviation System Performance Standard (MASPS) for Remote Tower Optical Systems’, September 2021

11.5. SESAR JU deliverables/publications

[13] SESAR Solution #71, ATC and AFIS service in a single low density aerodrome from a remote CWP, Contextual Note

[14] SESAR Solution #12, Single remote tower operations for medium traffic volumes, Contextual Note

[15] SESAR Solution #13, Remotely-provided air traffic services for contingency situations at aerodromes, Contextual Note

[16] SESAR Solution #52, Remotely Provided Air Traffic Services for Two Low Density Aerodromes, Contextual Note

[17] OSED for Remote Provision of ATS to Aerodromes, SESAR JU Deliverable D94, Edition 00.07.01, 2016-07-15

[18] Remote Tower Technical Specifications, SESAR JU Deliverable D09, Edition 01.00.00, 2016-03-07

[19] Remotely Provided Air Traffic Service for Single Aerodrome VALR (Remark: VALR=Validation report), SESAR JU Deliverable D08-02, Edition 00.05.02, 2014-05-01

[20] OFA06.03.01 Remote Tower - Safety Assessment Report for Single Remote Tower, SESAR JU Deliverable D108, Edition 00.02.01, 2016-07-26

[21] Contingency TWR Trial 1 & 2 Validation Report, SESAR JU Deliverable D12, Edition 00.03.01, 2015-11-02 (covered in [18])

[22] Contingency Tower V3 – VALR *(**Remark**: VALR=Validation report)* VP-752, SESAR JU Deliverable D107, Edition 00.01.01, 2016-05-15 covered in [18]

[23] 6.8.4 SAR (Remark: SAR=Safety *Assessment Report)* Contingency Tower - Final Update, SESAR JU Deliverable D110, Edition 00.02.01, 2016-08-22

[24] Human Performance Assessment - Contingency Tower, SESAR JU Deliverable D111, Edition 00.02.01, 2016-07-22

[25] Remotely Provided Air Traffic Service for Two Low Density Aerodromes Validation Report, SESAR JU Deliverable D13, Edition 00.04.01, 2015-11-23

[26] OFA06.03.01 Remote Tower - Safety Assessment Report for Multiple Remote Tower, SESAR JU Deliverable D32, Edition 00.01.01, 2015-11-18 covered in [17]

[27] Remotely provided Air Traffic Services for two low density aerodromes Appendix F: HP Assessment Report, SESAR JU Deliverable D28, Edition 00.01.01, 2015-09-01

[28] Demonstration Report RTO *(**Remark:** Demonstrations performed in Germany, the Netherlands and Sweden)*, SESAR JU Project LSD 02.05, Edition 00.02.00, 2016-10-28

[29] Demonstration Report *(**Remark**: Demonstrations performed in Budapest)*, SESAR JU Project LSD 02.10, Edition 01.00.20, 2016-12-15

[30] Remote Towers Demonstration Report *(**Remark:** Demonstrations performed in Ireland)*, SESAR JU Project LSD 02.04, Edition 00.02.00, 2016-10-24

11.6. Other publications

[31] European Operational Concept Validation Methodology (EOCVM) Version 3.0, 15 February 2010

[32] EUROCONTROL Manual for Aerodrome Flight Information Service (AFIS), Edition 1.0, 17 June 2010

[33] Effects of Lower Frame Rates in a Remote Tower Environment, The Tenth International Conference on Advances in Multimedia (MMEDIA 2018), IARIA, 2018, pp. 16-24, ISBN: 978-1-61208-627-9

12. Appendices

12.1. Appendix 1: Checklist for the implementation of remote aerodrome ATS

Based on the content of this document, the following elements are listed, for reference purposes only, in order to summarise some important aspects to be considered when implementing remote aerodrome ATS and for the related safety assessment.

— Assessment on configuration of technical enablers, based on operational context, needs and requirements and support from safety, security, and human factors assessments (see e.g. Sections 3.5, 5.2.8, 5.2.7.2 and 5.4).

— Assessment of socio-economic factors, including impact assessment before the decision to implement remote aerodrome ATS, checking the relevance of the initial impact assessment and social aspects during transition from a conventional TWR to an RTC (see Section 6.1).

— Development of operational visual performance requirements on the visual presentation and the binocular functionality, based on primary/direct and indirect regulatory requirements as well as other operational needs (see Sections 5.2.3, 5.2.4 and 5.2.5).

— Development of functional requirements on the visual presentation and the binocular functionality, supporting the above-mentioned operational visual performance requirements (see Section 5.2.7).

— Siting assessment of location and number of cameras at the aerodrome to meet view and operational visual performance requirements (see Section 5.2.6).

— Implementation of data recording of new system elements, for the purpose of supporting accident and incident investigations (see Section 5.6).

— Identification of redundancy needs for the technical architecture, particularly with regard to the communication link between the remote facility and the aerodrome (see Section 5.10).

— Assessment of impact on interfaces/interdependencies with external stakeholders/entities/persons/organisations and analysis of the necessary coordination processes and procedures (see Sections 5.1 and 6.2.2 as well as Chapters 7 and 8).

— Assessment of impact on existing and new tasks and the need for a possible reassignment of tasks, with particular reference to:

- ATS tasks (see Chapter 5);
- aerodrome operator tasks (see Section 5.1 and Chapter 7);
- MET-related tasks (see Section 5.8);
- AIS-related tasks (see Chapter 9); and
- maintenance tasks (see Sections 5.11 and 7.2.3).

— Human factors assessment, including working environment and ergonomics analysis (see Sections 6.33, 5.12 and 5.13.6).

— Security risk assessment (see Sections 6.66 and 7.2.2).

— Split of the remote aerodrome ATS technical system into constituents in accordance with the interoperability Regulation (see Section 6.8).

— Transition/implementation plan developed by the ATS provider and the aerodrome operator (see Section 6.5).

— Development of a contingency plan and related procedures, also including the need for coordination between the ATS provider, the aerodrome operator, and any other involved stakeholder (see Sections 6.7 and 7.2.1).

— Review and update of the aerodrome documentation (see Section 7.1).

— Review and documentation of roles and responsibilities assigned to the ATS provider and the aerodrome operator (see Section 7.1.3).

— Coordination between the ATS provider and the aerodrome operator in relation to safety assessment process and methodology (see Sections 6.2 and 7.2.4).

— Review and update of the training requirements for ATS provider's and aerodrome operator's personnel (see Chapters 7 and 10).

— Analysis of possible impact on operational procedures and/or airspace users (see Chapters 4, 5, 7 and 8).

— Analysis of aeronautical information products and services and proposed modifications (see Chapter 9).

12.2. Appendix 2: List of operational hazards for ATC services

Table 2 below lists the operational hazards and the operational effects for the ATC services, as derived from the SESAR safety work, performed in the framework of the SESAR JU programme. They are valid in the context of both single mode of operation as well as multiple mode of operation. However, it should be noted that the list of operational hazards was developed for the specific operational applications and context that was studied and using the specific methodology as described in the SESAR safety assessment reports [20], [23] and [26]. Therefore, if using this list as initial input, it needs to be adapted as necessary, taking into account the local conditions and the operational application and context of the particular implementation as well as the addition of potential system hazards.

Table 2: List of operational hazards (SESAR safety assessment — ATC case)

ID	Description	Operational effects
OH-01	Remote ATC incorrectly coordinates with other ATS unit with respect to inbound/outbound traffic.	A potential conflict can be induced. Imminent infringement.
OH-02	Remote ATC incorrectly manages the entry of a flight into traffic circuit.	A potential conflict can be induced. Imminent infringement.
OH-03	Remote ATC incorrectly manages arriving aircraft.	A potential conflict can be induced. Imminent infringement.
OH-04	Remote ATC incorrectly manages departing aircraft.	A potential conflict can be induced Imminent infringement
OH-05	Remote ATC fails to provide appropriate separation to traffic in the vicinity of the aerodrome.	Imminent infringement.
OH-06	Remote ATC fails to provide appropriate separation to traffic with respect to restricted areas.	Tactical conflict.
OH-07	Remote ATC incorrectly manages missed approach situation.	Imminent infringement.
OH-08	Remote ATC does not detect in time conflicts/ potential collision between aircraft in the vicinity of the aerodrome.	Imminent collision.
OH-09	Remote ATC does not detect in time restricted area infringements.	Tactical conflict.
OH-10	Remote ATC fails to provide appropriate instruction to resolve a conflict between traffic in the vicinity of the aerodrome.	Imminent collision.
OH-11	Remote ATC fails to provide appropriate instruction to resolve an airspace infringement.	Tactical conflict.
OH-12	Remote ATC fails to provide appropriate information to departing aircraft for the start-up.	Tactical taxiway conflict generated.
OH-13	Remote ATC fails to enable push-back/towing operations to appropriate aircraft.	Tactical taxiway conflict generated.

ID	Description	Operational effects
OH-14	Remote ATC provides inadequate taxiing instruction to aircraft on the manoeuvring area.	Encounter with aircraft, vehicle or obstacle.
OH-15	Remote ATC provides inadequate taxiing instruction to vehicle on the manoeuvring area.	Encounter with aircraft, vehicle or obstacle.
OH-16	Remote ATC does not detect in time potential conflict on the manoeuvring area.	Imminent collision.
OH-17	Remote ATC fails to provide appropriate instruction to resolve conflicts on the manoeuvring area.	Imminent collision.
OH-18	Remote ATC fails to provide (appropriate) navigation support to aircraft and vehicle on the manoeuvring area.	Tactical taxiway conflict generated.
OH-19	Remote ATC incorrectly manages runway entry for a departing aircraft (occupied runway).	Runway conflict.
OH-20	Remote ATC incorrectly manages runway exit for a landing aircraft.	Runway conflict.
OH-21	Remote ATC incorrectly manages runway crossing (occupied runway) for a vehicle or an aircraft.	Runway conflict.
OH-22	Remote ATC fails to properly support departing and landing aircraft (with respect to visual aids).	Runway conflict.
OH-23	Remote ATC incorrectly manages vehicle-related tasks on the runway.	Runway conflict.
OH-24	Remote ATC incorrectly manages aircraft take-off (occupied runway).	Runway conflict.
OH-25	Remote ATC incorrectly manages aircraft landing (occupied runway).	Runway conflict.
OH-26	Remote ATC fails to detect in time runway incursions (aircraft or vehicles).	Runway penetration.
OH-27	Remote ATC fails to provide appropriate instruction to resolve runway incursion and prevent potential collision on the runway.	Runway penetration.
OH-28	Remote ATC fails to detect in time a flight towards terrain in the vicinity of the aerodrome.	Imminent controlled flight into terrain (CFIT).
OH-29	Remote ATC fails to provide appropriate support to pilot in a CFIT situation.	Imminent CFIT.
OH-30	Remote ATC fails to establish sufficient wake-turbulence spacing between aircraft.	Turbulence in front of the aircraft at a distance less than the separation minima.
OH-31	Remote ATC fails to properly support landing/ take-off operations with respect to weather conditions.	Potential landing accident/runway excursion.
OH-32	Remote ATC fails to properly support landing/ take-off operations with respect to runway conditions and potential foreign object debris.	Potential landing accident/runway excursion.

ID	Description	Operational effects
OH-33	Remote ATC fails to properly support departing and arriving aircraft on the runway with respect to non-visual aids.	Potential landing accident/runway excursion.
OH-34	Remote ATC fails to detect in time an intrusion inside landing-air protection area.	Potential landing accident/runway excursion.
OH-35	Remote ATC fails to provide appropriate ATC services with respect to operational environment conditions on the aerodrome and its vicinity.	This hazard is already covered by more detailed hazards already identified above, potentially inducing conflicts in the vicinity of the aerodrome or on the manoeuvring area due to inappropriate understanding of the operational environment conditions. This hazard is related to all other hazards EXCEPT: OH-01, OH-08, OH-09, OH-13, OH-16, OH-26, OH-28, OH-34.
OH-36	ATC resources are incorrectly managed in the RTC for the remote provision of ATC services.	In case a controller has to manage more traffic than expected, the controller workload could be negatively impacted and so the capability to provide ATC services. This hazard is to be considered as part of ALL the other hazards in which controller errors are a potential cause.
OH-37	Remote ATC fails to provide appropriate ATC services due to inappropriate capability of the remote tower system.	This hazard is already considered as part of ALL other hazards already identified above in which equipment failure/errors are potential causes, potentially inducing conflicts in the vicinity of the aerodrome or on the manoeuvring area.

12.3. Appendix 3: List of operational hazards for AFIS

Table 3 below lists the operational hazards as derived from the results of the SESAR safety work (performed in the framework of the SESAR JU programme) that may be considered by the ATS provider for AFIS. They are valid in the context of both single mode of operation as well as multiple mode of operation. However, it should be noted that the list of operational hazards was developed for the specific operational applications and context that was studied and using the specific methodology as described in the SESAR safety assessment reports [20] and [26]. The SESAR safety work focused on the ATC service case, assuming that the most constraining results specifying the concept of remote aerodrome ATS would be derived from ATC services. Therefore, if using this list as an initial input, it needs to be adapted as necessary taking into account the local conditions and the operational application and context of the particular implementation as well as the addition of potential system hazards.

Table 3: Initial list of operational hazards (SESAR safety assessment — AFIS case)

ID	Description
OH-AFIS-01	Remote AFIS fails to properly select runway-in-use.
OH-AFIS-02	Remote AFIS fails to identify potential ‘conflicts’ in the vicinity of the aerodrome.
OH-AFIS-03	Remote AFIS fails to provide appropriate traffic information (including local traffic) to relevant traffic: — direction of flight or traffic concerned; — type of wake-turbulence category; — level of traffic and potential changes; — relative bearing (12-h clock indication); — other relevant information.
OH-AFIS-04	Remote AFIS fails to provide appropriate information concerning the availability of the runway for departing/arriving traffic.
OH-AFIS-05	Remote AFIS fails to provide appropriate traffic position information on the manoeuvring area.
OH-AFIS-06	Remote AFIS fails to provide appropriate wake-turbulence- and jet-blast-related information.
OH-AFIS-07	Remote AFIS fails to provide appropriate essential information on aerodrome conditions (surface conditions, maintenance works, obstacles, birds, lighting system failure, etc.) to departing and arriving traffic: — conditions on the manoeuvring area; — conditions on the parking area.
OH-AFIS-08	Remote AFIS fails to provide appropriate start-up instructions to departing traffic.
OH-AFIS-09	Remote AFIS fails to provide appropriate meteorological information to departing and arriving traffic.
OH-AFIS-10	Remote AFIS fails to manoeuvre the visual signals to indicate to traffic that the aerodrome is not safe.

ID	Description
OH-AFIS-11	Remote AFIS incorrectly coordinates with ATC for arriving traffic.
OH-AFIS-12	Remote AFIS incorrectly coordinates with ATC for departing traffic.
OH-AFIS-13	Remote AFIS fails to provide appropriate information on local traffic to assist taxiing operations.
OH-AFIS-14	Remote AFIS incorrectly provides authorisation to persons/vehicles to enter into the manoeuvring area.
OH-AFIS-15	Remote AFIS fails to provide light signals to vehicles and personnel on the manoeuvring area (when adequate or in case of radio communication failure).
OH-AFIS-16	Remote AFIS fails to provide appropriate relevant information on local traffic and aerodrome conditions to assist the flight crew in deciding when to take off.
OH-AFIS-17	Remote AFIS fails to provide appropriate relevant information on local traffic and aerodrome conditions to assist the flight crew in deciding whether to land or go around.
OH-AFIS-18	Remote AFIS fails to detect a runway incursion or the existence of any obstruction (including animals) on or in close proximity to the take-off/landing area.
OH-AFIS-19	Remote AFIS fails to operate aeronautical ground lights: — manoeuvring area lighting; — taxiway area lighting.
OH-AFIS-20	Remote AFIS fails to monitor visual aids status.

12.4. Appendix 4: SESAR division of basic and advanced features

The documentation of the SESAR JU programme often refers to a division of technical enablers into 'basic' and 'advanced' features, when presenting the results of the various validations and SESAR Solutions. Depending on the particularities of each validation and each SESAR Solution, this division between 'basic' and 'advanced' sometimes differs slightly between the SESAR deliverables. For the purpose of this document, a screening of the various technical set-ups regarding the division of 'basic' versus 'advanced', as described for the various SESAR Solutions ([13], [14], [15], [16]) and their related SESAR validations ([19], [21], [22], [25]), has been made and based on that, a representative division is presented below. When this document is discussing the results and validations of the SESAR JU programme and referring to 'basic' and 'advanced' equipage, the division presented below is assumed:

— **Basic features**

- visual presentation, replacing the OTW view of a conventional tower
- binocular functionality (e.g. a PTZ camera/function, as defined and described in ED-240A Change 1 [12]), fulfilling the function of a binocular in a conventional tower

— **Advanced features**

- additional visual 'hot spot' cameras
- the use of infrared or other optical sensors/cameras outside the visible spectrum
- binocular functionality automatically following moving objects (commonly referred to as 'PTZ tracking')
- dedicated means to facilitate the detection, identification and automatic following of aircraft or vehicles in the visual presentation (e.g. by labels based on surveillance data, complemented by flight plan correlation when available, commonly referred to as 'radar tracking');
- dedicated means to facilitate the detection and following of moving objects in the visual presentation (e.g. by highlighting/framing such objects based on image processing systems, commonly referred to as 'visual tracking');
- other overlaid information in the visual presentation such as framing and/or designation of runways, taxiways, etc., compass directions, meteorological information, aeronautical information (NOTAM, SNOWTAM, etc.), other operational information (e.g. runway conditions like water, snow or mud presence, coefficient of friction, etc.);
- ATS surveillance (air and/or ground radar presentation).

12.5. Appendix 5: List of acronyms

ACC	area control centre
AD	aerodrome
ADS-B	automatic dependent surveillance – broadcast
AFIS	aerodrome flight information service
AFISO	aerodrome flight information service officer
AIC	aeronautical information circular
AIP	aeronautical information publication
AIS	aeronautical information service
AMC	acceptable means of compliance
ANS	air navigation service
APP	approach control
ATC	air traffic control (in this document mostly used to specifically target ‘aerodrome control service’)
ATCO	air traffic controller
ATM	air traffic management
ATS	air traffic service
ATSEP	air traffic safety electronics personnel
CFIT	controlled flight into terrain
CNS	communication navigation surveillance
CWP	controller working position
EASA	European Union Aviation Safety Agency
EC	European Commission
ED Decision	Executive Director Decision
E-OCVM	European Operational Concept Validation Methodology
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
FIC	flight information centre
FOD	foreign object debris
GM	guidance material
HMI	human-machine interface
ICAO	International Civil Aviation Organization
ID	identifier
IFR	instrument flight rules
IR	implementing rule
IT	information technology
MASPS	Minimum Aviation System Performance Standards
MET	meteorological
METAR	meteorological terminal aviation routine weather report
NOTAM	notice to airmen
OH	operational hazard
OSED	operational services and environment description
OTW	out-of-the-window
PANS-ATM	Procedures for Navigation Services – Air Traffic Management

PSR	primary surveillance radar
PTZ	pan-tilt-zoom
QNH	Q code indicating atmospheric pressure adjusted to sea level
RFFS	rescue and firefighting services
RGL	runway guard lights
RTC	remote tower centre
RTM	remote tower module
RWY	runway
SAR	safety assessment report
SERA	standardised European rules of the air
SESAR	Single European Sky ATM Research
SESAR JU	Single European Sky ATM Research Joint Undertaking
SSR	secondary surveillance radar
TAF	terminal aerodrome forecast
UPS	uninterruptible power supply
VALR	validation report
VFR	visual flight rules
WAN	wide area network