Remote Tower (RT) Systems Minimum Functional and Performance Requirements for Non-Federal Applications

For Use in Class D Airspace
Version 3.0
January 2022

CONTENTS

1 INTRODUCTION

1.1 SCOPE

This document contains the minimum functional and performance requirements for Remote Tower (RT) systems consisting of a single Remote Tower Module (RTM) as referenced in the Federal Aviation Administration (FAA) Advisory Circular *Remote Towers (RT) Systems For Non-Federal Applications*. The minimum functional and performance requirements apply to all Non-Federal RT systems used in providing Airport Traffic Control Tower (ATCT) services for a single runway airport in Class D airspace, using Visual Flight Rules (VFR). The RT concept of operation is defined in the FAA *Remote Tower Systems Concept of Operations*. The minimum functional and performance requirements within this document do not address integration with any other forms of surveillance (e.g., Radio Detection and Ranging (RADAR), Automatic Dependent Surveillance-Broadcast (ADS-B), Multilateration, etc.).

1.1.1 DOCUMENT LAYOUT

Section 1.2 provides a high-level RT system overview.

Section 2 states the functional and performance requirements. The functional requirements are functions that the intended solution needs to perform to satisfy the mission of the RT system. The performance requirements quantitatively or qualitatively assert how well the functional requirement needs to perform to satisfy the mission of the RT system.

Section 3 states the RT system Physical Integration requirements.

Section 4 states the Human Factor considerations and requirements.

Section 5 states the Security and Safety requirements.

The Appendices contain a list of acronyms, glossary terms, references, human factors guidance, Verification Requirement Test Matrix (VRTM) criteria, and estimated inherent availability.

1.1.2 DOCUMENT CONVENTIONS

The requirements for RT systems contained in this document will utilize the following conventions:

a. **Must** – This is a mandatory functional requirement. It "must" perform this function. Example: The SLG must be capable of being directed at a target of interest.
b. **Shall** – This specifies the requirement of quantitative performance. The function "shall" perform within this specification. Example: The SLG function shall respond within 250 milliseconds of operator input.
c. **Should** – This is a requirement recommendation. The function "should" perform in this manner. Example: The AAA volume should be a logarithmic volume control.
d. **May** – This is an optional functionality. The system "may" provide this functionality. Example: The RT system may provide SVP functionality.

All of the requirements in this document will be tagged with a unique requirement identifier as [Rxxxx] or [Nxxxx].

where "xxxx" is a unique numerical value
"R" identifies minimum requirements (must and shall) and
"N" identifies optional and recommendation (may and should)

Unique requirement identifiers are not necessarily in numerical order within the requirement document, but are subject to change with the final version.

In the event of a conflict between referenced documents and the contents of this specification, the contents of this specification take precedence.

1.2 SYSTEM OVERVIEW

The RT system is composed of the following list of functions, synchronized with a common time reference and the sharing of data through a point-to-point closed network. The RT system functions are described in Table 1 along with components that may make up each function. The conceptual allocation of components represent one means, but not the only means, to architect an RT system.

1. Required Visual Presentation (RVP)
2. Ambient Airfield Audio (AAA)
3. Data Recorder (DR)
4. Signal Light Gun (SLG)
5. Control Status Display (CSD)
6. Maintenance Data Terminal (MDT)
7. Magnification
8. Supplemental Visual Presentation (SVP) (Optional)

Table 1 – RT System Functions

Function	Description	Conceptual Component Allocations
RVP	Provide an ATCS visual presentation of the airport environment and surrounding airspace to meet the FAA *Overarching Remote Tower System Research Operational Visual Requirements (OVRs)*. The RVP is composed of an RVP-Primary Display or an RVP-Primary Display in conjunction with an RVP-Secondary Display. The RVP-Primary Display is a continuous 360-degree fixed-view of the airport and surrounding airspace. RVP-Secondary Display(s) provide enhanced views of the airport and/or surrounding airspace. RVP-Secondary Display(s) can be shown on the RVP-Primary Display or a separate supporting display monitor. *Note: RVP-Secondary Displays are not required unless the RVP-Primary Display cannot satisfy all of the OVRs.*	Display Monitor(s) RVP Cameras Data Processor Encoders/Decoders Ancillary Equipment Control-Display Workstation

Function	Description	Conceptual Component Allocations
SVP	Provide an ATCS with auxiliary visual presentations or enhancements that provide additional situational awareness. The SVP is optional and is not required to satisfy meeting the OVRs. Supplemental information can be presented on the RVP at a preferred location chosen by ATCS or it can be presented on supporting display monitor(s). Supplemental information can be generated from the additional optical sensors (e.g., Pan-Tilt-Zoom (PTZ) cameras, thermal cameras, etc.) and/or software enhanced images (e.g., overlays, box-and-track, segment image enlargements, etc.).	Display Monitor(s) RVP Cameras Supplemental Cameras Data Processor Encoders/Decoders Ancillary Equipment Control-Display Workstation
AAA	Provides ATCS with an ambient airfield audio broadcast in the RTM.	Microphone(s) Speaker(s) Data Processor Encoders/Decoders Control-Display Workstation
DR	Records visual data to support accident/incident investigation.	Memory Storage Device
SLG	Provides capability to communicate with aircraft, vehicles, equipment, and personnel on the airport and surrounding airspace through visible light visual signals.	Control-Display Workstation Remote Light Gun (RLG)
MDT	The MDT function provides secure input and output capability for equipment, control, and monitoring of the RT system components.	Monitor and Input Devices
CSD	Provides a secure user interface (e.g., Graphical User Interface (GUI)) at the Controller Working Position (CWP) for all necessary annunciations and RT system control. Annunciations will include RT system status and any necessary Alerts and Alarms. RT system controls include, and are not limited to, controlling the RVP, AAA, SLG, SVP, and Magnification functions, as well as ancillary devices and audible or visual alerting, etc.	Control-Display Workstation
Magnification	Provide the capability to enhance through image magnification a portion of the RVP-Primary Display to meet the OVRs (e.g., PTZ camera, software digital zoom, or a short focal length optical device). The functionality is optionally allowed to be provided through an integrated PTZ camera, integrated software digital zoom, or a short focal length optical device.	(SVP Camera(s), Control-Display Workstation, Data Processor Encoders/Decoders, and Ancillary Equipment) or Short focal length optical device

The RT system is composed of all functionality that resides at either the Remote Tower Center (RTC), the Airport Remote Tower, or an MDT. Figure 1 illustrates a conceptual RT system allocation overview and how various components are allocated to physical locations.

Note: The minimum functional and performance requirements of this document only address an RTC hosting a single RTM.

The RTC is an indoor environment residing on the airport property or at a remote location (off-airport property). The Airport Remote Tower is located at the airport facility and is to be sited and installed in accordance with applicant requirements. The MDT can interface with the system at the Airport RT and/or at the RTM.

The MDT function provides secure user access for input and output to the RT system components. The MDT is a workstation that is equipped with the necessary processing capacity, GUI software, interfaces to enable real-time monitoring, maintenance, and control of the RT system. The MDT will be used by installers, maintainers, remote maintainers, and system administrators to conduct:

- System configuration updates (e.g., view system status information, control system, software updates, network configuration updates, configurable parameter setup/modifications, modify/view adaptation data, etc.).
- Maintenance activities (i.e., fault diagnostics, corrective and preventative maintenance, calibration, troubleshooting, Built-In-Test (BIT), etc.).
- Viewing of stored system data such as resources, faults, warnings, system errors, event logs, security audit logs, and networking information.

Note: Remote maintenance access through the MDT function is optional functionality.

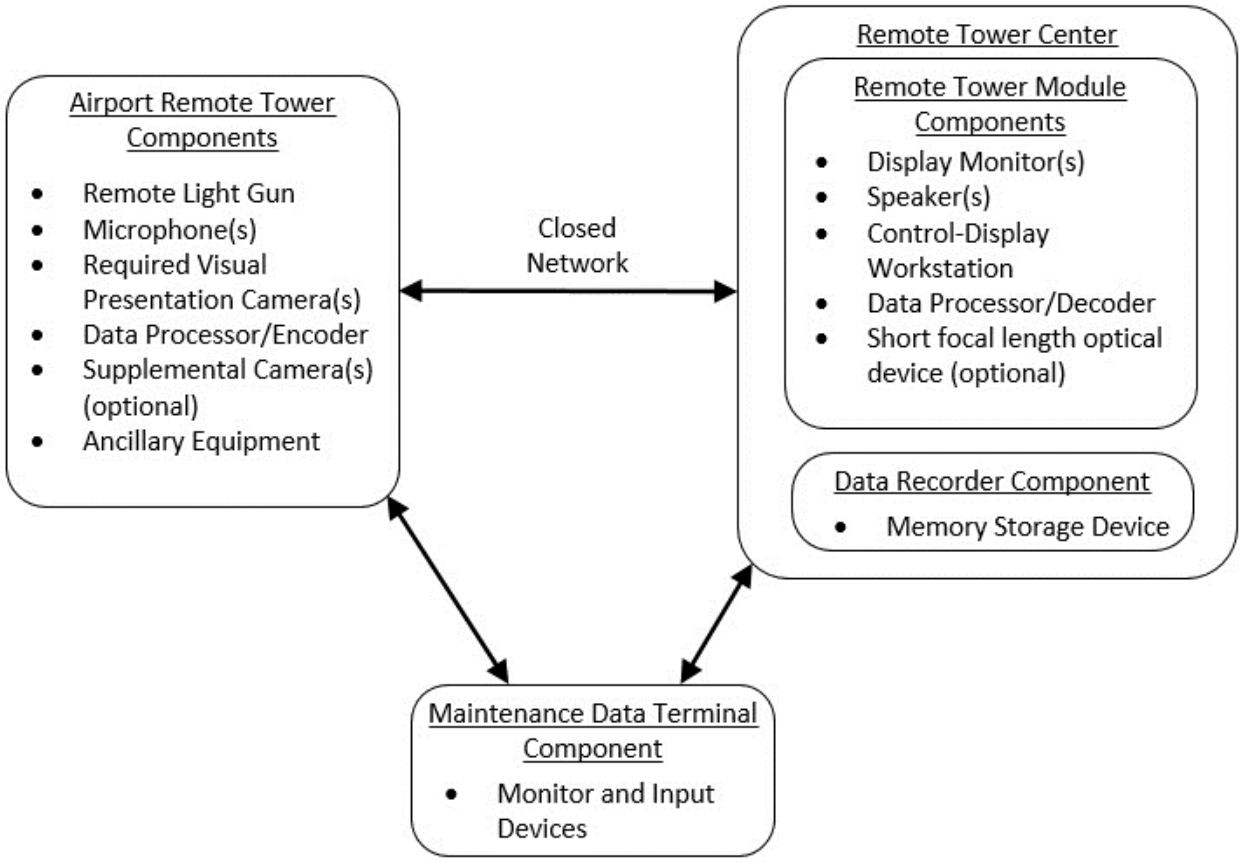

Figure 1 – System Overview

1.2.1 AIRPORT RT COMPONENTS

The Airport RT conceptual components consist of the RLG, RVP camera(s), microphone(s), supplemental camera(s), data processor/encoder, and ancillary equipment. The Airport RT components reside at the airport in both indoor and outdoor environments, providing the sensor data to the RTM via a point-to-point closed network. A description for each of the Airport RT conceptual components are shown in Table 2.

Table 2 – Airport RT Conceptual Components

Conceptual Components	Description
RLG	Remote control signal light gun capable of being directed in azimuth and elevation to cover backup communication with aircraft, vehicles, and personnel in areas of jurisdiction.
RVP Camera(s)	Camera(s) providing video information for RVP-Primary Display: Visible spectrum camera(s) composed of optical sensors that are fixed focal (fixed focal length, fixed angle of view, fixed level of zoom) are used to create the RVP-Primary Display's 360-degree out-the-window view. Camera(s) providing video information for RVP-Secondary Display: Visible spectrum camera(s) composed of optical sensors that are either fixed or variable focus/scan can be used to create the RVP-Secondary Display.

Conceptual Components	Description
Microphone(s)	Sound wave transducer(s) to capture ambient airfield sounds for the reproduction of AAA at the RTM.
Data Processors/Encoder	Provide the necessary processing of the optical sensors to produce a video stream and audio stream for creating the virtual airport environment for the RVP, AAA and optionally for the SVP and Magnification functions. The processor function can also support monitoring and control capability.
Supplemental Cameras	Cameras and controls to provide information for SVP(s) (e.g., additional cameras/views, PTZ cameras).
Ancillary Equipment	Any additional equipment used to support the required Remote Tower functions. Examples include the capability to control the amount of light exposure into the camera lens, keeping the camera lens clear of debris (dust, rain, etc.), improve power reliability, environmental control for equipment stability, and medium to transfer required data from Airport Remote Tower Components to the Remote Tower Center.

1.2.2 RTC CONCEPTUAL OVERVIEW

The RTC is divided between conceptual components that make up an RTM and a Data Recorder. The RTC conceptual components consist of display monitor(s), speakers, data recorder, control-display workstation, data processors/decoder, memory storage devices, and a short focal length optical device. The RTC conceptual components are shown in Table 3.

Table 3 – RTC Conceptual Components

Conceptual Components	Description
Display Monitor(s)	Component(s) making up the video wall for presentation of RVP-Primary Display, optional RVP-Secondary Display, and optional SVP(s). Component(s) making up separate displays for enhanced views supporting optional RVP-Secondary Display and SVP(s).
Speaker(s)	Sound wave transducer(s) for providing ATCS with audio sound.
Data Processor/Decoder	Provide the necessary video and AAA processing for creating the visual and audio presentation of the airport environment for the RVP, AAA, and optionally for the SVP and Magnification functions. The processor will also provide the necessary RT system Alerts, Alarms, control capability and Non-volatile Memory (NVM) for system event activity, security audit files, user authentication profile files, etc.
Control-Display Workstation	A computer workstation to host additional display monitor(s) and the CSD GUI for all necessary ATCS annunciations and RT system control. The Control-Display Workstation can interface with the SLG, AAA, RVP, SVP, and Magnification functions.
Short focal length optical device	7x50mm binoculars
Memory Storage Devices	NVM storage devices for recording and saving data in support of the Data Recorder Function.

2 FUNCTIONAL AND PERFORMANCE REQUIREMENTS

2.1 FUNCTIONAL REQUIREMENTS

The RT system must [R0190] consist of RVP, SLG, MDT, DR, Magnification, AAA, and CSD functions.

Note: Magnification function's capability can be a directable zooming/scanning capability provided on the RVP-Secondary Display, and/or short focal length binoculars used by ATCS in viewing the RVP-Primary Display. Magnification function is considered part of the RVP-Secondary Display if it is required to meet OVRs; otherwise, it is considered part of the SVP. Providing short focal length binoculars as part of the system to meet OVRs does not preclude providing a Magnification function to support optional enhanced views on the RVP or SVP.

The RT system may [N0191] provide SVP functionality.

Note: Supplemental information, such as overlays, box-and-track, thermal imagery, zoom functionality is not required as a minimum functionality. However, if SVP functionality is implemented, requirements in § 2.1.8 apply.

The RT system must [R0007] have an environmental impact mitigation capability which can be activated in response to environmental impacts affecting the RVP including, but not limited to, birds, insects, and weather (e.g., dust, snow, ice, rain).

Note: The activation can be accomplished manually, automatically, or a combination of manual and automatic means.

The environmental impact mitigation capability may [N0253] be a combination of manual and automatic features such as compressed air burst, defrosting elements, wipers, etc.

Some environmental impact mitigation capability may [N0254] be activated automatically, such as heaters in relation to a temperature control function.

The RT system's environmental impact mitigation's response time shall [R0201] be within 10 seconds of a command.

Note: The 10 seconds response time corresponds to the time between an ATCS command action (e.g., turn wiper on) and an RT system response (e.g., wiper is operational).

The RT system must [R0008] provide the capability to balance light exposure in the RVP video image(s) for ATCS viewing (e.g., analogous to "draw the shades" functionality).

Note: This is intended to limit the loss of visual information near sources of high variations in ambient light intensity such as the sun, reflection glare, or other lighting sources.

The RT system shall [R0066] be synchronized to a certified external Coordinated Universal Time (UTC) reference which supports a resolution less than or equal to 0.01 seconds.

The RT system synchronization to a certified external UTC reference shall [R0067] be maintained within 100 milliseconds.

The RT system must [R0014] indicate the status and signal mode of the SLG (FAA Order JO 7110.65 *Air Traffic Control* § 3-2-1, Light Signals).

2.1.1 REQUIRED VISUAL PRESENTATION

The RVP "out of the window" view is used by the ATCS to meet the OVRs and is generated using a combination of optical sensors, hardware, and software components.

Design considerations and tradeoffs for RVP are left to the manufacturer. These considerations and tradeoffs include display resolution, sensor resolution, field of view, frame rate, refresh rates, refresh contrast, video update rate, video compression, bandwidth, network latency, jitter, chromaticity, color contrast, luminance, contrast ratio, buffering, noise, packet loss, codec, image uniformity, size of the display monitor, display monitor pixel density, distance of the display monitor from the operator, visual angle of targets by size, and distance from the camera.

Additional guidance for design is provided in European Organization for Civil Aviation Equipment (EUROCAE) ED-240 *Minimum Aviation System Performance Standard for Remote Tower Optical Systems*. Further guidance on human factors considerations are provided in Appendix D Human Factors Guidance and Recommendations.

The RVP functionality must [R0180] be capable of meeting all OVRs.

Note: The FAA Overarching Remote Tower System Research Operational Visual Requirements document identify if the individual OVR is to be met by the ATCS utilizing either an RVP-Primary Display or an RVP-Primary Display in conjunction with an RVP-Secondary Display.

The RVP must [R0281] be composed of an RVP-Primary Display or an RVP-Primary Display in conjunction with an RVP-Secondary Display(s).

The RVP-Primary Display must [R0003] be a continuous 360-degree fixed-view of the airport environment and surrounding airspace.

Note 1: With respect to this requirement, continuous means a seamless view with no parts of the view missing.

Note 2: With respect to this requirement, fixed-view means the RVP-Primary Display will not be panned, rotated, or magnified.

The RVP-Primary Display's perspective must [R0004] be from a single fixed point of view, single fixed focal point, and single fixed level of zoom.

The RVP-Primary Display's video shall [R0182] only be from visible light spectrum cameras (i.e., cameras that capture light spectrum wavelengths 380-740 nanometers).

The RVP-Secondary Display(s) may [N0202] be presented on the RVP-Primary Display or separate supporting display monitor(s).

The RVP-Secondary Display(s) may [N0179] provide enhanced views of the airport and/or surrounding airspace.

Note: RVP-Secondary Display views (e.g., magnifications, infrared imagery, etc.) overlayed on the RVP-Primary Display are to be implemented in a manner that does not interfere with ATC operations (ability for meeting OVRs on the RVP-Primary Display).

The RVP-Secondary Display's enhanced views may [N0181] provide fixed focal length or zoom (i.e., variable focal length) view, with or without pan/tilt capability.

The RVP-Secondary Display's PTZ must [R0250] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.

Note: This is to ensure consistent and predictable responses to the users.

The RVP functionality shall [R0200] have a frame rate of 25 Hertz (Hz) or higher.

The RVP functionality must [R0009] present the system mode (See § 2.2.1) on the RVP-Primary Display.

The capture-to-display latency shall [R0012] be less than or equal to one second between an event in the real world and the visual presentation on the RVP.

Note: The RVP capture-to-display latency includes the time interval between consecutive frames.

2.1.2 SIGNAL LIGHT GUN

The SLG functionality must [R0184] provide the capability of transmitting signals in accordance with FAA Order JO 7110.65 *Air Traffic Control* § 3-2-1, Light Signals.

The SLG functionality must [R0016] be capable of being verified for proper operation by the ATCS.

Note: Proper operation consists of the ability to direct and transmit the intended signal.

The SLG functionality must [R0203] be capable of directing the RLG at a target of interest.

The SLG functionality shall [R0204] respond within 250 milliseconds of operator input.

The SLG functionality shall [R0205] be capable of reaching a continuous rotational speed of at least 60 degrees per second.

The SLG functionality shall [R0206] be capable of reaching a continuous tilting speed of at least 60 degrees per second.

The SLG functionality shall [R0208] provide the capability of movement between two positions in the horizontal plane which are 60 degrees apart from a resting state to a resting state within two seconds, not including control latency.

The SLG functionality shall [R0255] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SLG functionality control latency.

The SLG functionality must [R0015] be capable of being disabled in Maintenance Mode.

2.1.3 MAINTENANCE DATA TERMINAL

The MDT functionality for Access Level 3 is required to facilitate installation and maintenance activities. Access Level 4 is optional. Access Level definitions and example functionality can be found in § 5.1.

The MDT must [R0018] include a display monitor, keyboard, mouse or touchpad, and industry-standard communication port.

The MDT functionality must [R0019] enable the Access Level 1 and 3 users to interact with the RT system using a GUI.

The MDT functionality must [R0020] provide for Access Level 3 maintainers the capability to command and monitor all test and maintenance actions available within the RT system.

Note: The MDT is the primary maintenance tool for interfacing with the RT system.

The MDT functionality should [N0021] provide for Access Level 3 maintainers the capability to perform hardware, software, and interface fault diagnostics, detection, and isolation on all RT system elements.

The MDT functionality must [R0022] provide for Access Level 1 and 3 users diagnostic information to aid in fault isolation.

The MDT functionality must [R0023] provide for Access Level 3 maintainers the capability to initiate Key Performance Parameter (KPP) monitoring to aid in diagnostic and fault isolation.

Note: See § 2.2.2 for Key Performance Parameter (KPP) monitoring.

The MDT functionality must [R0024] provide for Access Level 3 maintainers the capability of initiating intrusive and non-intrusive diagnostics tests.

The MDT functionality must [R0026] provide for Access Level 3 maintainers the capability of retrieving the System Event Log from the RT system NVM.

The MDT functionality must [R0185] provide for Access Level 3 maintainers the capability to configure the RT system.

Note: System configuration includes view system status information, control system, software updates, network configuration updates, configurable parameter setup/modifications such as AAA, Alerts, Alarms, etc., modify/view adaptation data, and the optimization of visual presentations.

The MDT functionality must [R0186] provide for Access Level 3 maintainers the capability of installing RT software.

The MDT functionality must [R0187] be capable of showing the RT system's current software and adaptation version identification.

The MDT functionality must [R0027] provide for Access Level 1 and 3 users the capability for viewing System Events from the System Event Log.

The MDT functionality should [N0028] provide for Access Level 3 maintainers the capability for sorting and searching the System Event Log.

The MDT functionality must [R0029] provide for Access Level 3 maintainers the capability of exporting the System Event Log onto external media.

The MDT functionality must [R0030] provide for Access Level 3 maintainers the capability to clear the System Event Log.

The MDT functionality must [R0031] have the capability to view the current system state and system mode.

The MDT functionality should [N0032] enable the capability for Access Level 3 maintainers to manually override the automatic redundant element management actions.

The MDT functionality must [R0257] provide the capability of visually presenting Alarms, Service Alerts, Security Alerts, and Alerts.

The MDT functionality must [R0034] provide the capability for Access Level 3 maintainers to clear Alarms, Service Alerts, and Alerts.

The MDT functionality should [N0252] provide the capability to disable audible Alarms, Service Alerts, and Security Alerts annunciated by the CSD function during Maintenance Mode.

2.1.4 DATA RECORDING

The DR function must [R0035] record all the data provided on the RVP and SVP (if provided) to support playback and post-analysis.

The DR function must [R0047] record the Magnification function when provided as part of the RVP, with the visual presentation and the visual presentation control selections as a part of the normal visual presentation recording (i.e., if the control functions are selectable/viewable from the RVP).

The DR function shall [R0036] store the most recent 45 days of recorded data.

The DR function shall [R0037] timestamp all recorded data at a minimum frequency of one Hz.

The DR function timestamp shall [R0038] have an accuracy less than or equal to 0.01 seconds.

The DR function must [R0039] use NVM.

The DR function NVM storage must [R0040] be secured from tampering and manipulation.

The DR functionality must [R0042] provide the recording capability without degradation to the RT system or RVP.

The DR function's exported data format must [R0043] be documented in an Interface Control Document (ICD) for data interpretation.

The DR functionality must [R0044] provide the capability for data to be played back without loss of fidelity.

The DR functionality must [R0188] provide the capability of exporting the recorded data onto external media.

2.1.5 MAGNIFICATION

The Magnification functionality shall [R0209] be capable of providing seven times the magnification or greater.

The Magnification functionality must [R0210] be capable of being directed at an area of interest.

The Magnification functionality shall [R0211] respond within 250 milliseconds of operator input.

The Magnification functionality's PTZ shall [R0212] be capable of reaching a continuous rotational speed of at least 60 degrees per second.

The Magnification functionality's PTZ shall [R0213] be capable of reaching a continuous tilting speed of at least 60 degrees per second.

The Magnification functionality's PTZ shall [R0214] provide the capability of movement between two pan positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including Magnification functionality control latency.

The Magnification functionality's PTZ shall [R0258] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including Magnification functionality control latency.

The Magnification functionality's PTZ must [R0259] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.

Note: This is to ensure consistent and predictable responses to the users.

2.1.6 AMBIENT AIRFIELD AUDIO

The AAA functionality must [R0048] be reproduced at the RTM.

The AAA's time delay between the real-time audio and the reproduction audio shall [R0050] be less than one second.

The AAA functionality's upper and lower-level volume limits shall [R0215] be configurable between a range of volume settings from 0 dBA to +85 dBA.

The AAA functionality's volume control should [N0216] be a logarithmic volume control.

The AAA functionality must [R0192] be integrated into the RT system independent of the ATCS radio communication system.

Note: The AAA is to provide ATCS with additional situational awareness and is independent and separate from the ATCS radio communication system. The AAA is not to interfere with ATCS radio communication.

2.1.7 CONTROL STATUS DISPLAY

The CSD function is the ATCS user interface for the RT system. Access Level definitions can be found in § 5.1.

The CSD functionality must [R0260] provide a minimum of two Access Level 2 user interfaces.

The CSD functionality must [R0054] provide the capability for multiple independent Access Level 2 users at the same time.

The CSD functionality must [R0058] be a dedicated means for Access Level 2 user control, input, and output for the RT system.

Note: The user control includes interfacing with all the elements of the RT system necessary for the ATCS to fulfill their mission. Elements include RVP, SLG, Magnification, SVP, and AAA functions, as well as ancillary devices and audible or visual alerting, etc. Layout and design of control device(s), information display(s), and alerting methods need to provide a suitable human-machine interface design to minimize human error and maximize efficiency.

The CSD functionality must [R0218] provide the capability of visually presenting Alarms, Service Alerts, and Security Alerts to the Access Level 2 user.

The CSD functionality must [R0261] have the capability for Access Level 2 users to view the current system state and system mode.

The CSD functionality must [R0262] provide the capability for the audible presentation for Alarms, Service Alerts, and Security Alerts to the Access Level 2 user.

The CSD functionality must [R0217] provide the Access Level 2 user the capability to turn on and off the AAA.

The CSD functionality must [R0064] provide the capability for an Access Level 2 user to control the balancing of light exposure in the video image(s) (e.g., analogous to "draw the shades" functionality).

The CSD functionality must [R0079] provide the capability for an Access Level 2 user to mute individual audible Alarms, Service Alerts, and Security Alerts once activated.

The CSD functionality must [R0236] provide the capability for an Access Level 2 user to suppress individual visual Service Alerts and Security Alerts once activated.

The CSD functionality must [R0220] provide the capability for an Access Level 2 user to control and activate environmental impact ancillary equipment.

The CSD functionality must [R0221] provide the capability for an Access Level 2 user to control and activate the SLG.

The CSD functionality must [R0222] provide the capability for an Access Level 2 user to control and activate the Magnification function (non-short focal length optical device implementations).

The CSD functionality should [N0223] provide the capability for an Access Level 2 user to toggle on and off all SVP on the RVP-Primary Display with a single input by the user.

Note: This provides the capability to declutter the RVP-Primary Display by allowing the user to select and deselect all SVP with a single action.

The CSD functionality shall [R0224] respond within 250 milliseconds of Access Level 2 user inputs.

2.1.8 SUPPLEMENTAL VISUAL PRESENTATION

Supplemental information, such as overlays, box-and-track, thermal imagery, zoom functionality is not required as a minimum functionality. However, if the manufacture chooses to implement SVP functionality, the requirements in this section apply.

Design considerations and tradeoffs for SVP are left to the manufacturer. These considerations and tradeoffs include display resolution, sensor resolution, field of view, frame rate, refresh rates, refresh contrast, video update rate, video compression, bandwidth, network latency, jitter, chromaticity, color contrast, luminance, contrast ratio, buffering, noise, packet loss, codec, image uniformity, size of the display monitor, display monitor pixel density, distance of the display monitor from the operator, visual angle of targets by size and distance from the camera.

Additional guidance for design is provided in EUROCAE ED-240 *Minimum Aviation System Performance Standard for Remote Tower Optical Systems*. Further guidance on human factors considerations are provided in Appendix D Human Factors Guidance and Recommendations.

The SVP may [N0225] be presented on the RVP-Primary Display or a separate display monitor(s).

The SVP functionality shall [R0226] have a frame rate of 25 Hz or higher.

The capture-to-display latency shall [R0227] be less than or equal to one second between an event in the real world and the visual presentation on the SVP.

Note: The SVP capture-to-display latency includes the time interval between consecutive frames.

If the SVP is presented on a separate display monitor, the performance for luminance, chromaticity, and contrast must [R0228] be equivalent to the RVP (see Appendix D Human Factors Guidance and Recommendations).

Note: Equivalent is assumed to mean no discernible difference from an operators' view.

The SVP functionality's PTZ shall [R0229] respond within 250 milliseconds of operator input.

The SVP functionality's PTZ shall [R0230] be capable of reaching a continuous rotational speed of at least 60 degrees per second.

The SVP functionality's PTZ shall [R0231] be capable of reaching a continuous tilting speed of at least 60 degrees per second.

The SVP functionality's PTZ shall [R0232] provide the capability of movement between two pan positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SVP PTZ control latency.

The SVP functionality's PTZ shall [R0263] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SVP PTZ control latency.

The SVP functionality's PTZ must [R0233] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.

Note: This is to ensure consistent and predictable responses to the users.

2.2 PERFORMANCE REQUIREMENTS

2.2.1 STATES AND MODES

The RT system must [R0068] have two system states: ON and OFF.

Note: A system state of OFF has no electrical power applied to the system. A system state of ON has power applied to the system.

The RT system must [R0069] have the following three system modes: Operational, Non-Operational, Maintenance when the system state is ON.

Note: Table 4 identifies the typical expectation of the system operation associated with the system mode, alarms, and alerts.

Table 4 – Relationship between System Modes and Alarms and Alerts

System Mode	***Alarms & Alerts***	***Expectation***	***Indication[1]***
Operational	*No Alarms, Service Alerts, Alerts*	*The RT system is working as expected within the minimum performance requirements*	*Normal*
Operational	*Service Alert*	*The RT system is working as expected; however, some level of degradation has occurred indicating maintenance needs to be scheduled. (e.g., failed redundant component, could impact future continuity or availability)*	*Caution*
Operational	*Security Alert*	*The RT system is working as expected; however, some level of degradation to Security has occurred indicating the System Administrator needs to be notified.*	*Caution*
Operational	*Alert*	*The RT system is working as expected, however, some level of minor degradation in the expected performance has occurred indicating advisory for potential future maintenance needs.*	*Advisory*
Non-Operational	*Alarm*	*RT system is operating; however, the operational integrity is no longer meeting the required level of performance indicating the information shown on the RVP and SVP is not to be trusted or used.*	*Warning*
Maintenance	*N/A*	*The RT system is unavailable for use.*	*N/A*

Note 1 - FAA HF-STD-001 Human Factors Design Standard § 5.5.1.2.5 Establish priority system

The RT system must [R0074] transition to a Non-Operational Mode when an Alarm condition (See § 2.2.2) is detected.

The RT system must [R0170] only allow configuration changes that will impact Operational Mode while the System Mode is in Maintenance Mode.

Note: Examples of configuration changes include changes to the software, firmware, and adaptation data, and any hardware configurations that may be performed through the system interface.

The RT system must [R0171] automatically attempt to recover to the same system mode for any unplanned interrupt in operation from an unexpected event (e.g., power interruption).

The RT system shall [R0172] automatically transition the system state to OFF when operations cannot be maintained due to power conditions.

The RT system must [R0025] only allow intrusive diagnostics tests to be invoked during Maintenance Mode.

Note: Intrusive diagnostics is testing that introduces system behaviors impacting and/or interrupting the ATC service.

2.2.2 ALARMS AND ALERTS

The RT system must [R0071] automatically execute performance monitoring of all KPPs.

The RT system KPPs must [R0086] be uniquely identified as any parameter of the RT system, subsystem, interface, Line Replaceable Unit (LRU), or equipment, which is a critical indicator of whether or not it is performing its intended function.

The RT system KPPs must [R0072] be checked at a rate consistent with the required time-to-alert or time-to-alarm (see § 6.1.2 Integrity).

Note: Time-to-alert requirements will be defined by the manufacturer of the RT system.

The RT system must [R0073] generate an Alarm upon detecting a faulted condition for which the integrity of the system is no longer guaranteed (see § 6.1.2 Integrity).

The RT system must [R0075] generate a Service Alert upon detecting a faulted condition requiring corrective maintenance.

Note 1: KPP monitoring design and thresholds associated with Service Alerts need to be chosen to identify the need to schedule maintenance due to a failed device or component of the system.

Note 2: A Service Alert provides the user a warning the RT system requires maintenance to preserve the system's ability to maintain the MTBCF. See § 6.2 Reliability, Maintainability, and Availability (RMA) Requirements.

The RT system must [R0076] generate an Alert upon detecting a faulted condition not affecting the system's functional capabilities but is an advisory indication for potential maintenance needs.

Note: KPP monitoring design and thresholds associated with Alerts need to be chosen for generating pre-Alarm performance awareness. This relationship provides an advisory for action on system performance degradation situations and present the opportunity for preventative maintenance. This serves to aid preventative maintenance.

The RT system Alarm, Service Alert, Security Alert, and Alert indications should [N0117] be developed with the use of FAA HF-STD-001 *Human Factors Design Standard* § 5.5 Alarms, Audio and Voice Communication.

2.2.3 REDUNDANT ELEMENT MANAGEMENT

The RT system operation of all redundant elements must [R0081] be managed by performance monitoring.

2.2.4 EVENT LOGGING

The RT system must [R0085] automatically log all Alerts, Service Alerts, and Alarms, and all performance monitoring events in the System Event Log.

The RT system Events logged in the System Event Log should [N0084] be those that aid in diagnostic testing and fault isolation.

The RT system must [R0173] automatically log all state transitions, including those resulting from unexpected power interruptions in the System Event Log.

The RT system must [R0087] store System Events to a NVM System Event Log in chronological order with each event being uniquely identified and timestamped.

The RT system shall [R0088] be capable of storing 45 days of System Events in the System Event Log.

The RT system must [R0089] automatically log all system recovery events in the System Event Log.

The RT system must [R0090] automatically log all system events involving the clearing of Alarms, Service Alerts, and Alerts in the System Event Log.

The RT system must [R0046] record any activation of the integrated Magnification function, along with the control parameters (e.g., directing, zoom, etc.) as an event in the System Event Log.

The RT system must [R0239] record all commands that mute or suppress notifications for Alarms and Service Alerts in the System Event Log.

The RT system must [R0017] record the SLG activation command and the control parameters (e.g., directing (azimuth/elevation), transmitted signal selection) in the System Event Log.

2.2.5 ENVIRONMENT

Components making up the RT system shall [R0092] operate in either of the following environmental conditions, depending on siting and installation instructions:

* FAA-G-2100 *Electronic Equipment, General Requirements* § 3.2.1.1.3 Indoor Operating Environments

* FAA-G-2100 *Electronic Equipment, General Requirements* § 3.2.1.1.2 Common Outdoor Operating Environmental Conditions

2.2.6 POWER

The RT system equipment shall [R0093] meet requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.1.1 Electrical Power.

The RT system must [R0096] provide protection from input power conditions resulting in damage to equipment, false operation, misleading outputs, and loss of function.

The RT system equipment must [R0097] automatically restart after acceptable power input conditions are restored following a shutdown resulting from an out-of-tolerance power input condition.

2.2.7 MECHANICAL

The RT system equipment's mechanical design shall [R0098] meet requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.1.2 Mechanical.

Any RT system equipment masts located within the airport safety areas (Runway Safety Area, Object Free Area, and Obstacle Free Zone) shall [R0099] be frangible in accordance with 14 Code of Federal Regulations (CFR) part 139 *Certification of Airports* and FAA Advisory Circular 150/5300.13 *Airport Design*.

2.2.8 MATERIALS

The RT system equipment shall [R0108] meet the material requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.3.1 Materials, Processes, and Parts.

All RT system workstations and personal computer batteries shall [R0109] comply with requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.3.1.4.1 Batteries.

The RT system materials should [N0094] be non-nutrient to rodents, insects, non-hygroscopic and not adversely affected by the environmental conditions for which this equipment is installed.

2.2.9 ELECTROMAGNETIC EMISSIONS AND SUSCEPTIBILITY

The RT system equipment shall [R0264] meet the electromagnetic emissions and susceptibility requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.3.2 Electromagnetic Compatibility.

3 INTEGRATION REQUIREMENTS

3.1 PHYSICAL INTEGRATION

3.1.1 ENVIRONMENTAL SENSOR REQUIREMENTS

The RT system must [R0103] provide temperature sensor(s) in each separate enclosed cabinet.

The RT system must [R0105] monitor cabinet temperature sensors.

The RT system must [R0104] have a nominal operating range of temperatures by means of an upper and lower temperature threshold.

The RT system must [R0106] generate a Service Alert when the cabinet temperature exceeds either the upper or lower cabinet temperature threshold.

3.1.2 GROUNDING, BONDING, SHIELDING, LIGHTNING PROTECTION, CABLES, POWER, AND HVAC

The RT system earth grounding, AC power ground, bonding, shielding, and transient protection at the facility interface shall [R0110] meet the requirements specified by FAA-G-2100 *Electronic Equipment, General Requirements* § 3.1.1.9 Grounding and Bonding.

The RT system grounding design shall [R0111] employ multipoint grounding as specified in FAA-STD-019 *Lighting and Surge Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Electronic Equipment*.

4 HUMAN FACTORS

4.1 HUMAN FACTORS DESIGN

The design of an RT system involves many considerations relating to human factors. These primarily concern the interaction between the ATCS and the RT system. Section 2 contains the minimum functional requirements for RT system design. However, additional functional considerations need to be taken into account concerning human factors design of the RT system. Considerations and recommendations in relation to human factors design are contained in Appendix D Human Factors Guidance and Recommendations.

The RT system equipment shall [R0112] meet requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.3.6 Human Engineering.

4.2 EMPLOYEE SAFETY AND HEALTH

The design and installation of RT system equipment shall [R0118] meet requirements specified in FAA-G-2100 *Electronic Equipment, General Requirements* § 3.3.5 Personnel Safety and Health.

The RT system must [R0119] provide specific demarcation points for any maintenance requiring a lock-out/tag-out procedure.

RT system shall [R0121] comply with standards provided in FAA Order 3900.19 *Occupational Safety and Health (OSH) Policy* Chapter 4 Fall Protection, for all maintenance activities requiring climbing.

RT system shall [R0122] comply with standards provided in FAA Order 3900.19 *Occupational Safety and Health (OSH) Policy* Chapter 14 Electrical Safety, for all maintenance activities servicing electrical elements of system.

RT system shall [R0123] comply with standards provided in FAA Order 3900.19 *Occupational Safety and Health (OSH) Policy* Chapter 8 Hazardous Materials and Compressed Gas/Air Equipment, for all maintenance activities servicing compressed air and gas elements of system.

5 INFORMATION SYSTEMS SECURITY (ISS) REQUIREMENTS

It is the responsibility of each RT system operator or sponsor to implement and manage the security of their RT installation, operations and system domain. In order to provide operators or sponsors the capability to employ information security measures consistent with those provided in National Institute of Standards and Technology (NIST) Special Publication (SP) 800-37 *Risk Management Framework for Information Systems and Organizations*, these technical specifications provide the minimum necessary security functionality.

The RT system must [R0124] enforce the information system security requirements during all system modes of operation.

The RT system must [R0125] ensure that when security functions are invoked, they either complete successfully or recover to a consistent and secure state.

The RT system must [R0126] provide restrictive default values for all security attributes.

The RT system must [R0127] provide all data transfer by a closed, point-to-point, network in both Operational Mode and Non-Operational Mode.

The definition of a closed network is:

a. Any connection within the RT network is restricted from access from a public network to promote a secured environment.
b. The RT data network is configured in such a way that any devices outside the network cannot access it.
c. Only a selected set of devices can access the network through the RT access points.

The RT system must [R0238] disable unused ports, protocols, and/or services.

The RT system must [R0134] preserve a secure state following any system failure or power interruption which causes the system to restart.

5.1 ACCESS LEVELS

The RT system access levels are defined as follows, with Table 5 containing an example implementation.

The RT system Access Level 1 must [R0136] provide Read-Only access to users for General Use/System Monitoring privileges using MDT.

The RT system Access Level 2 must [R0137] provide Read/Write access for privileges allocated to ATCS using the CSD.

The RT system Access Level 3 must [R0138] provide Read/Write access for privileges allocated to a Certified Maintenance Specialist using the MDT.

The RT system Access Level 4 must [R0139] be reserved for providing optional remote Read/Write access for privileges allocated to a Remote Certified Maintenance Specialist.

The RT system Access Level 5 must [R0140] provide Read/Write access for privileges allocated to a System Administrator using the MDT.

Table 5 – Example Access Level Privileges

Privileges	**Access Level 1**		**Access Level 2**		**Access Level 3**		**Access Level 4**		**Access Level 5**	
	Read	**Write**	**Read**	**Write**	**Read**	**Write**	**Read**	**Write**	**Read**	**Write**
RVP User Settings	X		X	X						
RVP Adjustment Controls			X	X						
Mute Alarm	X		X	X	X	X	X	X		
Mute Service Alert	X		X	X	X	X	X	X		
Mute Security Alert	X		X	X	X		X		X	X
SVP Control	X		X	X						
Ancillary Functional Control	X		X	X						
System Configuration Parameters[1]	X				X	X	X	X		
Alarms	X		X		X	X	X	X		
Alerts	X				X	X	X	X		
Service Alerts	X		X		X	X	X	X	X	
Security Alerts	X		X		X		X		X	X
System Event Logs	X				X		X			
Clear System Event Logs						X		X		
AAA Control	X		X	X	X	X	X	X		
Initiate Diagnostics BIT (intrusive)					X	X	X	X		
Initiate Diagnostics BIT (non-intrusive)					X	X	X	X		
System Status Information and Monitoring Information	X		X		X	X	X	X	X	
System State	X		X	X	X	X	X		X	X
System Mode: Non-Operational or Maintenance	X		X		X	X	X		X	X

Privileges	Access Level 1		Access Level 2		Access Level 3		Access Level 4		Access Level 5	
	Read	Write	Read	Write	Read	Write	Read	Write	Read	Write
System Mode: Operational	X		X		X	X			X	
Software Configuration	X				X	X	X	X	X	
Firmware Configuration	X				X	X	X	X	X	
User IDs									X	X
Relinquish User Lockout									X	X
User Access Level									X	X
Security Audit Log									X	
User Access Blocking and Unblocking									X	X
Data Recorder Files									X	
Warning Banner	X		X		X		X		X	X

Note 1: System Configuration Parameters consists of items such as network port settings, site-specific IP addresses, alert and alarm volume settings, site-specific monitor threshold parameter settings, installation settings, etc.

5.2 ACCESS AUTHENTICATION

This section contains the minimum authentication requirements for Access Level 3 and 5. If additional measures beyond these are taken, apply the Center for Internet Security (CIS) Benchmark (https://www.cisecurity.org/cis-benchmarks/) Level 1 profile for the applicable operating system. Access Level 1 is a Read-Only access that does not require access control authentication. Access Level 2 is a Read/Write access used for the ATCS using the CSD and does not require access control authentication. Authentication requirements for Access level 4 are specified in § 5.3.

The RT system must [R0242] require each Access Level 3, 4, and 5 user to have a unique user identifier and prohibit the reuse of one user's identifier for a different user.

The RT system authentication for Access Level 3 and 5 users must [R0141] use Password Authentication before the user is allowed any access to the system.

The RT system must [R0133] provide access control authentication in a manner that does not disrupt or interfere with the system operation.

The RT system must [R0193] automatically terminate any open login sessions for Access Levels 3 and 5, which have been inactive for a configurable amount of time, based on Access Level.

The RT system must [R0195] be capable of presenting a warning banner to Access Level 3, 4, and 5 users prior to granting system access.

The RT system must [R0241] show the warning banner until the user takes explicit action to acknowledge the notification.

The RT system must [R0240] conceal all information on the MDT display monitor during a locked session.

The RT system shall [R0142] enforce a limit of five consecutive invalid login attempts within a 15 minute period for any one user identifier.

The RT system must [R0167] generate a Security Alert when the defined number of consecutive invalid login attempts has been reached for any one user identifier.

The RT system shall [R0144] be configured to automatically lock the user account for 15 minutes or until released by the System Administrator when the maximum number of unsuccessful login attempts is exceeded for any one user identifier.

5.2.1 PASSWORD AUTHENTICATION

The RT system must [R0147] automatically enforce user password authenticators to meet the length and complexity defined by the CIS Benchmarks (https://www.cisecurity.org/cis-benchmarks/), as specified in Table 6.

Table 6 – CIS Benchmarks

	CentOS Linux 8	**Red Hat Linux 8**	**Windows 10**	**Windows Server 2016**
Minimum Length	14	14	14	14
Minimum Class	4	4	3 of 4	3 of 4

Where Class is defined as (1) Digit, (2) Uppercase, (3) Lowercase, or (4) Special Character.

The RT system must [R0130] conceal passwords and Personal Identification Numbers (PINs) on the screen as the user enters their password on the keyboard.

The RT system must [R0149] prohibit passwords that use any of the following criteria: manufacturer default passwords, manufacturer-supplied default passwords, more than two consecutive characters of one's user identifier or full name, addresses, Social Security Numbers (SSN), birthdays, common character sequences, or dictionary words (spelled forward or backward).

Note: Pattern recognition can be used in lieu of creating a database of personal information (e.g., the sequence of "xxx-xx-xxxx", where x is a numeric value, would prohibit the use of a Social Security Number).

The RT system must [R0243] enforce password change upon the next login attempt when a temporary password is issued for account creation and for password replacements.

The RT system shall [R0150] not allow users to change their passwords for at least two days (48 hours) after setting a new password.

The RT system shall [R0151] force users to change their account password at least every 180 days.

The RT system shall [R0152] prevent users from repeating any of their 24 previous passwords.

The RT system must [R0153] prevent the reuse of a compromised password or PIN.

The RT system shall [R0155] allow users to change their passwords sooner than 180 days, but not less than every two days.

The RT system must [R0156] protect electronically stored passwords and PINs in accordance with NIST SP 800-63 *Digital Identity Guidelines*.

5.3 REMOTE ACCESS

Remote access for remote maintainers is not required as a minimum functionality. If the manufacturer chooses to implement remote access, apply the requirements in this section, as defined by the CIS Benchmark (https://www.cisecurity.org/cis-benchmarks/) Level 1 profile for the applicable operating system.

The RT system's remote access session(s) must [R0283] utilize a Virtual Private Network (VPN).

The RT system authentication for Access Level 4 remote maintainers must [R0284] use Multi-factor Authentication before a remote maintainer is allowed access to the system.

The RT system must [R0285] only allow Access Level 4 authentication during Maintenance Mode.

The RT system shall [R0286] automatically terminate any open login sessions for Access Level 4 at the end of the session or after 30 minutes of inactivity.

5.4 SYSTEM ADMINISTRATOR

The RT system security management of system access must [R0157] be provided by the System Administrator using the MDT via Access Level 5.

The System Administrator must [R0158] have sole rights and access to add, delete, deactivate, and change user authentication identifiers.

The System Administrator must [R0244] have sole rights to assign or change users' roles.

The System Administrator must [R0245] have sole rights to create initial passwords.

The System Administrator must [R0246] have rights to update compromised or lost passwords.

The System Administrator must [R0196] have sole rights to configure the warning banner.

The System Administrator must [R0197] have sole rights to unlock a user account.

The System Administrator must [R0198] have sole rights to retrieve the Security Audit Log (see § 5.6).

The System Administrator must [R0175] have sole rights to establish/set up recording parameters, modify recording parameters, and delete recorded information.

The RT system must [R0159] require confirmation of all changes to user authentication identifiers, roles, password, and warning banners by confirmation of the System Administrator's password.

The RT system authentication identifiers, roles, passwords, and warning banners must [R0161] be stored in an encrypted file in NVM.

The System Administrator must [R0280] have sole rights to clear Security Alerts.

5.5 MALWARE AND MALICIOUS CODE PROTECTION

The RT system must [R0287] employ malicious code protection mechanisms (e.g., anti-virus software for workstations, Intrusion Detection System at the boundaries) for assets associated with the following:

a. Network boundaries,
b. All Windows devices (e.g., workstations, servers, web servers, or mobile computing devices), and
c. All externally facing File Transfer Protocol (FTP) servers for all operating systems.

The RT system must [R0288] be capable of allowing updates to malicious code protection mechanisms.

The RT system must [R0289] be configured to perform real-time scans of files from external sources as the files are downloaded, opened, or executed.

5.6 SECURITY AUDIT

The RT system must [R0162] include monitor and generate a security audit event for the following:

a. Login and logout, successful and unsuccessful,
b. Account creation/modification and permissions or configuration changes,
c. Administrator level activities,
d. Startup/Shutdown of System/Services/processes,
e. Access to privileged functions including maintenance, and
f. Results from malicious code protection.

The RT system must [R0292] monitor and generate a Security Alert for the following:

a. Resource degradation,
b. Detection of malicious code, and
c. Corruption of the Security Audit Log.

The RT system must [R0163] record the security audit events and Security Alerts to a Security Audit Log during all system modes of operation.

The RT system must [R0290] automatically log all system commands involving the clearing of Security Alerts in the Security Audit Log.

The RT system must [R0291] record all commands that mute or suppress notifications for Security Alerts in the Security Audit Log.

Audit records must [R0247] contain the type of event, date, time, system source, where the event occurred, user/subject identification, and outcome of the event (success/failure).

Audit records must [R0248] not contain sensitive information (such as passwords, actual system data, or privacy information).

The RT system shall [R0164] retain the most recent 45 days of security audit events in the Security Audit Log.

The RT system must [R0165] maintain all activity associated with password usage and changes in the Security Audit Log.

The RT system must [R0166] time and date stamp all security audit events written to the Security Audit Log and include UTC time and date to within one second.

The RT system's Security Audit Log must [R0168] be stored as an encrypted file in NVM.

The RT system's Security Audit Log must [R0199] be protected against deletion and modification.

6 SAFETY AND RELIABILITY, MAINTAINABILITY, AND AVAILABILITY (RMA) REQUIREMENTS

6.1 SAFETY REQUIREMENTS

6.1.1 DESIGN ASSURANCE LEVELS

The following table defines the Design Assurance Levels (DALs) that each function must [R0169] meet as defined in SAE International ARP 4754A *Guidelines for Development of Civil Aircraft and Systems*, RTCA, Inc. DO-278A *Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems*, and RTCA, Inc. DO-254 *Design Assurance Guidance for Airborne Electronic Hardware*.

Note: The DALs are not directly derived based on the hazard severity as defined by the System Safety Process. They reflect an allocation from the hazard severity accounting for operational barriers and mitigations.

Table 7 - Function Design Assurance Levels

Function[1]	**Failure**	**ARP 4754A DAL**	**DO-278A DAL**	**DO-254 DAL**
RVP	Loss of Function	D	AL5	Level D
RVP	Malfunction	D	AL4	Level D
SLG	Loss of Function	E	AL6	Level E
SLG	Malfunction	E	AL6	Level E
Ambient Audio	Loss of Function	E	AL6	Level E
Ambient Audio	Malfunction	E	AL6	Level E
MDT	Loss of Function	E	AL6	Level E
MDT	Malfunctions leading to loss of system functionality (e.g., loss of visual presentation)[2]	D	AL5	Level D
MDT	Malfunctions leading to loss of integrity (e.g., HMI presented to ATCS)[2]	D	AL4	Level D
Data Recorder	Loss of Function	E	AL6	Level E
Data Recorder	Malfunction	E	AL6	Level E
Optional or Supplemental	Loss of Function or Malfunction	Note 3	Note 3	Note 3

Note 1: The DALs for each function also apply to sub-functions, including controls and monitoring.

Note 2: The level of design assurance for the strategy to mitigate the impact of MDT failures on other functions (e.g., design architecture, functional design assurance levels, procedural, etc., or a combination thereof) needs to be commensurate with the failure effects of the impacted function(s).

Note 3: The RT system DALs associated with optional or supplemental functions will be determined by the Remote Tower system manufacturer through the safety assessment.

6.1.2 INTEGRITY

The probability of an undetected malfunction of the RVP resulting in Hazardously Misleading Information (HMI) shall [R0176] be less than or equal to $3.0x10^{-5}$ per 120 seconds. HMI is defined as any failure contributing to a major hazard (e.g., Category B runway incursion or rejected landing near runway threshold), as defined in the FAA *Safety Management System Manual*.

Note: This probability can account for the presence of monitor(s) designed to detect malfunctions and other architectural mitigations.

The RT system's time-to-alarm for loss of integrity resulting in HMI shall [R0177] not exceed one second. The time-to-alarm is the elapsed time between the onset of HMI resulting from a failure and the generation of an alarm.

Note: See Appendix G Time-To-Alarm for additional information.

The RT system's MDT function must [R0249] not contribute to the failure (e.g., loss of function or malfunction) of any other system function under normal or failed MDT operation.

6.1.3 CONTINUITY

The probability of the loss of continuity of operation shall [R0101] be less than or equal to $1.5x10^{-5}$ per 120 seconds, where loss of continuity of operation is defined as a critical failure.

Note 1: Critical failures are those failures resulting in the loss of function of the RVP, and related sub-function failures, including control, monitoring, and status. Loss of continuity can account for built-in redundancy (reference § 2.2.3 Redundant Element Management) when determining loss of RVP function. The critical failures of the RVP are defined as those portions of the RVP that contain the areas of jurisdiction (i.e., runway, short final, and base turns).

Note 2: The continuity requirement and the MTTR requirement (R0279) can be translated into an associated inherent availability as explained in Appendix F Remote Tower Systems Availability.

Continuity of operation shall [R0083] be maintained such that the time to recovery from a critical failure is less than or equal to three seconds for automatic switchover and 30 seconds for manual switchover of redundant elements.

Note: The requirement for automatic switchover is intended to ensure that there is normally a seamless transition to backup components, so that there is no interruption to service. Manual switchover is allowed for elements that cannot be switched automatically.

6.2 RELIABILITY, MAINTAINABILITY, AND AVAILABILITY (RMA) REQUIREMENTS

The RT system shall [R0279] have a Mean Time To Repair (MTTR) less than or equal to two hours.

Note: The MTTR requirement and the continuity requirement (R0101) can be translated into an associated inherent availability as explained in Appendix F Remote Tower Systems Availability.

APPENDICES

Appendix A - ACRONYMS

Acronym	Definition
AAA	Ambient Airfield Audio
AC	Alternating Current
ADS-B	Automatic Dependent Surveillance-Broadcast
ARP	Aerospace Recommended Practices
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
ATCT	Airport Traffic Control Tower
BIT	Built-In-Test
CD	Compact Disc
cd/m^2	Candela per square meter
CIS	Center for Internet Security
CFR	Code of Federal Regulations
CNS/ATM	Communication, Navigation, Surveillance and Air Traffic Management
CSD	Control Status Display
CWP	Control Working Position
DAL	Design Assurance Level
DR	Data Recorder
dBA	A-weighted Decibel
FAA	Federal Aviation Administration
FTP	File Transfer Protocol
GUI	Graphical User Interface
HMI	Hazardously Misleading Information
Hz	Hertz
ICD	Interface Control Document
ID	Identification
ISS	Information Systems Security
KPP	Key Performance Parameter
LRU	Line Replaceable Unit
MASPS	Minimum Aviation System Performance Standards
MDT	Maintenance Data Terminal
mm	Millimeter
MTBCF	Mean Time Between Critical Failure
MTTR	Mean Time to Repair
NAS	National Airspace System
NIST	National Institute of Standards and Technology
NVM	Non-volatile Memory
OSH	Occupational Safety and Health
OVR	Operational Visual Requirements
PIN	Personal Identification Number
PTZ	Pan-Tilt-Zoom
RADAR	Radio Detection and Ranging
RLG	Remote Light Gun

Acronym	Definition
RMA	Reliability, Maintainability, and Availability
RT	Remote Tower
RTC	Remote Tower Center
RTM	Remote Tower Module
RVP	Required Visual Presentation
SD	Secure Digital
SLG	Signal Light Gun
SP	Special Publication
SPL	Sound Pressure Level
SSN	Social Security Number
STLSC	Service Thread Loss Severity Categories
SVP	Supplemental Visual Presentation
TC	Type Certification
USB	Universal Serial Bus
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VPN	Virtual Private Network
VRTM	Verification Requirement Test Matrix

Appendix B - GLOSSARY TERMS

Term	Definition
ΔE	A measurement of how much a displayed color can differ from its input color.
u', v'	Chromaticity coordinates from the CIE 1976 UCS diagram.
ΔE u' v'	Color difference in the CIELUV color space.
Alarm	A warning to identify the RT system's inability for the system to operate with the required integrity.
Alert	An early warning for action on system performance degradation situations that can present the opportunity for preventative maintenance.
Ambient Airfield Audio (AAA)	§1.2 Table 1
Ancillary Equipment	§1.2.1 Table 2
Area of Jurisdiction	An ATCT's airspace or area of responsibility.
Aspect Ratio	The ratio of the width to the height of an image.
Built-In-Test (BIT)	Test capabilities integrated into the system hardware and/or software for monitoring, fault detection and isolation.
Configuration Changes	Predefined attributes that can be modified or adapted for a particular installation by the maintainer or installer, such as camera angles, contrast, volume, camera settings, IP addresses, etc.
Contrast	The range between the lightest tones and the darkest tones. The lower the number value, the more closely the shades will resemble each other. The higher the number, the more the shades will stand out from each other.
Contrast Ratio	The luminance of the foreground divided by the luminance of the background. It indicates how much brighter a pure white output would be than a pure black output. The greater the contrast, the sharper the image will be. It is also called the luminance ratio.
Control-Display Workstation	§1.2.2 Table 3
Control Status Display (CSD)	§1.2 Table 1
Coordinated Universal Time (UTC)	It is a coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM)
Critical Failure	Failures resulting in the loss of function of the RVP, and related sub-function failures, including control, monitoring, and status.
Data Processor / Decoder	§1.2.2 Table 3
Data Processor / Encoder	§1.2.1 Table 2
Data Recorder (DR)	§1.2 Table 1
Display Compression	Mapping the 360-degree horizontal view to a 2-dimensional video wall presentation, which will be compressed into an arc of less than 360 degrees.
EUROCAE	European Organization for Civil Aviation Equipment

Term	Definition
Foot-lamberts	A measure that has been corrected for the visual system's differential sensitivity to different wavelengths, giving an approximation to perceived brightness.
Key Performance Parameters (KPP)	Manufacturer chosen vital characteristics, functions, or requirements that are measured and monitored to identify impacts on the system performance. Impacts result in system warnings, cautions and advisories used to provide Alarms, Alerts, Service Alerts, and Security Alerts.
Graphical User Interface	A user interface that includes graphical elements such as windows, icons, drop menus, buttons, etc., that can be controlled by devices such as mouse, track ball, keyboard and touch screens.
Luminance Ratio	The luminance of the foreground divided by the luminance of the background. It indicates how much brighter a pure white output would be than a pure black output. The greater the contrast, the sharper the image will be. It is also called the contrast ratio.
Maintenance Mode	The RT system is unavailable for use due to maintenance activities (i.e., fault diagnostics, corrective and preventative maintenance, calibration, troubleshooting, BIT, etc.).
Maintenance Data Terminal (MDT)	§1.2 Table 1
Mean Time To Repair (MTTR)	MTTR for the system is a weighted average MTTR based on individual LRU failure rates and repair times. The repair times assume an ideal support environment in which trained technicians with all necessary tools and spare parts are immediately available – but it does not include scheduled downtime for preventive maintenance, the time needed for a technician to arrive on scene, or delays in obtaining necessary spare parts.
Memory Storage Devices	§1.2.2 Table 3
Microphone(s)	§1.2.1 Table 2
Non-Operational Mode	This mode of operation indicates the operational integrity is no longer meeting the required level of performance. The RT system has issued an audible and visual Alarm indicating the information shown on the RVP and SVP is not to be trusted or used.
Operational Mode	This mode of operation indicates the system is working as expected within the required integrity performance expectations (no Alarms present). However, cautions and advisories (Service Alerts, Security Alerts, and Alerts) can still be present in this mode of operation.
Operational Visual Requirements (OVR)	The Operational Visual Requirements (OVRs) identify the visual informational needs of controllers at Airport Traffic Control Towers (ATCTs) providing operational air traffic services. These requirements are documented in the FAA *Overarching Remote Tower System Research Operational Visual Requirements*.
Required Visual Presentation (RVP)	§1.2 Table 1
RVP Camera(s)	§1.2.1 Table 2
RVP-Primary Display	Continuous 360-degree fixed-view of the airport and surrounding airspace.

Term	Definition
RVP-Secondary Display(s)	Enhanced view(s) of the airport and/or surrounding airspace.
Security Alert	Provides the user a caution that the RT system requires System Administrator attention.
Service Alert	Provides the user a caution that the RT system requires maintenance to preserve the system's ability to maintain continuity.
Signal Light Gun (SLG)	§1.2 Table 1
Speaker	§1.2.2 Table 3
Supplemental Visual Presentation (SVP)	§1.2 Table 1
Supplemental Camera(s)	§1.2.1 Table 2
Supporting Display Monitor(s)	May be used to present RVP-Secondary Display information and/or SVP information.
Video Wall	A group of display monitors arranged in an arc which projects the continuous 360-degree presentation for an “out-the-window” view of the airport and surrounding environment.

Appendix C - REFERENCE DOCUMENTS

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Appendix D - HUMAN FACTORS GUIDANCE AND RECOMMENDATIONS

The visual presentation is required to be a continuous 360-degree view. The visual presentation is generated using a multitude of optical sensors, hardware, and software components. The combination of these components is used to replicate an "out of the window" view. While replicating the user's "out of the window" visual performance in terms of, for example, angular resolution at the remote operator's visual presentation, is theoretically feasible from a technical perspective, it is not necessarily appropriate and indeed can involve tradeoffs with other aspects (e.g., frame rate). Fundamentally, the RVP-Primary Display and RVP-Secondary Display(s) need to satisfy the minimum Operational Visual Requirements.

The operator's impression of the visual presentation's quality results from a combination of many factors (e.g., display resolution, sensor resolution, field of view, frame rate, refresh rates, refresh contrast, video update rate, video compression, bandwidth, network latency, jitter, chromaticity, color contrast, luminance, contrast ratio, buffering, noise, packet loss, codec, image uniformity, size of the display monitor, display monitor pixel density, distance of the display monitor from the operator, visual angle of targets by size and distance from the camera). The implementation and design of the visual presentation should [N0282] address performance attributes relating to human factors involving ATCS abilities to perform the necessary tasks. In particular, video compression, video update rate, image resolution, jitter, and image uniformity need to be demonstrated against human factor requirements.

The continuous 360-degree presentation should [N0265] have the appearance of a single uniform and seamless presentation even though multiple cameras and multiple displays (e.g., video wall) will be used in its generation. When combining multiple optical sensor images to replicate an "out of the window" view, the manufacturer will account for consistency and uniformity in the presentations by addressing white balance, contrast, color consistency, chromatic aberration, etc. When combining multiple hardware display monitors to form a video wall, manufacturers will address performance related to uniformity in display monitor luminance, chromaticity, color contrast, contrast ratio, and display monitor refresh rates.

The design and implementation is required to accommodate multiple ATCS working concurrently. Any compression of the RVP-Primary Display's 360-degree video wall should [N0266] consider the level of resulting image distortion (including changes in aspect ratio). Display compression is defined as mapping the 360-degree horizontal view to a 2-dimensional video wall presentation.

FAA HF-STD-001 *Human Factors Design Standard* provides applicable guidance for addressing human factors requirements related to display monitors. Additional guidance can be found in EUROCAE ED-240 *Minimum Aviation System Performance Standard for Remote Tower Optical Systems*.

The following provide guidance and recommendations for various RT system functionality.

Required Visual Presentation (and Supplemental Visual Presentation, if provided):

The RVP and SVP should [N0267] be uniform luminance within 1.5:1 (LMax:LMin) from the center to the edge of each display monitor. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.1.5.2]

The RVP and SVP should [N0268] provide luminance of black < 2 cd/m2 (candela per square meter) when the luminance is set at the maximum brightness for critical display monitors and display monitors used in dark-adapted environments. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.1.9.7]

The RVP and SVP should [N0269] have uniform chromaticity.

The RVP and SVP should [N0270] provide a foreground to background contrast ratio on the display monitor greater than 3:1. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.1.5.9]

Note: Although the minimum requirement is 3:1, a contrast ratio of 7:1 is preferred.

The RVP and SVP should [N0271] provide color contrast greater than 40 ΔEYu'v' if absolute color classification is necessary, 100 ΔEYu'v' if relative color classification is necessary. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.1.9]

Where:
ΔE is the Color difference
Y is the luminance
u', v' is Chromaticity coordinates from the CIE 1976 UCS diagram

The RVP and SVP should [N0272] be visually shown so that each ATCS position has an unobstructed view of the entire presentation. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.2.2.5]

The RVP should [N0006] be visually shown so that the normal work areas of each ATCS position is within the acceptable off-centerline viewing area of each large display that each user needs to view. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.2.2.4]

The RVP should [N0274] not have a flash or display monitor refresh rate within the 15-20 Hz range.

If compass information is presented on the RVP, the compass markings should [N0275] be congruous with the RVP-Primary Display and in a manner that does not interfere with ATC operations.

The RT system should [N0276] present the system mode on the RVP in a manner that does not interfere with ATC operations.

Ambient Airfield Audio:

The AAA should [N0049] provide a multichannel (i.e., spatialized audio) sound reproduction presented to the ATCS as a multidirectional audible perspective consistent with the visual presentation focal reference.

The time delay between the AAA and the RVP should [N0051] optimally be less than +45 millisecond (lead) and -60 millisecond (lag). [International Telecommunication Union ITU-R BT.1359-1 *Relative Timing Of Sound and Vision for Broadcasting* Figure 2; and ITU-T G.1080 *Quality of experience requirements for IPTV services* Table 6-3]

The AAA control function may [N0052] be implemented as an independent function or integrated with other functions.

Control Status Display:

The CSD functions may [N0278] be hosted on a CWP that includes a dedicated display monitor, keyboard, and user input device(s).

The design of the CSD controls and displays should [N0113] be consistent with FAA HF-STD-001 *Human Factors Design Standard* §§ 5.6, 5.7.

The CSD should [N0056] be capable of configuring each independent Access Level 2 user interface and saving a configuration preset for each user.

The CSD should [N0189] allow the independent Access Level 2 user interfaces to combine/de-combine functionality, while retaining the functionality and configuration of each individual position.

The CSD should [N0059] provide a graphical user interface for Access Level 2 users.

The CSD should [N0063] provide the Access Level 2 user the capability to adjust the volume and mute or unmute the AAA reproduction.

The RT system should [N0277] have standardized terminology (language and symbology) consistent with FAA Orders and FARs. [FAA HF-STD-001 *Human Factors Design Standard* § 4.4.5]

All user inputs made through the CSD should [N0116] be capable of being made by an operator in the standing or seated position.

MDT Functionality:

The design of the MDT user interface should [N0114] be consistent with FAA HF-STD-001 *Human Factors Design Standard* §§ 5.6, 5.7.

Appendix E - VERIFICATION REQUIREMENT TEST MATRIX (VRTM)

The Verification Requirement Test Matrix (VRTM) provides the proposed test method(s) for each requirement. The requirement test method(s) indicated in the table can be used to verify RT system design and implementation compliance with RT system requirements. Verification coverage of a requirement can employ either a single test method or a combination of test methods, as needed.

The VRTM will utilize the following criteria to identify the verification method:

a. **Test (T)** - Verification by test involves the actual operation of system elements during ambient conditions or when subjected to expected operational environments to evaluate performance. There are two categories of tests: functional tests and environmental tests. Functional testing is an individual test or series of tests conducted with hardware, software, and procedures at conditions equal to or less than design specifications. The intent is to verify that the system element performs satisfactorily in accordance with the design and performance specifications. These tests are usually conducted at ambient conditions. Environmental testing involves an individual test or series of tests conducted on the systems or subsystems in various operating environments. Such tests typically include various power conditions, shock, vibration, thermal environments, etc. Tests typically include instrumentation to gather quantitative test data. Test data provides evidence of acceptable system performance.
b. **Demonstration (D)** - Verification by demonstration involves using actual demonstration techniques to verify that the system element can perform its design functions under specified scenarios. Often requirements associated with reliability, transportability, maintainability, serviceability, and human engineering factors are verified using this method. The system elements can be instrumented with quantitative limits of performance monitored; however, only checklists (Pass/Fail) are required rather than recordings of actual performance data.
c. **Inspection (I)** - Verification by inspection is the physical examination of hardware, documentation, or both, to verify compliance of the feature with a predetermined criterion. These typically involve non-destructive inspection of the physical design, manufacturing features, workmanship, dimensions, quality, and physical conditions. Inspection of manufacturing records, and other documentation, can also be used by this method.
d. **Analysis (A)** - Verification by analysis is used in lieu of or in addition to verification by test. This method involves technical or mathematical evaluation, mathematical models, simulations, algorithms, and circuit diagrams. Verification by similarity is a subset of verification by analysis. This is the process of assessing by review of prior acceptable data or hardware configuration and applications that the system element is similar or identical in design and manufacturing process to another system element that has been previously qualified to equivalent or more stringent specifications. Documentation needs to exist for the previously qualified system element. A "qualification by similarity" analysis is required when using this verification method. A critical part of the analysis is demonstrating that all aspects of the previous and the current system applications are significantly similar, including the predicted or actual environments. If there are items that are not significantly similar, "delta qualification" tests are performed to bring the item into full compliance with the requirements of the new application.

Req ID	RT System Requirements	T	D	I	A
R0003	The RVP-Primary Display must [R0003] be a continuous 360-degree fixed-view of the airport environment and surrounding airspace.		X		
R0004	The RVP-Primary Display's perspective must [R0004] be from a single fixed point of view, single fixed focal point, and single fixed level of zoom.		X		
R0007	The RT system must [R0007] have an environmental impact mitigation capability which can be activated in response to environmental impacts affecting the RVP including, but not limited to, birds, insects, and weather (e.g., dust, snow, ice, rain).		X		X
R0008	The RT system must [R0008] provide the capability to balance light exposure in the RVP video image(s) for ATCS viewing (e.g., analogous to "draw the shades" functionality).		X		
R0009	The RVP functionality must [R0009] present the system mode (See § 2.2.1) on the RVP-Primary Display.		X		
R0012	The capture-to-display latency shall [R0012] be less than or equal to one second between an event in the real world and the visual presentation on the RVP.	X			
R0014	The RT system must [R0014] indicate the status and signal mode of the SLG (FAA Order JO 7110.65 Air Traffic Control § 3-2-1, Light Signals).		X		
R0015	The SLG functionality must [R0015] be capable of being disabled in Maintenance Mode.		X		
R0016	The SLG functionality must [R0016] be capable of being verified for proper operation by the ATCS.		X		
R0017	The RT system must [R0017] record the SLG activation command and the control parameters (e.g., directing (azimuth/elevation), transmitted signal selection) in the System Event Log.		X		
R0018	The MDT must [R0018] include a display monitor, keyboard, mouse or touchpad, and industry-standard communication port.			X	
R0019	The MDT functionality must [R0019] enable the Access Level 1 and 3 users to interact with the RT system using a GUI.		X		
R0020	The MDT functionality must [R0020] provide for Access Level 3 maintainers the capability to command and monitor all test and maintenance actions available within the RT system.		X		
R0022	The MDT functionality must [R0022] provide for Access Level 1 and 3 users diagnostic information to aid in fault isolation.		X		X
R0023	The MDT functionality must [R0023] provide for Access Level 3 maintainers the capability to initiate Key Performance Parameter (KPP) monitoring to aid in diagnostic and fault isolation.		X		X
R0024	The MDT functionality must [R0024] provide for Access Level 3 maintainers the capability of initiating intrusive and non-intrusive diagnostics tests.		X		
R0025	The RT system must [R0025] only allow intrusive diagnostics tests to be invoked during Maintenance Mode.		X		
R0026	The MDT functionality must [R0026] provide for Access Level 3 maintainers the capability of retrieving the System Event Log from the RT system NVM.		X		
R0027	The MDT functionality must [R0027] provide for Access Level 1 and 3 users the capability for viewing System Events from the System Event Log.		X		
R0029	The MDT functionality must [R0029] provide for Access Level 3 maintainers the capability of exporting the System Event Log onto external media.		X		
R0030	The MDT functionality must [R0030] provide for Access Level 3 maintainers the capability to clear the System Event Log.		X		
R0031	The MDT functionality must [R0031] have the capability to view the current system state and system mode.		X		
R0034	The MDT functionality must [R0034] provide the capability for Access Level 3 maintainers to clear Alarms, Service Alerts, and Alerts.		X		
R0035	The DR function must [R0035] record all the data provided on the RVP and SVP (if provided) to support playback and post-analysis.		X		
R0036	The DR function shall [R0036] store the most recent 45 days of recorded data.	X			X
R0037	The DR function shall [R0037] timestamp all recorded data at a minimum frequency of one Hz.	X			
R0038	The DR function timestamp shall [R0038] have an accuracy less than or equal to 0.01 seconds.	X			
R0039	The DR function must [R0039] use NVM.		X		
R0040	The DR function NVM storage must [R0040] be secured from tampering and manipulation.		X		
R0042	The DR functionality must [R0042] provide the recording capability without degradation to the RT system or RVP.		X		
R0043	The DR function's exported data format must [R0043] be documented in an Interface Control Document (ICD) for data interpretation.			X	

Req ID	RT System Requirements	T	D	I	A
R0044	The DR functionality must [R0044] provide the capability for data to be played back without loss of fidelity.		X		
R0046	The RT system must [R0046] record any activation of the integrated Magnification function, along with the control parameters (e.g., directing, zoom, etc.) as an event in the System Event Log.		X		
R0047	The DR function must [R0047] record the Magnification function when provided as part of the RVP, with the visual presentation and the visual presentation control selections as a part of the normal visual presentation recording (i.e., if the control functions are selectable/viewable from the RVP).		X		
R0048	The AAA functionality must [R0048] be reproduced at the RTM.		X		
R0050	The AAA's time delay between the real-time audio and the reproduction audio shall [R0050] be less than one second.	X			X
R0054	The CSD functionality must [R0054] provide the capability for multiple independent Access Level 2 users at the same time.		X		
R0058	The CSD functionality must [R0058] be a dedicated means for Access Level 2 user control, input, and output for the RT system.			X	
R0064	The CSD functionality must [R0064] provide the capability for an Access Level 2 user to control the balancing of light exposure in the video image(s) (e.g., analogous to "draw the shades" functionality).		X		
R0066	The RT system shall [R0066] be synchronized to a certified external Coordinated Universal Time (UTC) reference which supports a resolution less than or equal to 0.01 seconds.	X			
R0067	The RT system synchronization to a certified external UTC reference shall [R0067] be maintained within 100 milliseconds.	X			
R0068	The RT system must [R0068] have two system states: ON and OFF.		X		
R0069	The RT system must [R0069] have the following three system modes: Operational, Non-Operational, Maintenance when the system state is ON.		X		
R0071	The RT system must [R0071] automatically execute performance monitoring of all KPPs.	X			
R0072	The RT system KPPs must [R0072] be checked at a rate consistent with the required time-to-alert or time-to-alarm (see § 6.1.2 Integrity).	X			X
R0073	The RT system must [R0073] generate an Alarm upon detecting a faulted condition for which the integrity of the system is no longer guaranteed (see § 6.1.2 Integrity).	X			X
R0074	The RT system must [R0074] transition to a Non-Operational Mode when an Alarm condition (See § 2.2.2) is detected.	X			
R0075	The RT system must [R0075] generate a Service Alert upon detecting a faulted condition requiring corrective maintenance.	X			X
R0076	The RT system must [R0076] generate an Alert upon detecting a faulted condition not affecting the system's functional capabilities but is an advisory indication for potential maintenance needs.	X			X
R0079	The CSD functionality must [R0079] provide the capability for an Access Level 2 user to mute individual audible Alarms, Service Alerts, and Security Alerts once activated.		X		
R0081	The RT system operation of all redundant elements must [R0081] be managed by performance monitoring.		X		
R0083	Continuity of operation shall [R0083] be maintained such that the time to recovery from a critical failure is less than or equal to three seconds for automatic switchover and 30 seconds for manual switchover of redundant elements.	X			
R0085	The RT system must [R0085] automatically log all Alerts, Service Alerts, and Alarms, and all performance monitoring events in the System Event Log.	X			
R0086	The RT system KPPs must [R0086] be uniquely identified as any parameter of the RT system, subsystem, interface, Line Replaceable Unit (LRU), or equipment, which is a critical indicator of whether or not it is performing its intended function.	X			X
R0087	The RT system must [R0087] store System Events to a NVM System Event Log in chronological order with each event being uniquely identified and timestamped.		X		
R0088	The RT system shall [R0088] be capable of storing 45 days of System Events in the System Event Log.		X		X
R0089	The RT system must [R0089] automatically log all system recovery events in the System Event Log.		X		
R0090	The RT system must [R0090] automatically log all system events involving the clearing of Alarms, Service Alerts, and Alerts in the System Event Log.		X		

Req ID	RT System Requirements	T	D	I	A
R0092	Components making up the RT system shall [R0092] operate in either of the following environmental conditions, depending on siting and installation instructions: * FAA-G-2100 Electronic Equipment, General Requirements § 3.2.1.1.3 Indoor Operating Environments * FAA-G-2100 Electronic Equipment, General Requirements § 3.2.1.1.2 Common Outdoor Operating Environmental Conditions	X	X		X
R0093	The RT system equipment shall [R0093] meet requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.1.1 Electrical Power.	X	X	X	X
R0096	The RT system must [R0096] provide protection from input power conditions resulting in damage to equipment, false operation, misleading outputs, and loss of function.			X	X
R0097	The RT system equipment must [R0097] automatically restart after acceptable power input conditions are restored following a shutdown resulting from an out-of-tolerance power input condition.	X			
R0098	The RT system equipment's mechanical design shall [R0098] meet requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.1.2 Mechanical.	X	X	X	X
R0099	Any RT system equipment masts located within the airport safety areas (Runway Safety Area, Object Free Area, and Obstacle Free Zone) shall [R0099] be frangible in accordance with 14 Code of Federal Regulations (CFR) part 139 Certification of Airports and FAA Advisory Circular 150/5300.13 Airport Design.	X			X
R0101	The probability of the loss of continuity of operation shall [R0101] be less than or equal to 1.5x10-5 per 120 seconds, where loss of continuity of operation is defined as a critical failure.				X
R0103	The RT system must [R0103] provide temperature sensor(s) in each separate enclosed cabinet.			X	
R0104	The RT system must [R0104] have a nominal operating range of temperatures by means of an upper and lower temperature threshold.		X		
R0105	The RT system must [R0105] monitor cabinet temperature sensors.		X		
R0106	The RT system must [R0106] generate a Service Alert when the cabinet temperature exceeds either the upper or lower cabinet temperature threshold.		X		
R0108	The RT system equipment shall [R0108] meet the material requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.3.1 Materials, Processes, and Parts.	X	X	X	X
R0109	All RT system workstations and personal computer batteries shall [R0109] comply with requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.3.1.4.1 Batteries.			X	
R0110	The RT system earth grounding, AC power ground, bonding, shielding, and transient protection at the facility interface shall [R0110] meet the requirements specified by FAA-G-2100 Electronic Equipment, General Requirements § 3.1.1.9 Grounding and Bonding.			X	X
R0111	The RT system grounding design shall [R0111] employ multipoint grounding as specified in FAA-STD-019 Lighting and Surge Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Electronic Equipment.			X	X
R0112	The RT system equipment shall [R0112] meet requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.3.6 Human Engineering.	X	X	X	X
R0118	The design and installation of RT system equipment shall [R0118] meet requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.3.5 Personnel Safety and Health.	X	X	X	X
R0119	The RT system must [R0119] provide specific demarcation points for any maintenance requiring a lock-out/tag-out procedure.	X	X	X	X
R0121	RT system shall [R0121] comply with standards provided in FAA Order 3900.19 Occupational Safety and Health (OSH) Policy Chapter 4 Fall Protection, for all maintenance activities requiring climbing.			X	X
R0122	RT system shall [R0122] comply with standards provided in FAA Order 3900.19 Occupational Safety and Health (OSH) Policy Chapter 14 Electrical Safety, for all maintenance activities servicing electrical elements of system.			X	X
R0123	RT system shall [R0123] comply with standards provided in FAA Order 3900.19 Occupational Safety and Health (OSH) Policy Chapter 8 Hazardous Materials and Compressed Gas/Air Equipment, for all maintenance activities servicing compressed air and gas elements of system.			X	X
R0124	The RT system must [R0124] enforce the information system security requirements during all system modes of operation.		X		

Req ID	RT System Requirements	T	D	I	A
R0125	The RT system must [R0125] ensure that when security functions are invoked, they either complete successfully or recover to a consistent and secure state.		X		
R0126	The RT system must [R0126] provide restrictive default values for all security attributes.		X		
R0127	The RT system must [R0127] provide all data transfer by a closed, point-to-point, network in both Operational Mode and Non-Operational Mode.		X		
R0130	The RT system must [R0130] conceal passwords and Personal Identification Numbers (PINs) on the screen as the user enters their password on the keyboard.		X		
R0133	The RT system must [R0133] provide access control authentication in a manner that does not disrupt or interfere with the system operation.		X		
R0134	The RT system must [R0134] preserve a secure state following any system failure or power interruption which causes the system to restart.		X		
R0136	The RT system Access Level 1 must [R0136] provide Read-Only access to users for General Use/System Monitoring privileges using MDT.		X		
R0137	The RT system Access Level 2 must [R0137] provide Read/Write access for privileges allocated to ATCS using the CSD.		X		
R0138	The RT system Access Level 3 must [R0138] provide Read/Write access for privileges allocated to a Certified Maintenance Specialist using the MDT.		X		
R0139	The RT system Access Level 4 must [R0139] be reserved for providing optional remote Read/Write access for privileges allocated to a Remote Certified Maintenance Specialist.		X		
R0140	The RT system Access Level 5 must [R0140] provide Read/Write access for privileges allocated to a System Administrator using the MDT.		X		
R0141	The RT system authentication for Access Level 3 and 5 users must [R0141] use Password Authentication before the user is allowed any access to the system.		X		
R0142	The RT system shall [R0142] enforce a limit of five consecutive invalid login attempts within a 15 minute period for any one user identifier.	X			
R0144	The RT system shall [R0144] be configured to automatically lock the user account for 15 minutes or until released by the System Administrator when the maximum number of unsuccessful login attempts is exceeded for any one user identifier.	X			
R0147	The RT system must [R0147] automatically enforce user password authenticators to meet the length and complexity defined by the CIS Benchmarks (https://www.cisecurity.org/cis-benchmarks/), as specified in Table 6.		X		
R0149	The RT system must [R0149] prohibit passwords that use any of the following criteria: manufacturer default passwords, manufacturer-supplied default passwords, more than two consecutive characters of one's user identifier or full name, addresses, Social Security Numbers (SSN), birthdays, common character sequences, or dictionary words (spelled forward or backward).		X		
R0150	The RT system shall [R0150] not allow users to change their passwords for at least two days (48 hours) after setting a new password.	X			
R0151	The RT system shall [R0151] force users to change their account password at least every 180 days.	X			
R0152	The RT system shall [R0152] prevent users from repeating any of their 24 previous passwords.	X			
R0153	The RT system must [R0153] prevent the reuse of a compromised password or PIN.		X		
R0155	The RT system shall [R0155] allow users to change their passwords sooner than 180 days, but not less than every two days.	X			
R0156	The RT system must [R0156] protect electronically stored passwords and PINs in accordance with NIST SP 800-63 Digital Identity Guidelines.		X		
R0157	The RT system security management of system access must [R0157] be provided by the System Administrator using the MDT via Access Level 5.		X		
R0158	The System Administrator must [R0158] have sole rights and access to add, delete, deactivate, and change user authentication identifiers.		X		
R0159	The RT system must [R0159] require confirmation of all changes to user authentication identifiers, roles, password, and warning banners by confirmation of the System Administrator's password.		X		
R0161	The RT system authentication identifiers, roles, passwords, and warning banners must [R0161] be stored in an encrypted file in NVM.		X		
R0162	The RT system must [R0162] include monitor and generate a security audit event for the following:		X		

Req ID	RT System Requirements	T	D	I	A
R0163	The RT system must [R0163] record the security audit events and Security Alerts to a Security Audit Log during all system modes of operation.		X		
R0164	The RT system shall [R0164] retain the most recent 45 days of security audit events in the Security Audit Log.		X		X
R0165	The RT system must [R0165] maintain all activity associated with password usage and changes in the Security Audit Log.		X		
R0166	The RT system must [R0166] time and date stamp all security audit events written to the Security Audit Log and include UTC time and date to within one second.		X		
R0167	The RT system must [R0167] generate a Security Alert when the defined number of consecutive invalid login attempts has been reached for any one user identifier.		X		
R0168	The RT system's Security Audit Log must [R0168] be stored as an encrypted file in NVM.		X		
R0169	The following table defines the Design Assurance Levels (DALs) that each function must [R0169] meet as defined in SAE International ARP 4754A Guidelines for Development of Civil Aircraft and Systems, RTCA, Inc. DO-278A Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems, and RTCA, Inc. DO-254 Design Assurance Guidance for Airborne Electronic Hardware.			X	
R0170	The RT system must [R0170] only allow configuration changes that will impact Operational Mode while the system mode is in Maintenance Mode.		X		
R0171	The RT system must [R0171] automatically attempt to recover to the same system mode for any unplanned interrupt in operation from an unexpected event (e.g., power interruption).		X		
R0172	The RT system shall [R0172] automatically transition the system state to OFF when operations cannot be maintained due to power conditions.		X		
R0173	The RT system must [R0173] automatically log all state transitions, including those resulting from unexpected power interruptions in the System Event Log.		X		
R0175	The System Administrator must [R0175] have sole rights to establish/set up recording parameters, modify recording parameters, and delete recorded information.		X		
R0176	The probability of an undetected malfunction of the RVP resulting in Hazardously Misleading Information (HMI) shall [R0176] be less than or equal to 3.0x10-5 per 120 seconds. HMI is defined as any failure contributing to a major hazard (e.g., Category B runway incursion or rejected landing near runway threshold), as defined in the FAA Safety Management System Manual.				X
R0177	The RT system's time-to-alarm for loss of integrity resulting in HMI shall [R0177] not exceed one second. The time-to-alarm is the elapsed time between the onset of HMI resulting from a failure and the generation of an alarm.	X			X
R0180	The RVP functionality must [R0180] be capable of meeting all OVRs.	X	X		X
R0182	The RVP-Primary Display's video shall [R0182] only be from visible light spectrum cameras (i.e., cameras that capture light spectrum wavelengths 380-740 nanometers).			X	
R0184	The SLG functionality must [R0184] provide the capability of transmitting signals in accordance with FAA Order JO 7110.65 Air Traffic Control § 3-2-1, Light Signals.		X		
R0185	The MDT functionality must [R0185] provide for Access Level 3 maintainers the capability to configure the RT system.		X		
R0186	The MDT functionality must [R0186] provide for Access Level 3 maintainers the capability of installing RT software.		X		
R0187	The MDT functionality must [R0187] be capable of showing the RT system's current software and adaptation version identification.		X		
R0188	The DR functionality must [R0188] provide the capability of exporting the recorded data onto external media.		X		
R0190	The RT system must [R0190] consist of RVP, SLG, MDT, DR, Magnification, AAA, and CSD functions.			X	
R0192	The AAA functionality must [R0192] be integrated into the RT system independent of the ATCS radio communication system.			X	
R0193	The RT system must [R0193] automatically terminate any open login sessions for Access Levels 3 and 5, which have been inactive for a configurable amount of time, based on Access Level.		X		
R0195	The RT system must [R0195] be capable of presenting a warning banner to Access Level 3, 4, and 5 users prior to granting system access.		X		
R0196	The System Administrator must [R0196] have sole rights to configure the warning banner.		X		
R0197	The System Administrator must [R0197] have sole rights to unlock a user account.		X		

Req ID	RT System Requirements	T	D	I	A
R0198	The System Administrator must [R0198] have sole rights to retrieve the Security Audit Log (see § 5.6).		X		
R0199	The RT system's Security Audit Log must [R0199] be protected against deletion and modification.		X		
R0200	The RVP functionality shall [R0200] have a frame rate of 25 Hertz (Hz) or higher.	X			
R0201	The RT system's environmental impact mitigation's response time shall [R0201] be within 10 seconds of a command.	X			
R0203	The SLG functionality must [R0203] be capable of directing the RLG at a target of interest.		X		
R0204	The SLG functionality shall [R0204] respond within 250 milliseconds of operator input.	X			
R0205	The SLG functionality shall [R0205] be capable of reaching a continuous rotational speed of at least 60 degrees per second.	X			
R0206	The SLG functionality shall [R0206] be capable of reaching a continuous tilting speed of at least 60 degrees per second.	X			
R0208	The SLG functionality shall [R0208] provide the capability of movement between two positions in the horizontal plane which are 60 degrees apart from a resting state to a resting state within two seconds, not including control latency.	X			
R0209	The Magnification functionality shall [R0209] be capable of providing seven times the magnification or greater.		X		X
R0210	The Magnification functionality must [R0210] be capable of being directed at an area of interest.		X		
R0211	The Magnification functionality shall [R0211] respond within 250 milliseconds of operator input.	X			
R0212	The Magnification functionality's PTZ shall [R0212] be capable of reaching a continuous rotational speed of at least 60 degrees per second.	X			
R0213	The Magnification functionality's PTZ shall [R0213] be capable of reaching a continuous tilting speed of at least 60 degrees per second.	X			
R0214	The Magnification functionality's PTZ shall [R0214] provide the capability of movement between two pan positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including Magnification functionality control latency.	X			
R0215	The AAA functionality's upper and lower-level volume limits shall [R0215] be configurable between a range of volume settings from 0 dBA to +85 dBA.	X			
R0217	The CSD functionality must [R0217] provide the Access Level 2 user the capability to turn on and off the AAA.		X		
R0218	The CSD functionality must [R0218] provide the capability of visually presenting Alarms, Service Alerts, and Security Alerts to the Access Level 2 user.		X		
R0220	The CSD functionality must [R0220] provide the capability for an Access Level 2 user to control and activate environmental impact ancillary equipment.		X		
R0221	The CSD functionality must [R0221] provide the capability for an Access Level 2 user to control and activate the SLG.		X		
R0222	The CSD functionality must [R0222] provide the capability for an Access Level 2 user to control and activate the Magnification function (non-short focal length optical device implementations).		X		
R0224	The CSD functionality shall [R0224] respond within 250 milliseconds of Access Level 2 user inputs.	X			
R0226	The SVP functionality shall [R0226] have a frame rate of 25 Hz or higher.	X			
R0227	The capture-to-display latency shall [R0227] be less than or equal to one second between an event in the real world and the visual presentation on the SVP.	X			
R0228	If the SVP is presented on a separate display monitor, the performance for luminance, chromaticity, and contrast must [R0228] be equivalent to the RVP (see Appendix D Human Factors Guidance and Recommendations).			X	
R0229	The SVP functionality's PTZ shall [R0229] respond within 250 milliseconds of operator input.	X			
R0230	The SVP functionality's PTZ shall [R0230] be capable of reaching a continuous rotational speed of at least 60 degrees per second.	X			
R0231	The SVP functionality's PTZ shall [R0231] be capable of reaching a continuous tilting speed of at least 60 degrees per second.	X			
R0232	The SVP functionality's PTZ shall [R0232] provide the capability of movement between two pan positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SVP PTZ control latency.	X			
R0233	The SVP functionality's PTZ must [R0233] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.	X	X		

Req ID	RT System Requirements	T	D	I	A
R0236	The CSD functionality must [R0236] provide the capability for an Access Level 2 user to suppress individual visual Service Alerts and Security Alerts once activated.		X		
R0238	The RT system must [R0238] disable unused ports, protocols, and/or services.		X		
R0239	The RT system must [R0239] record all commands that mute or suppress notifications for Alarms and Service Alerts in the System Event Log.		X		
R0240	The RT system must [R0240] conceal all information on the MDT display monitor during a locked session.		X		
R0241	The RT system must [R0241] show the warning banner until the user takes explicit action to acknowledge the notification.		X		
R0242	The RT system must [R0242] require each Access Level 3, 4, and 5 user to have a unique user identifier and prohibit the reuse of one user's identifier for a different user.		X		
R0243	The RT system must [R0243] enforce password change upon the next login attempt when a temporary password is issued for account creation and for password replacements.		X		
R0244	The System Administrator must [R0244] have sole rights to assign or change users' roles.		X		
R0245	The System Administrator must [R0245] have sole rights to create initial passwords.		X		
R0246	The System Administrator must [R0246] have rights to update compromised or lost passwords.		X		
R0247	Audit records must [R0247] contain the type of event, date, time, system source, where the event occurred, user/subject identification, and outcome of the event (success/failure).		X		
R0248	Audit records must [R0248] not contain sensitive information (such as passwords, actual system data, or privacy information).		X		
R0249	The RT system's MDT function must [R0249] not contribute to the failure (e.g., loss of function or malfunction) of any other system function under normal or failed MDT operation.				X
R0250	The RVP-Secondary Display's PTZ must [R0250] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.	X	X		
R0255	The SLG functionality shall [R0255] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SLG functionality control latency.	X			
R0257	The MDT functionality must [R0257] provide the capability of visually presenting Alarms, Service Alerts, Security Alerts, and Alerts.		X		
R0258	The Magnification functionality's PTZ shall [R0258] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including Magnification functionality control latency.	X			
R0259	The Magnification functionality's PTZ must [R0259] traverse the full range of the lens in less than four seconds with a speed variation less than 10 percent.	X	X		
R0260	The CSD functionality must [R0260] provide a minimum of two Access Level 2 user interfaces.		X		
R0261	The CSD functionality must [R0261] have the capability for Access Level 2 users to view the current system state and system mode.		X		
R0262	The CSD functionality must [R0262] provide the capability for the audible presentation for Alarms, Service Alerts, and Security Alerts to the Access Level 2 user.		X		
R0263	The SVP functionality's PTZ shall [R0263] provide the capability of movement between two tilt positions which are 60 degrees apart from a resting state to a resting state within two seconds, not including SVP PTZ control latency.	X			
R0264	The RT system equipment shall [R0264] meet the electromagnetic emissions and susceptibility requirements specified in FAA-G-2100 Electronic Equipment, General Requirements § 3.3.2 Electromagnetic Compatibility.	X			
R0279	The RT system shall [R0279] have a Mean Time To Repair (MTTR) less than or equal to two hours.				X
R0280	The System Administrator must [R0280] have sole rights to clear Security Alerts.		X		
R0281	The RVP must [R0281] be composed of an RVP-Primary Display or an RVP-Primary Display in conjunction with an RVP-Secondary Display(s).			X	
R0283	The RT system's remote access session(s) must [R0283] utilize a Virtual Private Network (VPN).		X		
R0284	The RT system authentication for Access Level 4 remote maintainers must [R0284] use Multi-factor Authentication before a remote maintainer is allowed access to the system.		X		
R0285	The RT system must [R0285] only allow Access Level 4 authentication during Maintenance Mode.		X		
R0286	The RT system shall [R0286] automatically terminate any open login sessions for Access Level 4 at the end of the session or after 30 minutes of inactivity.	X			

Req ID	RT System Requirements	T	D	I	A
R0287	The RT system must [R0287] employ malicious code protection mechanisms (e.g., anti-virus software for workstations, Intrusion Detection System at the boundaries) for assets associated with the following:		X	X	
R0288	The RT system must [R0288] be capable of allowing updates to malicious code protection mechanisms.		X		
R0289	The RT system must [R0289] be configured to perform real-time scans of files from external sources as the files are downloaded, opened, or executed.		X		
R0290	The RT system must [R0290] automatically log all system commands involving the clearing of Security Alerts in the Security Audit Log.		X		
R0291	The RT system must [R0291] record all commands that mute or suppress notifications for Security Alerts in the Security Audit Log.		X		
R0292	The RT system must [R0292] monitor and generate a Security Alert for the following:		X		
N0006	The RVP should [N0006] be visually shown so that the normal work areas of each ATCS position is within the acceptable off-centerline viewing area of each large display that each user needs to view. [FAA HF-STD-001 Human Factors Design Standard § 5.3.2.2.4]		X		
N0021	The MDT functionality should [N0021] provide for Access Level 3 maintainers the capability to perform hardware, software, and interface fault diagnostics, detection, and isolation on all RT system elements.		X		X
N0028	The MDT functionality should [N0028] provide for Access Level 3 maintainers the capability for sorting and searching the System Event Log.		X		
N0032	The MDT functionality should [N0032] enable the capability for Access Level 3 maintainers to manually override the automatic redundant element management actions.		X		
N0049	The AAA should [N0049] provide a multichannel (i.e., spatialized audio) sound reproduction presented to the ATCS as a multidirectional audible perspective consistent with the visual presentation focal reference.		X		
N0051	The time delay between the AAA and the RVP should [N0051] optimally be less than +45 millisecond (lead) and -60 millisecond (lag). [International Telecommunication Union ITU-R BT.1359-1 Relative Timing Of Sound and Vision for Broadcasting Figure 2; and ITU-T G.1080 Quality of experience requirements for IPTV services Table 6-3]	X			X
N0052	The AAA control function may [N0052] be implemented as an independent function or integrated with other functions.			X	
N0056	The CSD should [N0056] be capable of configuring each independent Access Level 2 user interface and saving a configuration preset for each user.		X	X	
N0059	The CSD should [N0059] provide a graphical user interface for Access Level 2 users.		X	X	
N0063	The CSD should [N0063] provide the Access Level 2 user the capability to adjust the volume and mute or unmute the AAA reproduction.		X		
N0084	The RT system Events logged in the System Event Log should [N0084] be those that aid in diagnostic testing and fault isolation.			X	
N0094	The RT system materials should [N0094] be non-nutrient to rodents, insects, non-hygroscopic and not adversely affected by the environmental conditions for which this equipment is installed.	X	X	X	X
N0113	The design of the CSD controls and displays should [N0113] be consistent with FAA HF-STD-001 Human Factors Design Standard §§ 5.6, 5.7.		X	X	X
N0114	The design of the MDT user interface should [N0114] be consistent with FAA HF-STD-001 Human Factors Design Standard §§ 5.6, 5.7.		X	X	X
N0116	All user inputs made through the CSD should [N0116] be capable of being made by an operator in the standing or seated position.		X		
N0117	The RT system Alarm, Service Alert, Security Alert, and Alert indications should [N0117] be developed with the use of FAA HF-STD-001 Human Factors Design Standard § 5.5 Alarms, Audio and Voice Communication.	X	X	X	X
N0179	The RVP-Secondary Display(s) may [N0179] provide enhanced views of the airport and/or surrounding airspace.		X	X	
N0181	The RVP-Secondary Display's enhanced views may [N0181] provide fixed focal length or zoom (i.e., variable focal length) view, with or without pan/tilt capability.		X		
N0189	The CSD should [N0189] allow the independent Access Level 2 user interfaces to combine/de-combine functionality, while retaining the functionality and configuration of each individual position.		X		

Req ID	RT System Requirements	T	D	I	A
N0191	The RT system may [N0191] provide SVP functionality.			X	
N0202	The RVP-Secondary Display(s) may [N0202] be presented on the RVP-Primary Display or separate supporting display monitor(s).		X		
N0216	The AAA functionality's volume control should [N0216] be a logarithmic volume control.	X			
N0223	The CSD functionality should [N0223] provide the capability for an Access Level 2 user to toggle on and off all SVP on the RVP-Primary Display with a single input by the user.		X		
N0225	The SVP may [N0225] be presented on the RVP-Primary Display or a separate display monitor(s).		X		
N0252	The MDT functionality should [N0252] provide the capability to disable audible Alarms, Service Alerts, and Security Alerts annunciated by the CSD function during Maintenance Mode.		X		
N0253	The environmental impact mitigation capability may [N0253] be a combination of manual and automatic features such as compressed air burst, defrosting elements, wipers, etc.	X	X	X	X
N0254	Some environmental impact mitigation capability may [N0254] be activated automatically, such as heaters in relation to a temperature control function.	X	X		
N0265	The continuous 360-degree presentation should [N0265] have the appearance of a single uniform and seamless presentation even though multiple cameras and multiple displays (e.g., video wall) will be used in its generation. When combining multiple optical sensor images to replicate an "out of the window" view, the manufacturer will account for consistency and uniformity in the presentations by addressing white balance, contrast, color consistency, chromatic aberration, etc. When combining multiple hardware display monitors to form a video wall, manufacturers will address performance related to uniformity in display monitor luminance, chromaticity, color contrast, contrast ratio, and display monitor refresh rates.	X	X	X	X
N0266	The design and implementation is required to accommodate multiple ATCS working concurrently. Any compression of the RVP-Primary Display's 360-degree video wall should [N0266] consider the level of resulting image distortion (including changes in aspect ratio). Display compression is defined as mapping the 360-degree horizontal view to a 2-dimensional video wall presentation.		X		X
N0267	The RVP and SVP should [N0267] be uniform luminance within 1.5:1 (LMax:LMin) from the center to the edge of each display monitor. [FAA HF-STD-001 Human Factors Design Standard § 5.3.1.5.2]	X			
N0268	The RVP and SVP should [N0268] provide luminance of black < 2 cd/m2 (candela per square meter) when the luminance is set at the maximum brightness for critical display monitors and display monitors used in dark-adapted environments. [FAA HF-STD-001 Human Factors Design Standard § 5.3.1.9.7]	X			
N0269	The RVP and SVP should [N0269] have uniform chromaticity.	X	X		
N0270	The RVP and SVP should [N0270] provide a foreground to background contrast ratio on the display monitor greater than 3:1. [FAA HF-STD-001 Human Factors Design Standard § 5.3.1.5.9]	X			
N0271	The RVP and SVP should [N0271] provide color contrast greater than 40 ΔEYu'v' if absolute color classification is necessary, 100 ΔEYu'v' if relative color classification is necessary. [FAA HF-STD-001 Human Factors Design Standard § 5.3.1.9]	X			X
N0272	The RVP and SVP should [N0272] be visually shown so that each ATCS position has an unobstructed view of the entire presentation. [FAA HF-STD-001 Human Factors Design Standard § 5.3.2.2.5]		X		
N0274	The RVP should [N0274] not have a flash or display monitor refresh rate within the 15-20 Hz range.	X		X	
N0275	If compass information is presented on the RVP, the compass markings should [N0275] be congruous with the RVP-Primary Display and in a manner that does not interfere with ATC operations.		X		
N0276	The RT system should [N0276] present the system mode on the RVP in a manner that does not interfere with ATC operations.		X		
N0277	The RT system should [N0277] have standardized terminology (language and symbology) consistent with FAA Orders and FARs. [FAA HF-STD-001 Human Factors Design Standard § 4.4.5]			X	
N0278	The CSD functions may [N0278] be hosted on a CWP that includes a dedicated display monitor, keyboard, and user input device(s).			X	

Req ID	RT System Requirements	T	D	I	A
N0282	The operator's impression of the visual presentation's quality results from a combination of many factors (e.g., display resolution, sensor resolution, field of view, frame rate, refresh rates, refresh contrast, video update rate, video compression, bandwidth, network latency, jitter, chromaticity, color contrast, luminance, contrast ratio, buffering, noise, packet loss, codec, image uniformity, size of the display monitor, display monitor pixel density, distance of the display monitor from the operator, visual angle of targets by size and distance from the camera). The implementation and design of the visual presentation should [N0282] address performance attributes relating to human factors involving ATCS abilities to perform the necessary tasks. In particular, video compression, video update rate, image resolution, jitter, and image uniformity need to be demonstrated against human factor requirements.	X	X	X	X

Appendix F - REMOTE TOWER SYSTEMS AVAILABILITY

FAA RMA-HDBK-006 *FAA Reliability, Maintainability, and Availability (RMA) Handbook* defines Inherent Availability (A_i) of a system as:

$$A_i = \frac{MTBCF}{(MTBCF + MTTR)}$$

Where,

MTBCF = Mean Time Between Critical Failure
MTTR = Mean Time To Repair

In the case of RT systems, a critical failure is defined as one resulting in the loss of the Required Visual Presentation (RVP) function. While an availability requirement is not specified, the inherent availability can be derived based on the MTBCF and the required MTTR. An approximation for the MTBCF can be derived from the continuity requirement (R0101), as follows:

$$MTBCF = \frac{1}{(Continuity \times Exposure\ Time)}$$

$$MTBCF = \frac{1}{\left((1.5 \times 10^{-5})\left(\frac{60\ min/hr}{2\ min}\right)\right)} = 2222\ Hours$$

With a required MTTR equal to or less than two hours (R0279), the achieved inherent availability is:

$$A_i = \frac{2222}{(2222 + 2\ )} = 0.999$$

The RMA requirements in the RMA Handbook are defined according to Service Thread Loss Severity Categories (STLSC), listed below.

1. Safety-Critical – Service thread loss would present an unacceptable safety hazard during the transition to reduced capacity operations.
2. Efficiency-Critical – Service thread loss could be accommodated by reducing capacity without compromising safety, but the resulting impact might have a localized or system-wide economic impact on NAS efficiency.
3. Essential – Service thread loss could be accommodated by reducing capacity without compromising safety, with only a localized impact on NAS efficiency.
4. Routine – A service which, if lost, would have a minor impact on the risk associated with providing safe and efficient NAS operations.

The service availability associated with these categories is defined in FAA NAS-RD-2013 *National Airspace System Requirements Document*.

1. Safety-Critical: Service threads shall be accomplished by greater than or equal to two service threads
2. Efficiency-Critical: 0.9999
3. Essential: 0.999
4. Routine: 0.99

Therefore, the inherent availability is estimated to meet the Essential service category.

Appendix G - TIME-TO-ALARM

The time-to-alarm associated with the integrity requirement R0177 is further explained in this appendix. Figure 2 illustrates an example, based on a failure to meet the RVP latency requirement R0012, which allows one second between an event in the real world and the visual presentation. It is assumed that HMI could result if the one second latency requirement were exceeded.

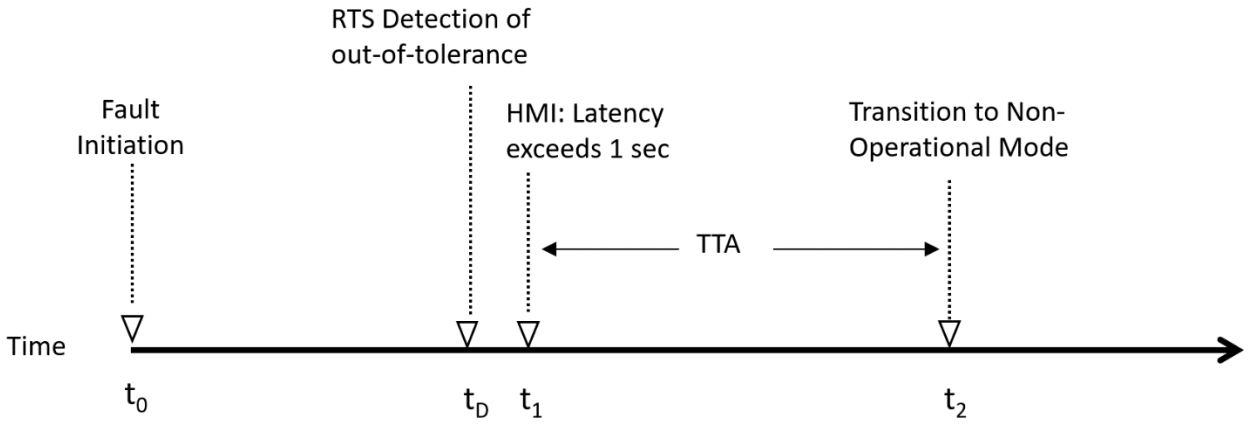

Figure 2 – Time-to-Alarm Timeline Example

The initial fault occurs at t_F. An example latency fault would be a frozen video display. If the display is frozen for more than one second, this results in HMI (t_{HMI}). The HMI event starts the clock for the time-to-alarm (TTA). The RT system must detect latency being out-of-tolerance. The time of detection (t_D) depends on the monitor design. Optimally, it would occur at t_{HMI}, however that may not be practical or necessary. The time of detection (t_D) needs to enable the alarm to occur within one second ($t_A - t_{HMI} \leq 1$ second), and the system to transition to Non-Operational Mode.

The time between t_F and t_{HMI} can vary depending on the nature of the fault. For example, an instantaneous change would be an object appearing in an erroneous location on the display. A second example would be a fault causing an increasing level of video distortion.