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

For Use in Class D Airspace
Version 5.0
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CONTENTS

1 INTRODUCTION

1.1 SCOPE

This document contains the minimum functional and performance requirements for Remote Tower (RT) systems where a Remote Tower Center (RTC) is dedicated to a single co-located airport, 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. 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 other forms of surveillance (e.g., Radio Detection and Ranging (RADAR), Automatic Dependent Surveillance-Broadcast (ADS-B), and/or Multilateration).

1.1.1 DOCUMENT LAYOUT

Section 1.2 provides a high-level RT system overview.

Section 2 states the System, Functional, and Performance requirements. The system and 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, Human Factors considerations and requirements, and Employee Safety and Health requirements.

Section 4 states the Information Systems Security requirements.

Section 5 states the Safety and Reliability, Maintainability, and Availability (RMA) requirements.

The Appendices contain a list of acronyms, references, Verification Requirement Test Matrix (VRTM) criteria, estimated inherent availability, Time-to-Annunciate guidance, and test case guidance.

1.1.2 DOCUMENT CONVENTIONS

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

a. **Must** – This is a mandatory functional requirement. It "must" perform this function. Example: The AAA functionality must be reproduced at the RTM.
b. **Shall** – This specifies the requirement of quantitative performance. The function "shall" perform within this specification. Example: The DR function shall store the most recent 45 days of recorded data.
c. **Should** – This is a requirement recommendation. The function "should" perform in this manner. Example: The AAA functionality's volume control should be a logarithmic volume control.
d. **May** – This is an optional functionality. The system "may" provide this functionality. Example: The RVP-Tertiary Display(s) may be presented on the RVP-Primary Display, RVP-Secondary Display(s), or separate supporting display monitor(s).

All of the requirements in this document are 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 a list of generic components potentially utilized by each function. The generic list of components represents one means, but not the only means, to architect an RT system.

1. Visual Presentation
    a. Required Visual Presentation (RVP)
    b. Supplemental Visual Presentation (SVP) (Optional)
    c. Magnification
2. Signal Light Gun (SLG)
3. Ambient Airfield Audio (AAA)
4. Maintenance Data Terminal (MDT)
5. Data Recorder (DR)

Table 1 – RT System Functions

Function	Description	Generic Architecture Components
RVP	Provide an Air Traffic Control Specialist (ATCS) the visual presentation of the airfield and surrounding airspace for use by the ATCS in providing operational air traffic services. The RVP is composed of an RVP-Primary Display and optionally includes RVP-Secondary Display(s), and RVP-Tertiary Display(s). The RVP-Primary Display is a continuous 360-degree fixed-view of the airfield and surrounding airspace. The RVP-Secondary Display(s) provide fixed view(s) of the airfield and/or surrounding airspace for the active runway(s). The RVP-Tertiary Display(s) provide directable and aimable views of the airfield and/or surrounding airspace using the Magnification function. The RVP-Secondary Display(s) are shown on separate supporting display monitor(s). RVP-Tertiary Display(s) can be shown on the RVP-Primary Display, the RVP-Secondary Display, or a separate supporting display monitor. Additional information on the role of the RVP-Primary Display, RVP-Secondary Display(s), and RVP-Tertiary Display(s) can be found in the FAA *Remote Tower System Pilot Program Operational Visual Requirements* (OVRs).	Display Monitor(s) RVP Camera(s) Data Processor Encoders/Decoders Control-Display Workstation Environment Mitigation Equipment Ancillary Equipment
SVP	Provide an ATCS with auxiliary visual presentations or enhancements that provide additional situational awareness. The SVP is optional and not required to satisfy the RVP performance capability requirements. Supplemental information can be presented on the RVP at a preferred location chosen by ATCS or on separate supporting display monitor(s). Supplemental information can be generated from the additional optical sensors (e.g., Pan-Tilt-Zoom [PTZ] cameras and/or non-visible light cameras) and/or software enhanced images (e.g., overlays, box-and-track, and/or segment image enlargements).	Display Monitor(s) RVP Camera(s) Supplemental Cameras Data Processor Encoders/Decoders Control-Display Workstation Environment Mitigation Equipment Ancillary Equipment

Function	Description	Generic Architecture Components
Magnification	Provide an ATCS the capability to enhance, through image enlargement, the field of view of any location shown on the RVP-Primary Display. This function can be a directable zooming/scanning capability provided on the RVP-Tertiary Display(s) using PTZ camera(s), software digital zoom, and/or short focal length binoculars used by ATCS in viewing the RVP-Primary Display. The Magnification function can be part of the RVP when used to meet the OVRs; otherwise, it is considered part of the SVP.	(PTZ Camera(s), Control-Display Workstation, Data Processor Encoders/Decoders, and Ancillary Equipment) or Short focal length optical device
SLG	Provide an ATCS the capability to communicate with aircraft, vehicles, equipment, and personnel on the airfield and surrounding airspace through visible light visual signals.	Control-Display Workstation Remote Light Gun (RLG) Ancillary Equipment
AAA	Provide an ATCS with an ambient airfield audio broadcast in the Remote Tower Module (RTM).	Microphone(s) Speaker(s) Data Processor Encoders/Decoders Control-Display Workstation Ancillary Equipment
MDT	The MDT function provides secure input and output capability for equipment, control, and monitoring of the RT system components.	Monitor and Input Devices Ancillary Equipment
DR	Records visual data to support accident/incident investigation.	Memory Storage Device Ancillary Equipment

The RT system is composed of all functionalities that reside at either the RTC, the Airport Remote Tower, or an MDT. Figure 1 illustrates a generic RT system architecture overview and how various components can be utilized and allocated to physical locations.

The RTC is an indoor environment residing on the airport property or at a remote location (off-airport property). The RTM located within the RTC provides the ATCS with a user interface that has the ability to control the necessary RT system equipment.

The Airport Remote Tower is located at the airport facility and is to be sited and installed in accordance with manufacturer requirements.

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, interfaces to enable real-time monitoring, maintenance, and control of the RT system. The MDT can interface with the system at the Airport RT and/or at the RTM. The MDT is used by installers, maintainers, and system administrators to:

- Conduct updates to System Configuration Parameters (e.g., system mode, software, network configuration, adaptation data, installation settings, and/or optimization data).
- Conduct maintenance activities (e.g., fault diagnostics, corrective and preventive maintenance, calibration, troubleshooting, and/or Built-In-Test [BIT]).
- View stored system data (e.g., status information, resources, faults, warnings, system errors, event logs, security audit logs, and/or networking information).

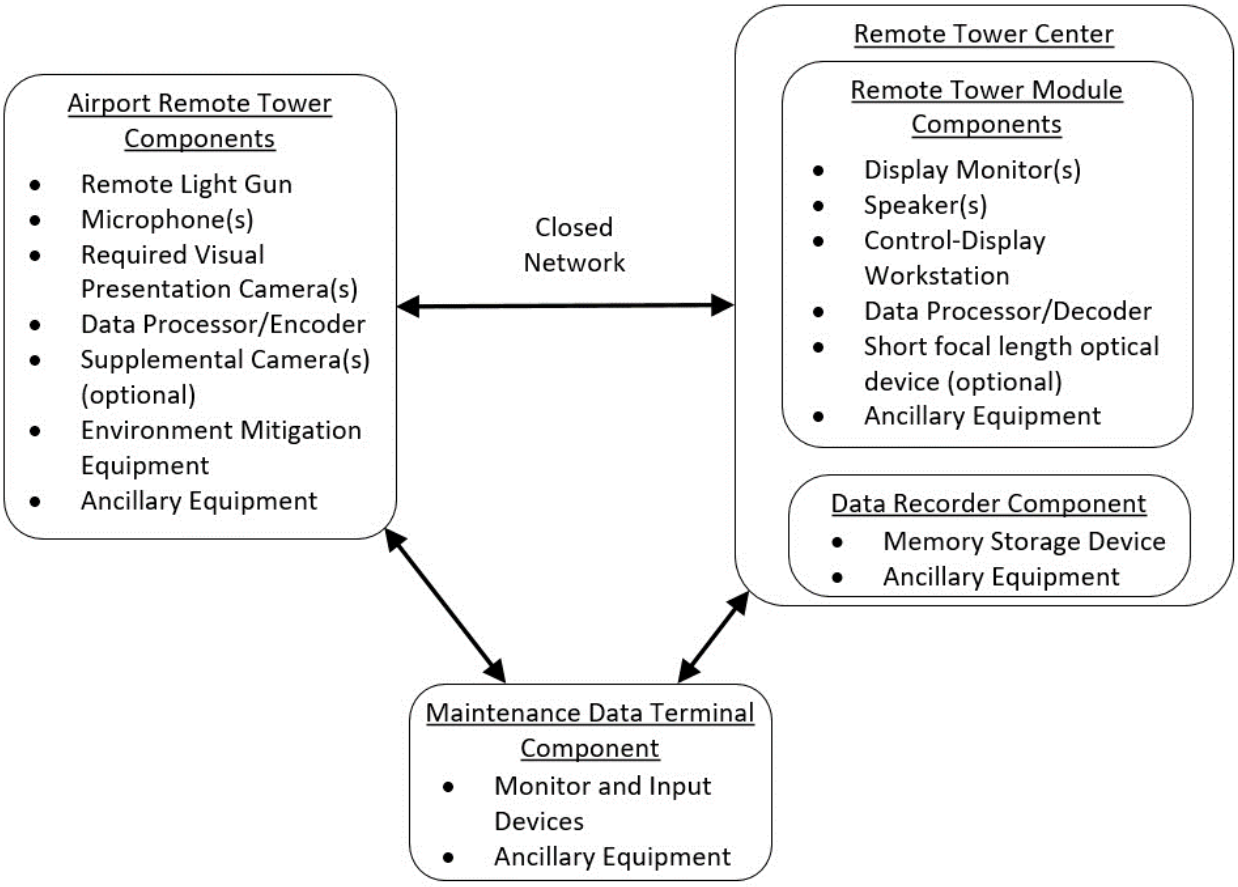

Figure 1 – Generic RT System Architecture Overview

1.2.1 AIRPORT REMOTE TOWER COMPONENTS

The Airport RT components consist of the RLG, RVP camera(s), microphone(s), supplemental camera(s), data processor/encoder, environment mitigation equipment, 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 components are shown in Table 2.

Table 2 – Airport RT Components

Components	Description
RLG	Remote control signal light gun capable of being directed in azimuth and elevation to any location shown on the RVP-Primary Display in order to provide backup communication with aircraft, vehicles, and personnel.
RVP Camera(s)	Camera(s) providing video information for RVP-Primary Display: Visible spectrum camera(s) composed of fixed optical sensors (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 fixed optical sensors (fixed focal length, fixed angle of view, fixed level of zoom) are used to create the RVP-Secondary Display's partial out-the-window view of the airfield and surrounding airspace. Camera(s) providing video information for RVP-Tertiary Display: Visible spectrum camera(s) composed of optical sensors that are either fixed or variable focus/scan can be used to create the RVP-Tertiary Display.
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 and audio sensors to produce a video stream and audio stream for creating the virtual airfield and surrounding airspace 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 and/or PTZ cameras).
Ancillary Equipment	Any additional equipment used to support the required Remote Tower functions (e.g., communication lines, power source, redundant power source, power conditioning, and/or sponsor provided services in support of the equipment).
Environment Mitigation Equipment	Any equipment used to abate environmental effects on the RT system (e.g., equipment used to keep the camera lens clear of debris and/or heaters).

1.2.2 REMOTE TOWER CENTER OVERVIEW

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

Table 3 – RTC Components

Components	**Description**
Display Monitor(s)	Component(s) making up the video wall for presentation of RVP-Primary Display, optional RVP-Secondary Display(s), optional RVP-Tertiary Display(s), and optional SVP(s). Component(s) making up separate displays for enhanced views supporting optional RVP-Tertiary 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 airfield and surrounding airspace for the RVP, AAA, and optionally for the SVP and Magnification functions. The processor also provides 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 a Controller Working Position (CWP). The CWP is a human-machine interface that provides the ATCS with all the required functions (§ 2.2), annunciations, (§ 2.1.2), and control (§ 2.1.6.1) of the RT system. ATCS will serve as tower team members providing ATC services, in accordance with FAA Orders JO 7110.65 *Air Traffic Control* and 7210.3 *Facility Operation and Administration*.
Short focal length optical device	Binoculars
Memory Storage Devices	NVM storage devices for recording and saving data in support of the Data Recorder Function.

2 SYSTEM, FUNCTIONAL, AND PERFORMANCE REQUIREMENTS

2.1 SYSTEM REQUIREMENTS

2.1.1 STATES AND MODES

The RT system must [R0068] have two system states: ON and OFF. A system state of OFF means no system functionality is active. A system state of ON means at least some system functionality is active.

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

The RT system must [R0170] only allow configuration changes to System Configuration Parameters, command diagnostic tests, and clearing ATC Alarms while in Maintenance Mode.

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

The RT system must [R0025] only allow an intrusive diagnostic test to be invoked during Maintenance Mode. An intrusive diagnostic test introduces system behaviors impacting and/or interfering with ATCS providing operational air traffic services.

2.1.2 ALARMS AND ALERTS

Table 4 identifies 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***	***Description***	***Indication[1]***
Operational	*None*	*The RT system is working as expected within the minimum performance requirements.*	*Normal*
Operational	*Corrective Maintenance Alert*	*The RT system has detected a failure indicating maintenance needs to be scheduled (e.g., failed redundant component that could impact future continuity or availability); however, ATCS can still provide operational air traffic services.*	*Caution*
Operational	*Security Alert*	*The RT system is working as expected; however, an increased security threat has occurred, indicating the System Administrator needs to be notified.*	*Caution*
Operational	*Preventive Maintenance Alert*	*The RT system is working as expected. This indication provides information for routine maintenance actions.*	*Advisory*

System Mode	***Alarms & Alerts***	***Description***	***Indication[1]***
Degraded	*ATC Alarm*	*An alarm has been generated indicating either a loss of integrity or a partial or total loss of RVP function. If a site's Operational Contingency Plan or Standard Operating Procedures provide mitigation for the alarm, the RT system can remain operational. Otherwise, the RT system can no longer be used by ATCS in providing operational air traffic services.*	*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 [R0075] generate a Corrective Maintenance Alert upon detecting a faulted condition requiring corrective maintenance. Monitoring design and thresholds associated with Corrective Maintenance Alerts need to be chosen to identify the need to schedule maintenance due to a failed device or component of the system.

The RT system should [N0076] generate a Preventive Maintenance Alert upon detecting a condition not affecting the system's functional capabilities but as an advisory indication for potential maintenance needs.

The RT system must [R0073] generate an ATC Alarm when either a loss of integrity (§ 5.1.1) or a partial or total loss of RVP function (§ 5.1.2) is detected.

The RT system must [R0074] transition to a Degraded Mode within the Time-to-Annunciate (TTA) (§ 5.1.1) when an ATC Alarm condition is detected.

The RT system must [R0312] present the visual warning annunciation for an ATC Alarm within the TTA (§ 5.1.1).

The RT system must [R0313] present the audible warning annunciation for an ATC Alarm within the TTA (§ 5.1.1).

The RT system must [R0218] provide the capability of visually annunciating the presence of an ATC Alarm, a Corrective Maintenance Alert, and a Security Alert to the Access Level 2 user.

The RT system's operationally relevant diagnostic information associated with ATC Alarms and Corrective Maintenance Alerts should [N0331] be made available to the Access Level 2 user. [FAA HF-STD-001 *Human Factors Design Standard* §§ 5.5.1.1.2, 5.5.1.1.3, 5.5.1.1.4, 5.5.1.1.9]

The RT system must [R0262] provide the capability for the audible annunciation of the presence of an ATC Alarm, a Corrective Maintenance Alert, and a Security Alert to the Access Level 2 user.

The RT system must [R0236] provide the capability for any Access Level 2 user to suppress individual visual Corrective Maintenance Alerts and Security Alerts, once activated.

The RT system must [R0079] provide the capability for any Access Level 2 user to mute individual audible ATC Alarms, Corrective Maintenance Alerts, and Security Alerts, once activated.

The RT system must [R0332] not visually or audibly annunciate the presence of a Preventive Maintenance Alert on the RVP.

2.1.2.1 KEY PERFORMANCE PARAMETERS

Key Performance Parameters (KPPs) are manufacturer chosen vital characteristics, functions, or requirements that are measured and monitored to identify impacts on the system performance. KPPs aid in diagnostic and fault isolation as well as generate ATC Alarms, Preventive Maintenance Alerts, and Corrective Maintenance Alerts.

The RT system must [R0023] provide the capability for Access Level 3 users to manually initiate KPP monitoring to aid in diagnostic and fault isolation.

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 must [R0071] automatically execute performance monitoring of all KPPs to detect the need for the generation of ATC Alarms, Preventive Maintenance Alerts, and Corrective Maintenance Alerts.

2.1.3 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 users.

The RT system Access Level 3 must [R0138] provide Read/Write access for privileges allocated to a Maintenance Technician 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 Maintenance Technician.

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 ATC Alarm	X		X	X	X	X	X	X		
Mute Corrective Maintenance Alert	X		X	X	X	X	X	X		
Mute Security Alert	X		X	X	X		X		X	X
SVP Control	X		X	X						
Environment Mitigation Equipment Control	X		X	X						
System Configuration Parameters	X				X	X	X	X		
ATC Alarms	X		X		X	X	X	X	X	
Preventive Maintenance Alerts	X				X	X	X	X		
Corrective Maintenance Alerts	X		X		X	X	X	X	X	
Security Alerts	X		X		X		X		X	X
System Event Logs	X				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

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: Degraded or Maintenance	X		X		X	X	X		X	X
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

2.1.4 EVENT LOGGING

The RT system must [R0085] automatically log all Preventive Maintenance Alerts, Corrective Maintenance Alerts, ATC 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 and mode 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 ATC Alarms, Corrective Maintenance Alerts, and Preventive Maintenance 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 [azimuth/elevation] and zoom), in the System Event Log.

The RT system must [R0239] record all commands that mute or suppress notifications for ATC Alarms and Corrective Maintenance 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] and transmitted signal selection) in the System Event Log.

2.1.5 TIMING

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

The RT system shall [R0067] maintain synchronization to an external UTC reference within 100 milliseconds.

The RT system's time delay between the AAA and the RVP should [N0051] optimally be less than +45 milliseconds (lead) and -60 milliseconds (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]

2.1.6 CONTROLLER WORKING POSITION

The RT system must [R0260] provide a minimum of two CWPs.

The RT system must [R0058] provide a dedicated means (i.e., user interface) for any Access Level 2 user to control the system from each CWP.

The RT system must [R0341] provide the capability that allows the Access Level 2 user(s) access and control of all visual presentations and annunciations of the RT system from each CWP. This supports the ability for the tower team to fulfill their responsibilities from each CWP.

The RT system must [R0342] provide the capability that allows a single Access Level 2 user access and control of all visual presentations and annunciations of the RT system from each CWP. This supports the consolidation of positions to one team member who can provide ATC service from each CWP.

The RT system must [R0343] provide the capability that allows Access Level 2 user(s) to consolidate any separated functionality based on tower team positions from each CWP.

2.1.6.1 STATUS AND CONTROL

The RT system must [R0054] provide access capability for multiple independent Access Level 2 users at the same time.

The RT system shall [R0224] respond within 250 milliseconds of Access Level 2 user inputs. The response time is intended to be the duration of time measured between a user-initiated input and expected system response (e.g., the response for the user turning off the airfield audio is measured as the time difference between the user initiating the airfield audio off command and airfield audio no longer being output from the speakers).

The RT system must [R0305] provide the current status of any RT system configuration setting impacting shared resources (e.g., RVP and/or audio) to each Access Level 2 user.

The RT system must [R0222] provide the capability for any Access Level 2 user to control and activate the Magnification function for non-short focal length optical implementations.

The RT system's current status and signal mode of the RLG must [R0014] be visible to all Access Level 2 user(s) at all times (FAA Order JO 7110.65 *Air Traffic Control* § 3-2-1, Light Signals).

The RT system must [R0221] provide the capability for any Access Level 2 user to control and activate the SLG.

The RT system must [R0016] provide the capability for any Access Level 2 user to visually observe the RLG is functioning properly.

The RT system must [R0217] provide the capability for any Access Level 2 user to turn on and off the AAA.

The RT system should [N0063] provide the capability for any Access Level 2 user to adjust the volume and mute and unmute the AAA reproduction.

The RT system must [R0220] provide the capability for any Access Level 2 user to control and activate environment mitigation equipment.

The RT system must [R0064] provide the capability for any Access Level 2 user to control the balancing of light exposure in the video image(s) (e.g., analogous to drawing the shades in a brick-and-mortar tower).

If a manufacturer chooses to provide different user interfaces to Access Level 2 users, each CWP shall [R0345] have a fully functioning Access Level 2 user interface within 10 seconds when switching.

2.1.6.1.1 User Preference Sets

User preference sets are not required as a minimum functionality. If the manufacturer chooses to implement user preference sets, the requirements in this section apply.

The RT system must [R0189] be capable of establishing user preferences for each Access Level 2 user.

The RT system must [R0056] be capable of saving user preferences for each Access Level 2 user.

The RT system must [R0346] have a fully functioning Access Level 2 user interface within 10 seconds when switching between user preference sets.

2.2 FUNCTIONAL AND PERFORMANCE REQUIREMENTS

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

2.2.1 VISUAL PRESENTATION

2.2.1.1 REQUIRED VISUAL PRESENTATION

The RVP out-the-window view is used by the ATCS in providing operational air traffic services and is generated using a combination of optical sensors, hardware, and software components. Design considerations and trade-offs for RVP are left to the manufacturer. Additional guidance for design is provided in European Organisation for Civil Aviation Equipment (EUROCAE) ED-240 *Minimum Aviation System Performance Standard for Remote Tower Optical Systems*. Further guidance on human factors considerations is provided in § 3.2.

The RVP must [R0281] be composed of an RVP-Primary Display.

The RVP may [N0321] include an RVP-Secondary Display.

The RVP may [N0322] include an RVP-Tertiary Display.

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

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

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

All images combined from multiple cameras for the RVP shall [R0303] be from the same point in time ± one frame.

2.2.1.1.1 Required Visual Presentation - Primary Display

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

The RVP-Primary Display must [R0320] provide an out-the-window view of the airfield and surrounding airspace.

When presenting images from multiple cameras across multiple display monitors, the resulting RVP-Primary Display should [N0323] not interfere with ATCS providing operational air traffic services (e.g., due to missing, duplicated, or misaligned parts of the view).

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 RT system must [R0009] present the current system mode at all times (§ 2.1.1) on the RVP-Primary Display.

Any information (e.g., system mode [§ 2.1.1], RVP-Tertiary Display(s), and/or SVP) overlaid on the RVP-Primary Display must [R0302] be implemented in a manner that does not interfere with ATCS providing operational air traffic services.

The RT system should [N0223] provide the capability for any Access Level 2 user to declutter the RVP-Primary Display by toggling on and off all SVP (if provided) with a single input by the user.

2.2.1.1.2 Required Visual Presentation - Secondary Display(s)

If an RVP includes a Secondary Display, the requirements in this section apply.

The RVP-Secondary Display(s) must [R0324] be presented on separate supporting display monitor(s).

The RVP-Secondary Display(s) must [R0325] provide an out-the-window view of a portion of the airfield and surrounding airspace.

The RVP-Secondary Display's perspective must [R0326] be from a single fixed point of view, single fixed focal point, and single fixed level of zoom.

Multiple RVP-Secondary Displays must [R0327] present the same perspective to the Access Level 2 user. The same perspective ensures maintaining the spatial relationship between objects on all RVP-Secondary Displays, as perspective denotes the same impression of an object's height, width, depth, and position.

The RT system should [N0328] provide the capability for any Access Level 2 user to declutter their CWP position specific RVP-Secondary Display(s) by toggling on and off all SVP (if provided) with a single input by the user.

The RT system must [R0330] provide the capability for any Access Level 2 user to select the active runway(s) to be displayed on the RVP-Secondary Display(s).

2.2.1.1.3 Required Visual Presentation - Tertiary Display(s)

If an RVP includes a Tertiary Display, the requirements in this section apply.

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

The RVP-Tertiary Display(s) must [R0179] provide enhanced views of the airfield and/or surrounding airspace.

The RVP-Tertiary Display's enhanced views must [R0181] be provided by the Magnification function.

The RT system should [N0329] provide the capability for any Access Level 2 user to declutter their CWP position specific RVP-Tertiary Display(s) by toggling on and off all SVP (if provided) with a single input by the user.

2.2.1.1.4 Required Visual Presentation Performance Capability

This section forms a framework under which the applicant will define quantitative RVP performance capability requirements, which is then used to establish manufacturer's siting constraints. The maximum LOS distance is between the RVP camera and the Object-of-Interest within the field of view. Table 6 provides visual performance definitions for observation types: Detect, Recognize, and Identify.

Table 6 – Visual Performance Definitions

Visual Performance	Definition
Detect	Determine if an Object-of-Interest is present; however, not necessarily providing the capability to discern any of the Object-of-Interest's main features.
Recognize	Discern enough of the main features unique to an Object-of-Interest to discern a general class, such as person, vehicle, or aircraft.
Identify	Discern enough of the main features unique to each Object-of-Interest class such that it can be uniquely identified.

Table 7 defines the Object-of-Interest's minimum main features and representative volumes for each class of object used in the visual performance requirements.

Table 7 – Objects-of-Interest

Class	Description	Main Features	Volume in Meters		
			Width	Height	Length
Person	Adult human being	Average size adult human, face, head, torso, arms, legs, and orientation.	2	0.5	0.5
Vehicle	Motorized truck with four wheels (e.g., truck or car)	Wheels, body, windows, grill, roof, hood, and orientation.	2	2	5
Small Aircraft	General aviation single-engine piston airplane to light jet and helicopters (e.g., Cessna 152, Beechcraft Bonanza, Piper M350, and Robinson R22)	Wings, wing location (e.g., upper or lower), windscreen, propulsion, vertical and horizontal stabilizer, fuselage, tail numbers, landing gear, attitude, and orientation.	3	8	11

The RVP-Primary Display LOS distances are to be accomplished:

1. Without the use of enhancement options provided by the Magnification function (§ 2.2.1.3).
2. Under nominal lighting conditions (day light [illumination of at least 10,000 lux], no clouds [color temperature of the sky of approximately 25,000 Kelvin] and visibility of at least 10 kilometers).
3. Using the maximum defined viewing distance between the RVP video wall and CWP, as specified by the manufacturer's siting constraints.

If the manufacturer chooses to implement the RVP-Secondary Display functionality, the RVP-Secondary Display LOS distances are to be accomplished:

1. Without the use of enhancement options provided by the Magnification function (§ 2.2.1.3).
2. Under nominal lighting conditions (day light [illumination of at least 10,000 lux], no clouds [color temperature of the sky of approximately 25,000 Kelvin] and visibility of at least 10 kilometers).
3. Using the maximum defined viewing distance between the RVP-Secondary Display(s) and CWP, as specified by the manufacturer's siting constraints.

If the manufacturer chooses to implement the RVP-Tertiary Display functionality, the RVP-Tertiary Display LOS distances are to be accomplished:

1. Using one or more enhancement options provided by the Magnification function (§ 2.2.1.3).
2. Under nominal lighting conditions (day light [illumination of at least 10,000 lux], no clouds [color temperature of the sky of approximately 25,000 Kelvin] and visibility of at least 10 kilometers).
3. Using the maximum defined viewing distance between the RVP-Tertiary Display(s) and CWP, as specified by the manufacturer's siting constraints.

The RT system must [R0333] satisfy a set of visual performance values in terms of LOS applicable to the manufacturer's RT system architecture for each RVP display (unique RVP image capturing-display portion of the system), as identified by the applicant, including detection, recognition, and identification, as shown in Table 8 (LOS01 - LOS15).

Table 8 – Qualitative Visual Capability Requirements

Area-of-Interest	Object-of-Interest	Primary Display		Secondary Display(s)		Tertiary Display(s)	
		Task	Range	Task	Range	Task	Range
Ground	Vehicle	D	LOS01	D	LOS07	D	LOS13
Airborne	Small Aircraft	D	LOS02	D	LOS08		
Ground	Person	D	LOS03	D	LOS09	D	LOS14
Ground	Vehicle	R	LOS04	R	LOS10		
Ground	Small Aircraft	R	LOS05	R	LOS11		
Ground	Small Aircraft	I	LOS06	I	LOS12	I	LOS15

Where:

1) Area-of-interest is an area, either on the ground or in the air, which is specified to be of interest by ATCS.

2) Objects-of-Interest are described in Table 7.

3) Tasks are denoted as Detect (D), Recognize (R), and Identify (I), as defined in Table 6.

4) The manufacturer is expected to quantify all RVP display visual performance range values (LOSXX).

5) Visual performance range values identify the Line-of-Sight distance from the applicable camera lens to the Object-of-Interest. Multiple columns could be needed for a single display type if the implementation employs multiple or optional configurations.

2.2.1.2 SUPPLEMENTAL VISUAL PRESENTATION

Supplemental information, such as overlays, box-and-track, and non-visible light imagery, is not required as a minimum functionality. However, if the manufacturer chooses to implement SVP functionality, the requirements in this section apply. Design considerations and trade-offs for SVP are left to the manufacturer. 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 is provided in § 3.2.

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

If the SVP is presented on a separate display monitor, the performance (e.g., luminance, chromaticity, and contrast) must [R0228] have no discernible difference to the RVP from the Access Level 2 users' view (§ 3.2).

2.2.1.3 MAGNIFICATION

The following requirements in this section apply to PTZ cameras or digital zoom functionality.

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

The Magnification functionality must [R0210] provide the capability of directing the field of view to any location shown on the RVP-Primary Display.

The Magnification functionality shall [R0310] provide the capability of moving the field of view from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 60 degrees apart within two seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.

The Magnification functionality shall [R0311] provide the capability of moving the field of view from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 180 degrees apart within four seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.

The Magnification functionality shall [R0259] provide the capability of traversing the full range of the zoom in less than four seconds with a speed variation less than 10 percent. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the initial input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.

2.2.2 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 [R0203] provide the capability to direct the RLG at a target of interest shown on the RVP-Primary Display.

The SLG functionality shall [R0308] provide the capability of moving the RLG from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 60 degrees apart within two seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.

The SLG functionality shall [R0309] provide the capability of moving the RLG from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 180 degrees apart within four seconds. The time required for moving the RLG is the amount of time for the SLG functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.

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

2.2.3 AMBIENT AIRFIELD AUDIO

The AAA functionality must [R0048] be reproduced at the RTM and be representative of audio corresponding to the RVP-Primary Display.

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 logarithmic.

The AAA functionality should [N0049] provide a multichannel (i.e., spatialized audio) sound reproduction presented to the Access Level 2 user as a multidirectional audible perspective consistent with the visual presentation focal reference.

The AAA functionality must [R0192] be integrated into the RT system independent of the ATCS radio communication system. The AAA is not to interfere with ATCS radio communication.

2.2.4 MAINTENANCE DATA TERMINAL

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

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

The MDT functionality must [R0187] have the capability to view the current software and adaptation version identification.

The MDT functionality must [R0027] have the capability to view events from the System Event Log.

The MDT functionality must [R0022] have the capability to view diagnostic information to aid in fault isolation.

The MDT functionality must [R0257] provide the capability of visually annunciating ATC Alarms, Corrective Maintenance Alerts, Security Alerts, and Preventive Maintenance Alerts.

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

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

The MDT functionality must [R0024] provide the capability for an Access Level 3 user to initiate intrusive and non-intrusive diagnostics tests.

The MDT functionality must [R0185] provide the capability for an Access Level 3 user to configure the System Configuration Parameters.

The MDT functionality must [R0186] provide the capability for an Access Level 3 user to install RT software.

The MDT functionality should [N0028] provide the capability for an Access Level 3 user to sort and search the System Event Log.

The MDT functionality must [R0029] provide the capability for an Access Level 3 user to export the System Event Log from NVM onto external media.

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

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

The MDT functionality must [R0034] provide the capability for an Access Level 3 user to clear ATC Alarms, Corrective Maintenance Alerts, and Preventive Maintenance Alerts.

The MDT functionality should [N0252] provide the capability for an Access Level 3 user to disable audible ATC Alarms, Corrective Maintenance Alerts, and Security Alerts annunciated by the RT system during Maintenance Mode.

2.2.5 DATA RECORDING

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

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

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

The DR functionality shall [R0038] timestamp all recorded data with an accuracy less than or equal to 0.01 seconds.

The DR functionality must [R0039] use NVM.

The DR functionality must [R0040] secure NVM storage from tampering and manipulation.

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

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.

3 INTEGRATION REQUIREMENTS

3.1 PHYSICAL INTEGRATION

3.1.1 ENVIRONMENTAL 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 Corrective Maintenance Alert when the cabinet temperature exceeds either the upper or lower cabinet temperature threshold.

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

The RT system must [R0008] provide the capability to balance light exposure in the RVP video image(s) (e.g., analogous to drawing the shades in a brick-and-mortar tower). 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 RVP and any SVP views shall [R0306] be stable in both 45 mile-per-hour wind with the camera mast(s) encased in 1/2 inch radial ice and in 56 mile-per-hour wind, such that display movement does not interfere with ATCS providing operational air traffic services.

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

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

The RT system earth grounding, alternating current power ground, bonding, shielding, and transient protection at the facility interface shall [R0110] meet requirements specified in 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*.

3.1.3 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.

3.1.4 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 (e.g., 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*.

3.1.5 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.

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.

3.1.6 ELECTROMAGNETIC EMISSIONS AND SUSCEPTIBILITY

The RT system equipment shall [R0264] meet the appropriate Federal Communications Commission (FCC) authorizations as defined in 47 CFR part 15 *Radio Frequency Devices* for conducted and radiated emissions.

The RT system equipment shall [R0334] not be degraded due to electromagnetic susceptibility by other National Airspace System (NAS) equipment.

The RT system equipment electromagnetic emissions shall [R0335] not degrade other NAS equipment.

3.2 HUMAN FACTORS

The design of an RT system involves many considerations related 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 human factors design characteristics and features need to be considered.

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

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

The design of the RT system controls should [N0307] provide consistent and predictable outputs in relation to inputs. [FAA HF-STD-001 *Human Factors Design Standard* §§ 5.4.1.1.2.1, 5.2.10.17, 5.4.3.1.3, 5.4.3.1.4, 5.4.3.1.5, 5.4.3.1.6, 5.4.3.3.11]

3.2.1 VISUAL PRESENTATION

The ATCS's perception of the airfield and surrounding airspace is greatly influenced by the quality of the video presented on the RVP. The resulting quality is a combination of many design factors and trade-offs, such as 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 Access Level 2 user, visual angle of targets by size and distance from the camera. These are left to the manufacturers to define. FAA HF-STD-001 *Human Factors Design Standard* provides applicable guidance for addressing human factors requirements related to display monitors. The following provides guidance and recommendations for the design of the RVP.

The implementation and design of the visual presentation should [N0282] address performance attributes relating to human factors involving the ATCS's abilities to perform the necessary tasks. [FAA HF-STD-001 *Human Factors Design Standard* § 5.3.1]

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.

The RVP should [N0274] not have a flash or display monitor refresh rate within the 15-20 Hz range. [FAA HF-STD-001 *Human Factors Design Standard* § 5.6.13.10.2.4]

The RVP and SVP should [N0272] be visually shown so that each Access Level 2 user 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 Access Level 2 user 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]

3.2.2 ACCESS LEVEL 2 USER INTERFACE

The design of the RT system controls and displays used by the Access Level 2 user should [N0113] be consistent with FAA HF-STD-001 *Human Factors Design Standard* §§ 5.6, 5.7.

The design of the RT system Access Level 2 user interface(s) should [N0344] be consistent with the tower team positions outlined in FAA Order JO 7110.65 *Air Traffic Control* § 2-10-3, Tower Team Position Responsibilities.

The design of the Access Level 2 user interface should [N0116] allow all user inputs to be made by an Access Level 2 user in both standing and sitting positions.

The design of the RT system ATC Alarm, Corrective Maintenance Alert, Security Alert, and Preventive Maintenance 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.

3.2.3 REMOTE LIGHT GUN

The manual control for the RLG should [N0315] smoothly transition from the starting position to the target position regardless of small or large angular movements.

The manual control (e.g., course and fine adjustments and/or slew rates) for the RLG should [N0316] be proportional between input and output response.

The movement of the RLG should [N0317] be a smooth transition from the starting position to the target position without overshoot or oscillation regardless of small or large angular movements when being automatically controlled (e.g., commanded to preset targets or selected targets).

The RLG should [N0318] be capable of being panned continually in either direction through more than 360 degrees azimuth without any rotational hard stops.

3.2.4 PAN-TILT-ZOOM CAMERAS

PTZ cameras are not required as a minimum functionality. However, if the RT system uses PTZ cameras, the requirements in this section apply.

The manual control for the PTZ cameras should [N0336] smoothly transition from the starting position to the target position regardless of small or large angular movements.

The manual control (e.g., course and fine adjustments and/or slew rates) for the PTZ cameras should [N0337] be proportional between input and output response.

The movement of the PTZ cameras should [N0338] be a smooth transition from the starting position to the target position without overshoot or oscillation regardless of small or large angular movements when being automatically controlled (e.g., commanded to preset targets or selected targets).

The PTZ cameras should [N0339] be capable of being panned continually in either direction through more than 360 degrees azimuth without any rotational hard stops.

3.2.5 MAINTENANCE DATA TERMINAL

The design of the Access Levels 3, 4, and 5 user interface(s) should [N0114] be consistent with FAA HF-STD-001 *Human Factors Design Standard* §§ 5.6, 5.7.

3.3 EMPLOYEE SAFETY AND HEALTH

These requirements ensure the physical architecture is safe for personnel to install, maintain, and operate.

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.

The 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.

The 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 the system.

The 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 the system.

4 INFORMATION SYSTEMS SECURITY 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 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 Degraded 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 services.

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

4.1 ACCESS AUTHENTICATION

This section contains the minimum authentication requirements for Access Levels 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 Read-Only access that does not require access control authentication. Access Level 2 is Read/Write access used for the Access Level 2 user interface and does not require access control authentication. Authentication requirements for Access Level 4 are specified in § 4.2.

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.

The RT system shall [R0304] automatically disable a user identifier's account after 90 days of inactivity for that user identifier.

4.1.1 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 9.

Table 9 – 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, common character sequences, or dictionary words (spelled forward or backward).

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*.

4.2 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) using encryption standards described in Federal Information Processing Standards (FIPS) 140-2 (valid until 2026) or FIPS 140-3, *Security Requirements for Cryptographic Modules*.

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.

4.3 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 (§ 4.5).

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

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.

The System Administrator must [R0319] have sole rights to access the DR functionality (§ 2.2.5).

4.4 MALWARE AND MALICIOUS CODE PROTECTION

The RT system must [R0287] employ malicious code protection mechanisms (e.g., anti-virus software for workstations and 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.

4.5 SECURITY AUDIT

The RT system must [R0162] 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 (i.e., success/failure).

Audit records must [R0248] not contain sensitive information (e.g., 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.

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

5.1 SAFETY REQUIREMENTS

5.1.1 INTEGRITY

The probability of an undetected malfunction resulting in Hazardously Misleading Information (HMI) shall [R0176] be less than or equal to $3.0x10^{-5}$ in any 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*. This probability can account for the presence of monitor(s) designed to detect malfunctions and other architectural mitigations.

The RT system's TTA for loss of integrity resulting in HMI shall [R0177] not exceed one second. The TTA is the elapsed time between the onset of HMI resulting from a failure and the warning annunciations. The warning annunciations consist of a system mode transition to Degraded Mode and annunciation of a visual and audible ATC Alarm (§ 2.1.2). See Appendix E Time-To-Annunciate for additional information.

5.1.2 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. 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 when determining loss of RVP function. The critical failures of the RVP are defined as those portions of the RVP that contain the ATCT's airspace or area of responsibility. The continuity requirement and the MTTR requirement (R0279) can be translated into an associated inherent availability, as explained in Appendix D Remote Tower Systems Availability.

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

The RT system operation of redundant elements should [N0081] be managed by performance monitoring.

5.1.3 ASSURANCE LEVELS

The Functional Development Assurance Levels (FDALs) are defined in SAE International ARP 4754B *Guidelines for Development of Civil Aircraft and Systems*. The software Assurance Levels (ALs) are defined in RTCA, Inc. DO-278A *Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems*. The hardware Development Assurance Levels (DALs) are defined in RTCA, Inc. DO-254 *Design Assurance Guidance for Airborne Electronic Hardware*. The assurance levels 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.

All RT system functions whose malfunction could result in HMI being presented to an Access Level 2 user must [R0169] be developed to ARP 4754B FDAL D, RTCA DO-278A AL 4, and RTCA DO-254 DAL D.

All RT system functions whose failure could result in loss of continuity must [R0340] be developed to ARP 4754B FDAL D, RTCA DO-278A AL 5, and RTCA DO-254 DAL D.

The RT system assurance levels associated with optional or supplemental functions that are beyond the functionality identified in this specification will be evaluated by the RT system manufacturer through their System Safety Process.

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

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.

APPENDICES

Appendix A ACRONYMS

Acronym	Definition
AAA	Ambient Airfield Audio
ADS-B	Automatic Dependent Surveillance-Broadcast
AL	Assurance Level
ARP	Aerospace Recommended Practices
ATCS	Air Traffic Control Specialist
ATCT	Airport Traffic Control Tower
BIT	Built-In-Test
CIS	Center for Internet Security
CFR	Code of Federal Regulations
CNS/ATM	Communication, Navigation, Surveillance and Air Traffic Management
CWP	Control Working Position
DAL	Development Assurance Level
DR	Data Recorder
dBA	A-weighted Decibel
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FDAL	Functional Development Assurance Level
FTP	File Transfer Protocol
HMI	Hazardously Misleading Information
Hz	Hertz
KPP	Key Performance Parameter
LOS	Line-of-sight
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
RMA	Reliability, Maintainability, and Availability
RT	Remote Tower
RTC	Remote Tower Center
RTM	Remote Tower Module

Acronym	Definition
RVP	Required Visual Presentation
SLG	Signal Light Gun
SP	Special Publication
STLSC	Service Thread Loss Severity Categories
SVP	Supplemental Visual Presentation
TTA	Time-to-Annunciate
UTC	Coordinated Universal Time
UUT	Unit Under Test
VPN	Virtual Private Network
VRTM	Verification Requirement Test Matrix

Appendix B REFERENCE DOCUMENTS

The following documents are referenced and/or applicable to this document. Unless specifically noted, the latest revision of the document applies.

European Organisation for Civil Aviation Equipment (EUROCAE). *Minimum Aviation System Performance Standards (MASPS) for Remote Tower Optical Systems*. (ED-240)

Federal Aviation Administration (FAA). *Electronic Equipment, General Requirements*. (FAA-G-2100)

Federal Aviation Administration (FAA). *Airport Design*. (Advisory Circular 150/5300-13)

Federal Aviation Administration (FAA). *National Airspace System Requirements Document*. (NAS-RD-2013)

Federal Aviation Administration (FAA). *Reliability, Maintainability, and Availability (RMA) Handbook*. (RMA-HDBK-006)

Federal Aviation Administration (FAA). *Lighting and Surge Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Electronic Equipment*. (FAA-STD-019)

Federal Aviation Administration (FAA). *FAA Occupational Safety and Health (OSH) Policy*. (FAA Order 3900.19)

Federal Aviation Administration (FAA). *Air Traffic Control*. (FAA Order JO 7110.65)

Federal Aviation Administration (FAA). *Facility Operation and Administration.* (FAA Order JO 7210.3)

Federal Aviation Administration (FAA). *Remote Tower (RT) Systems for Non-federal Applications*. (Advisory Circular ###/####-###)

Federal Aviation Administration (FAA), Air Traffic Organization. *Safety Management Systems Manual*.

Federal Aviation Administration (FAA), Office of NextGen, Portfolio Management and Technology Development. *Remote Tower System Pilot Program Operational Visual Requirements*

Federal Aviation Administration (FAA), Office of NextGen, Portfolio Management and Technology Development. *Remote Tower Systems Concept of Operations (ConOps)*

Federal Aviation Administration (FAA), Office of NextGen, William J. Hughes Technical Center. *Human Factors Design Standard*. (HF-STD-001)

Federal Information Processing Standards (FIPS). (2001 May 25). *Security Requirements for Cryptographic Modules*. (FIPS 140-2)

Federal Information Processing Standards (FIPS). (2019 March 22). *Security Requirements for Cryptographic Modules*. (FIPS 140-3)

International Telecommunication Union. *Relative Timing Of Sound and Vision for Broadcasting*. (ITU-R BT.1359-1)

International Telecommunication Union. *Quality of experience requirements for IPTV services*. (ITU-T G.1080)

National Institute of Standards and Technology (NIST). *Digital Identity Guidelines*. (SP 800-63). https://www.nist.gov/identity-access-management/nist-special-publication-800-63-digital-identity-guidelines

National Institute of Standards and Technology (NIST). *Risk Management Framework for Information Systems and Organizations*. (SP 800-37). https://doi.org/10.6028/NIST.SP.800-37r2

RTCA, Inc. (2000 April 19). *Design Assurance Guidance for Airborne Electronic Hardware*. (DO-254)

RTCA, Inc. (2011 December 13). *Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems*. (DO-278A)

Radio Frequency Devices, 47 C.F.R. § 15

SAE International. (2023 December 20). *Guidelines for Development of Civil Aircraft and Systems*. (ARP 4754B)

Safety Enhancements – Certification of Airports, 14 C.F.R. § 139

Appendix C 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 utilizes 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 view of the airfield 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 environment mitigation equipment that can be activated in response to environmental impacts affecting the RVP including, but not limited to, birds, insects, dust, and weather (e.g., snow, ice, and/or rain).		X		X
R0008	The RT system must [R0008] provide the capability to balance light exposure in the RVP video image(s) (e.g., analogous to drawing the shades in a brick-and-mortar tower). 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.		X		
R0009	The RT system must [R0009] present the current system mode at all times (§ 2.1.1) 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. The capture-to-display latency includes the time interval between consecutive frames.	X			
R0014	The RT system's current status and signal mode of the RLG must [R0014] be visible to all Access Level 2 user(s) at all times (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 RT system must [R0016] provide the capability for any Access Level 2 user to visually observe the RLG is functioning properly.		X		
R0017	The RT system must [R0017] record the SLG activation command and the control parameters (e.g., directing [azimuth/elevation] and 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	
R0020	The MDT functionality must [R0020] provide the capability for an Access Level 3 user to command and monitor all test and maintenance actions available within the RT system.		X		
R0022	The MDT functionality must [R0022] have the capability to view diagnostic information to aid in fault isolation.		X		X
R0023	The RT system must [R0023] provide the capability for Access Level 3 users to manually initiate KPP monitoring to aid in diagnostic and fault isolation.		X		X
R0024	The MDT functionality must [R0024] provide the capability for an Access Level 3 user to initiate intrusive and non-intrusive diagnostics tests.		X		
R0025	The RT system must [R0025] only allow an intrusive diagnostic test to be invoked during Maintenance Mode. An intrusive diagnostic test introduces system behaviors impacting and/or interfering with ATCS providing operational air traffic services.		X		
R0027	The MDT functionality must [R0027] have the capability to view events from the System Event Log.		X		
R0029	The MDT functionality must [R0029] provide the capability for an Access Level 3 user to export the System Event Log from NVM onto external media.		X		
R0030	The MDT functionality must [R0030] provide the capability for an Access Level 3 user 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 an Access Level 3 user to clear ATC Alarms, Corrective Maintenance Alerts, and Preventive Maintenance Alerts.		X		
R0035	The DR functionality must [R0035] record all the data provided on the RVP and SVP (if provided) to support playback and post-analysis.		X		

Req ID	RT System Requirements	T	D	I	A
R0036	The DR functionality shall [R0036] store the most recent 45 days of recorded data.	X			X
R0037	The DR functionality shall [R0037] timestamp all recorded data at a minimum frequency of one Hz.	X			
R0038	The DR functionality shall [R0038] timestamp all recorded data with an accuracy less than or equal to 0.01 seconds.	X			
R0039	The DR functionality must [R0039] use NVM.		X		
R0040	The DR functionality must [R0040] secure NVM storage from tampering and manipulation.		X		
R0042	The DR functionality must [R0042] provide the recording capability without degradation to the RT system or RVP.		X		
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 [azimuth/elevation] and zoom), in the System Event Log.		X		
R0047	The DR functionality 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 and be representative of audio corresponding to the RVP-Primary Display.		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 RT system must [R0054] provide access capability for multiple independent Access Level 2 users at the same time.		X		
R0056	The RT system should [R0056] be capable of saving user preferences for each Access Level 2 user.		X	X	
R0058	The RT system must [R0058] provide a dedicated means (i.e., user interface) for any Access Level 2 user to control the system from each CWP.			X	
R0064	The RT system must [R0064] provide the capability for any Access Level 2 user to control the balancing of light exposure in the video image(s) (e.g., analogous to drawing the shades in a brick-and-mortar tower).		X		
R0066	The RT system shall [R0066] be synchronized to an external Coordinated Universal Time (UTC) reference, which supports a resolution less than or equal to 0.01 seconds.	X			
R0067	The RT system shall [R0067] maintain synchronization to an external UTC reference within 100 milliseconds.	X			
R0068	The RT system must [R0068] have two system states: ON and OFF. A system state of OFF means no system functionality is active. A system state of ON means at least some system functionality is active.		X		
R0069	The RT system must [R0069] have the following three system modes when the system state is ON: Operational, Degraded, and Maintenance.		X		
R0071	The RT system must [R0071] automatically execute performance monitoring of all KPPs to detect the need for the generation of ATC Alarms, Preventive Maintenance Alerts, and Corrective Maintenance Alerts.	X			
R0073	The RT system must [R0073] generate an ATC Alarm when either a loss of integrity (§ 5.1.1) or a partial or total loss of RVP function (§ 5.1.2) is detected.	X			X
R0074	The RT system must [R0074] transition to a Degraded Mode within the Time-to-Annunciate (TTA) (§ 5.1.1) when an ATC Alarm condition is detected.	X			

Req ID	RT System Requirements	T	D	I	A
R0075	The RT system must [R0075] generate a Corrective Maintenance Alert upon detecting a faulted condition requiring corrective maintenance. Monitoring design and thresholds associated with Corrective Maintenance Alerts need to be chosen to identify the need to schedule maintenance due to a failed device or component of the system.	X			X
R0079	The RT system must [R0079] provide the capability for any Access Level 2 user to mute individual audible ATC Alarms, Corrective Maintenance Alerts, and Security Alerts, once activated.		X		
R0083	Continuity of operation shall [R0083] be maintained such that the time to recover from a critical failure is less than or equal to three seconds for automatic switchover and 30 seconds for manual switchover of redundant elements. 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.	X			
R0085	The RT system must [R0085] automatically log all Preventive Maintenance Alerts, Corrective Maintenance Alerts, ATC 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 ATC Alarms, Corrective Maintenance Alerts, and Preventive Maintenance Alerts in the System Event Log.		X		
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 (e.g., 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

Req ID	RT System Requirements	T	D	I	A
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. 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 when determining loss of RVP function. The critical failures of the RVP are defined as those portions of the RVP that contain the ATCT's airspace or area of responsibility. The continuity requirement and the MTTR requirement (R0279) can be translated into an associated inherent availability, as explained in Appendix D Remote Tower Systems Availability.				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 Corrective Maintenance 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
R0110	The RT system earth grounding, alternating current power ground, bonding, shielding, and transient protection at the facility interface shall [R0110] meet requirements specified in 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	The 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	The 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 the system.			X	X
R0123	The 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 the system.			X	X
R0124	The RT system must [R0124] enforce the information system security requirements during all system modes of operation.		X		
R0125	The RT system must [R0125] ensure 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 Degraded Mode.		X		

Req ID	RT System Requirements	T	D	I	A
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 users.		X		
R0138	The RT system Access Level 3 must [R0138] provide Read/Write access for privileges allocated to a Maintenance Technician 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 Maintenance Technician.		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 9.		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, 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		

Req ID	RT System Requirements	T	D	I	A
R0162	The RT system must [R0162] monitor and generate a security audit event for the following:		X		
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	All RT system functions whose malfunction could result in HMI being presented to an Access Level 2 user must [R0169] be developed to ARP 4754B FDAL D, RTCA DO-278A AL 4, and RTCA DO-254 DAL D.			X	
R0170	The RT system must [R0170] only allow configuration changes to System Configuration Parameters, command diagnostic tests, and clearing ATC Alarms while 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 must [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 and mode 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 and modify recording parameters.		X		
R0176	The probability of an undetected malfunction resulting in Hazardously Misleading Information (HMI) shall [R0176] be less than or equal to 3.0x10-5 in any 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. This probability can account for the presence of monitor(s) designed to detect malfunctions and other architectural mitigations.				X
R0177	The RT system's TTA for loss of integrity resulting in HMI shall [R0177] not exceed one second. The TTA is the elapsed time between the onset of HMI resulting from a failure and the warning annunciations. The warning annunciations consist of a system mode transition to Degraded Mode and annunciation of a visual and audible ATC Alarm (§ 2.1.2). See Appendix E Time-To-Annunciate for additional information.	X			X
R0179	The RVP-Tertiary Display(s) must [R0179] provide enhanced views of the airfield and/or surrounding airspace.		X	X	
R0181	The RVP-Tertiary Display's enhanced views must [R0181] be provided by the Magnification function.		X		
R0182	The RVP 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 the capability for an Access Level 3 user to configure the System Configuration Parameters.		X		
R0186	The MDT functionality must [R0186] provide the capability for an Access Level 3 user to install RT software.		X		

Req ID	RT System Requirements	T	D	I	A
R0187	The MDT functionality must [R0187] have the capability to view the 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		
R0189	The RT system should [R0189] be capable of establishing user preferences for each Access Level 2 user.		X		
R0190	The RT system must [R0190] consist of RVP, SLG, MDT, DR, Magnification, and AAA functions.			X	
R0192	The AAA functionality must [R0192] be integrated into the RT system independent of the ATCS radio communication system. The AAA is not to interfere with ATCS radio communication.			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		
R0198	The System Administrator must [R0198] have sole rights to retrieve the Security Audit Log (§ 4.5).		X		
R0199	The RT system's Security Audit Log must [R0199] be protected against deletion and modification.		X		
R0200	The RVP video shall [R0200] have a frame rate of 25 Hertz (Hz) or higher.	X			
R0203	The SLG functionality must [R0203] provide the capability to direct the RLG at a target of interest shown on the RVP-Primary Display.		X		
R0209	The Magnification functionality shall [R0209] be capable of providing seven times magnification or greater.		X		X
R0210	The Magnification functionality must [R0210] provide the capability of directing the field of view to any location shown on the RVP-Primary Display.		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 RT system must [R0217] provide the capability for any Access Level 2 user to turn on and off the AAA.		X		
R0218	The RT system must [R0218] provide the capability of visually annunciating the presence of an ATC Alarm, a Corrective Maintenance Alert, and a Security Alert to the Access Level 2 user.		X		
R0220	The RT system must [R0220] provide the capability for any Access Level 2 user to control and activate environment mitigation equipment.		X		
R0221	The RT system must [R0221] provide the capability for any Access Level 2 user to control and activate the SLG.		X		
R0222	The RT system must [R0222] provide the capability for any Access Level 2 user to control and activate the Magnification function for non-short focal length optical implementations.		X		
R0224	The RT system shall [R0224] respond within 250 milliseconds of Access Level 2 user inputs. The response time is intended to be the duration of time measured between a user-initiated input and expected system response (e.g., the response for the user turning off the airfield audio is measured as the time difference between the user initiating the airfield audio off command and airfield audio no longer being output from the speakers).	X			
R0226	The SVP video 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. The capture-to-display latency includes the time interval between consecutive frames.	X			

Req ID	RT System Requirements	T	D	I	A
R0228	If the SVP is presented on a separate display monitor, the performance (e.g., luminance, chromaticity, and contrast) must [R0228] have no discernible difference to the RVP from the Access Level 2 users' view (§ 3.2).			X	
R0236	The RT system must [R0236] provide the capability for any Access Level 2 user to suppress individual visual Corrective Maintenance Alerts and Security Alerts, once activated.		X		
R0238	The RT system must [R0238] disable unused ports, protocols, and services.		X		
R0239	The RT system must [R0239] record all commands that mute or suppress notifications for ATC Alarms and Corrective Maintenance 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 (i.e., success/failure).		X		
R0248	Audit records must [R0248] not contain sensitive information (e.g., passwords, actual system data, or privacy information).		X		
R0257	The MDT functionality must [R0257] provide the capability of visually annunciating ATC Alarms, Corrective Maintenance Alerts, Security Alerts, and Preventive Maintenance Alerts.		X		
R0259	The Magnification functionality shall [R0259] provide the capability of traversing the full range of the zoom in less than four seconds with a speed variation less than 10 percent. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the initial input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.	X	X		
R0260	The RT system must [R0260] provide a minimum of two CWPs.		X		
R0262	The RT system must [R0262] provide the capability for the audible annunciation of the presence of an ATC Alarm, a Corrective Maintenance Alert, and a Security Alert to the Access Level 2 user.		X		
R0264	The RT system equipment shall [R0264] meet the appropriate Federal Communications Commission (FCC) authorizations as defined in 47 CFR part 15 Radio Frequency Devices for conducted and radiated emissions.	X			
R0279	The RT system shall [R0279] have a Mean Time To Repair (MTTR) less than or equal to two hours. The MTTR requirement and the continuity requirement (R0101) can be translated into an associated inherent availability, as explained in Appendix D Remote Tower Systems Availability.				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.			X	
R0283	The RT system's remote access session(s) must [R0283] utilize a Virtual Private Network (VPN) using encryption standards described in Federal Information Processing Standards (FIPS) 140-2 (valid until 2026) or FIPS 140-3, Security Requirements for Cryptographic Modules.		X		

Req ID	RT System Requirements	T	D	I	A
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			
R0287	The RT system must [R0287] employ malicious code protection mechanisms (e.g., anti-virus software for workstations and 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		
R0302	Any information (e.g., system mode [§ 2.1.1], RVP-Tertiary Display(s), and/or SVP) overlaid on the RVP-Primary Display must [R0302] be implemented in a manner that does not interfere with ATCS providing operational air traffic services.		X		
R0303	All images combined from multiple cameras for the RVP shall [R0303] be from the same point in time ± one frame.	X			
R0304	The RT system shall [R0304] automatically disable a user identifier's account after 90 days of inactivity for that user identifier.	X			
R0305	The RT system must [R0305] provide the current status of any RT system configuration setting impacting shared resources (e.g., RVP and/or audio) to each Access Level 2 user.		X		
R0306	The RVP and any SVP views shall [R0306] be stable in both 45 mile-per-hour wind with the camera mast(s) encased in 1/2 inch radial ice and in 56 mile-per-hour wind, such that display movement does not interfere with ATCS providing operational air traffic services.	X			X
R0308	The SLG functionality shall [R0308] provide the capability of moving the RLG from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 60 degrees apart within two seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.	X			
R0309	The SLG functionality shall [R0309] provide the capability of moving the RLG from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 180 degrees apart within four seconds. The time required for moving the RLG is the amount of time for the SLG functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.	X			
R0310	The Magnification functionality shall [R0310] provide the capability of moving the field of view from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 60 degrees apart within two seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.	X			

Req ID	RT System Requirements	T	D	I	A
R0311	The Magnification functionality shall [R0311] provide the capability of moving the field of view from a starting rest state to an ending rest state between two positions shown on the RVP-Primary Display which are 180 degrees apart within four seconds. The time required for moving the field of view is the amount of time for the Magnification functionality to start, progress, and stop the movement. It does not include the input response time specified in requirement R0224. The specified movement encompasses both vertical and horizontal directions.	X			
R0312	The RT system must [R0312] present the visual warning annunciation for an ATC Alarm within the TTA (§ 5.1.1).	X			X
R0313	The RT system must [R0313] present the audible warning annunciation for an ATC Alarm within the TTA (§ 5.1.1).	X			X
R0319	The System Administrator must [R0319] have sole rights to access the DR functionality (§ 2.2.5).		X		
R0320	The RVP-Primary Display must [R0320] provide an out-the-window view of the airfield and surrounding airspace.		X		
R0324	The RVP-Secondary Display(s) must [R0324] be presented on separate supporting display monitor(s).		X		
R0325	The RVP-Secondary Display(s) must [R0325] provide an out-the-window view of a portion of the airfield and surrounding airspace.		X		
R0326	The RVP-Secondary Display's perspective must [R0326] be from a single fixed point of view, single fixed focal point, and single fixed level of zoom.		X		
R0327	Multiple RVP-Secondary Displays must [R0327] present the same perspective to the Access Level 2 user. The same perspective ensures maintaining the spatial relationship between objects on all RVP-Secondary Displays, as perspective denotes the same impression of an object's height, width, depth, and position.		X		
R0330	The RT system must [R0330] provide the capability for any Access Level 2 user to select the active runway(s) to be displayed on the RVP-Secondary Display(s).		X		
R0332	The RT system must [R0332] not visually or audibly annunciate the presence of a Preventive Maintenance Alert on the RVP.		X		
R0333	The RT system must [R0333] satisfy a set of visual performance values in terms of LOS applicable to the manufacturer's RT system architecture for each RVP display (unique RVP image capturing-display portion of the system), as identified by the applicant, including detection, recognition, and identification, as shown in Table 8 (LOS01 - LOS15).	X			X
R0334	The RT system equipment shall [R0334] not be degraded due to electromagnetic susceptibility by other National Airspace System (NAS) equipment.	X			
R0335	The RT system equipment electromagnetic emissions shall [R0335] not degrade other NAS equipment.	X			
R0340	All RT system functions whose failure could result in loss of continuity must [R0340] be developed to ARP 4754B FDAL D, RTCA DO-278A AL 5, and RTCA DO-254 DAL D.			X	
R0341	The RT system must [R0341] provide the capability that allows the Access Level 2 user(s) access and control of all visual presentations and annunciations of the RT system from each CWP. This supports the ability for the tower team to fulfill their responsibilities from each CWP.		X		
R0342	The RT system must [R0342] provide the capability that allows a single Access Level 2 user access and control of all visual presentations and annunciations of the RT system from each CWP. This supports the consolidation of positions to one team member who can provide ATC service from each CWP.		X		
R0343	The RT system must [R0343] provide the capability that allows Access Level 2 user(s) to consolidate any separated functionality based on tower team positions from each CWP.		X		

Req ID	RT System Requirements	T	D	I	A
R0345	If a manufacturer chooses to provide different user interfaces to Access Level 2 users, each CWP shall [R0345] have a fully functioning Access Level 2 user interface within 10 seconds when switching.	X			
R0346	The RT system should [R0346] have a fully functioning Access Level 2 user interface within 10 seconds when switching between user preference sets.	X			
N0006	The RVP should [N0006] be visually shown so that the normal work areas of each Access Level 2 user 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 the capability for an Access Level 3 user 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 the capability for an Access Level 3 user to sort and search the System Event Log.		X		
N0032	The MDT functionality should [N0032] provide the capability for an Access Level 3 user to manually override the automatic redundant element management actions.		X		
N0049	The AAA functionality should [N0049] provide a multichannel (i.e., spatialized audio) sound reproduction presented to the Access Level 2 user as a multidirectional audible perspective consistent with the visual presentation focal reference.		X		
N0051	The RT system's time delay between the AAA and the RVP should [N0051] optimally be less than +45 milliseconds (lead) and -60 milliseconds (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
N0063	The RT system should [N0063] provide the capability for any Access Level 2 user to adjust the volume and mute and unmute the AAA reproduction.		X		
N0076	The RT system should [N0076] generate a Preventive Maintenance Alert upon detecting a condition not affecting the system's functional capabilities but as an advisory indication for potential maintenance needs.	X			X
N0081	The RT system operation of redundant elements should [N0081] be managed by performance monitoring.		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 RT system controls and displays used by the Access Level 2 user 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 Access Levels 3, 4, and 5 user interface(s) should [N0114] be consistent with FAA HF-STD-001 Human Factors Design Standard §§ 5.6, 5.7.		X	X	X
N0116	The design of the Access Level 2 user interface should [N0116] allow all user inputs to be made by an Access Level 2 user in both standing and sitting positions.		X		
N0117	The design of the RT system ATC Alarm, Corrective Maintenance Alert, Security Alert, and Preventive Maintenance 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
N0202	The RVP-Tertiary Display(s) may [N0202] be presented on the RVP-Primary Display, RVP-Secondary Display(s), or separate supporting display monitor(s).		X		
N0216	The AAA functionality's volume control should [N0216] be logarithmic.	X			
N0223	The RT system should [N0223] provide the capability for any Access Level 2 user to declutter the RVP-Primary Display by toggling on and off all SVP (if provided) with a single input by the user.		X		

Req ID	RT System Requirements	T	D	I	A
N0252	The MDT functionality should [N0252] provide the capability for an Access Level 3 user to disable audible ATC Alarms, Corrective Maintenance Alerts, and Security Alerts annunciated by the RT system during Maintenance Mode.		X		
N0266	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
N0272	The RVP and SVP should [N0272] be visually shown so that each Access Level 2 user 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. [FAA HF-STD-001 Human Factors Design Standard § 5.6.13.10.2.4]	X		X	
N0277	The RT system should [N0277] have standardized terminology (i.e., language and symbology) consistent with FAA Orders and FARs. [FAA HF-STD-001 Human Factors Design Standard § 4.4.5]			X	
N0282	The implementation and design of the visual presentation should [N0282] address performance attributes relating to human factors involving the ATCS's abilities to perform the necessary tasks. [FAA HF-STD-001 Human Factors Design Standard § 5.3.1]	X	X	X	X
N0307	The design of the RT system controls should [N0307] provide consistent and predictable outputs in relation to inputs. [FAA HF-STD-001 Human Factors Design Standard §§ 5.4.1.1.2.1, 5.2.10.17, 5.4.3.1.3, 5.4.3.1.4, 5.4.3.1.5, 5.4.3.1.6, 5.4.3.3.11]		X		X
N0315	The manual control for the RLG should [N0315] smoothly transition from the starting position to the target position regardless of small or large angular movements.		X		
N0316	The manual control (e.g., course and fine adjustments and/or slew rates) for the RLG should [N0316] be proportional between input and output response.		X		X
N0317	The movement of the RLG should [N0317] be a smooth transition from the starting position to the target position without overshoot or oscillation regardless of small or large angular movements when being automatically controlled (e.g., commanded to preset targets or selected targets).		X		
N0318	The RLG should [N0318] be capable of being panned continually in either direction through more than 360 degrees azimuth without any rotational hard stops.		X		
N0321	The RVP may [N0321] include an RVP-Secondary Display.			X	
N0322	The RVP may [N0322] include an RVP-Tertiary Display.			X	
N0323	When presenting images from multiple cameras across multiple display monitors, the resulting RVP-Primary Display should [N0323] not interfere with ATCS providing operational air traffic services (e.g., due to missing, duplicated, or misaligned parts of the view).		X		
N0328	The RT system should [N0328] provide the capability for any Access Level 2 user to declutter their CWP position specific RVP-Secondary Display(s) by toggling on and off all SVP (if provided) with a single input by the user.		X		
N0329	The RT system should [N0329] provide the capability for any Access Level 2 user to declutter their CWP position specific RVP-Tertiary Display(s) by toggling on and off all SVP (if provided) with a single input by the user.		X		
N0331	The RT system's operationally relevant diagnostic information associated with ATC Alarms and Corrective Maintenance Alerts should [N0331] be made available to the Access Level 2 user. [FAA HF-STD-001 Human Factors Design Standard §§ 5.5.1.1.2, 5.5.1.1.3, 5.5.1.1.4, 5.5.1.1.9]		X		
N0336	The manual control for the PTZ cameras should [N0336] smoothly transition from the starting position to the target position regardless of small or large angular movements.		X		
N0337	The manual control (e.g., course and fine adjustments and/or slew rates) for the PTZ cameras should [N0337] be proportional between input and output response.		X		X

Req ID	RT System Requirements	T	D	I	A
N0338	The movement of the PTZ cameras should [N0338] be a smooth transition from the starting position to the target position without overshoot or oscillation regardless of small or large angular movements when being automatically controlled (e.g., commanded to preset targets or selected targets).		X		
N0339	The PTZ cameras should [N0339] be capable of being panned continually in either direction through more than 360 degrees azimuth without any rotational hard stops.		X		
N0344	The design of the RT system Access Level 2 user interface(s) should [N0344] be consistent with the tower team positions outlined in FAA Order JO 7110.65 Air Traffic Control § 2-10-3, Tower Team Position Responsibilities.		X		

Appendix D 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 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 E TIME-TO-ANNUNCIATE

The time-to-annunciate associated with the integrity requirement (R0177) is further explained in this appendix. Figure 2 illustrates examples for three different integrity monitors.

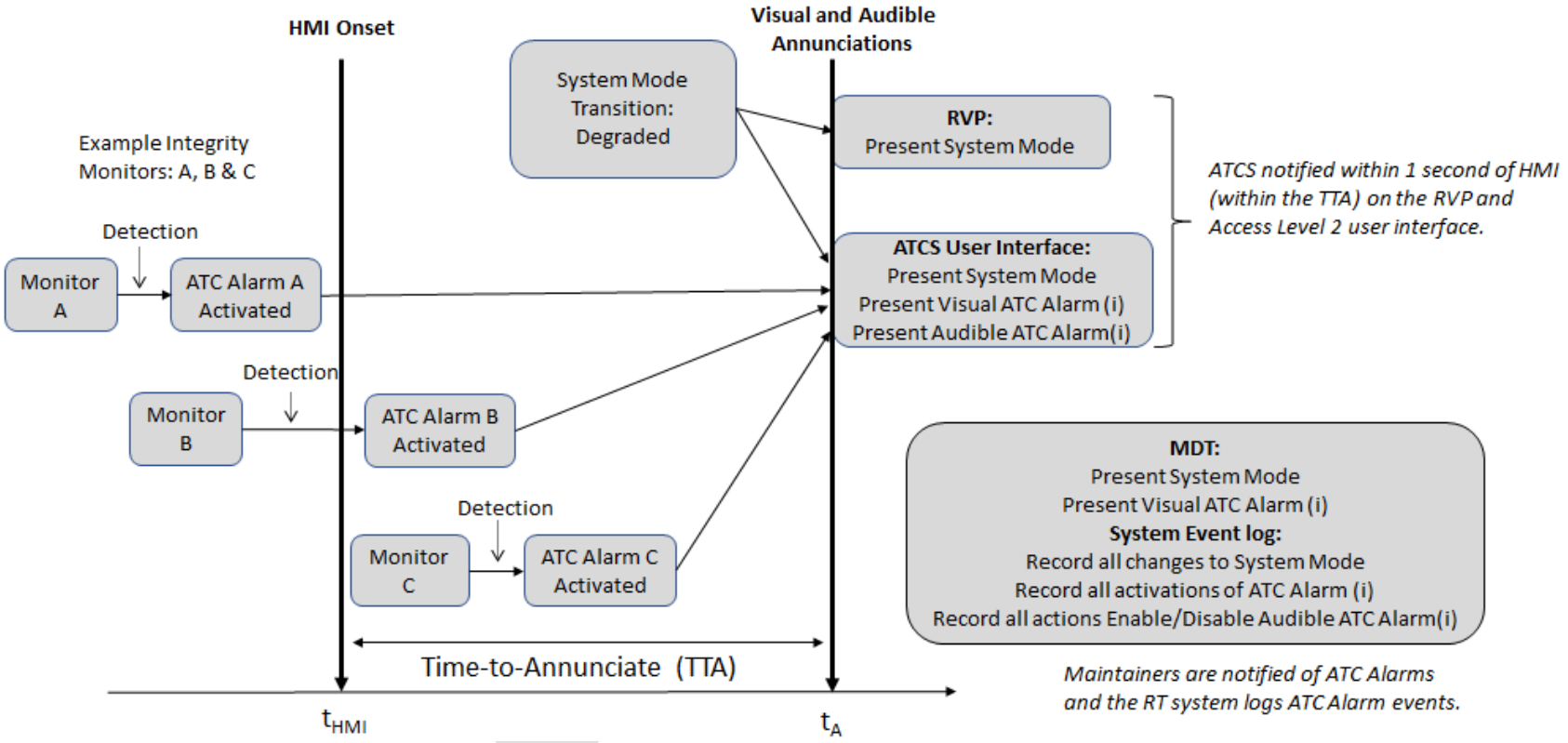

Figure 2 – Time-to-Annunciate Timeline Examples

The RT system is required to monitor and detect integrity related parameters being out-of-tolerance potentially resulting in HMI. The time of detection depends on the monitor design. The three integrity monitors in Figure 2 show examples of detection before, concurrent, and after the onset of HMI. Regardless of the monitor detection times and ATC Alarm activation, the HMI event (t_{HMI}) starts the clock for the TTA. The time of detection needs to enable the alarm to occur, such that the annunciation of the system transitions to Degraded Mode on the RVP and annunciation of the ATC Alarm on the Access Level 2 user interface occur within one second of HMI (t_A - t_{HMI}). In addition, the ATC Alarm is required to be annunciated on the MDT and recorded in the System Event Log; however, there is no minimum time requirement associated with annunciations on the MDT or logging system events.

Appendix F TEST CASES

This appendix contains test cases for key requirements. The test cases are guidance and are considered one means, but not the only means, of demonstrating compliance with the requirements. The first three sections (F.1, F.2, and F.3) concern RVP latency, integrity, and continuity requirements. The fourth section (F.4) concerns the requirements related to the RVP performance capability.

F.1. RVP AND SVP LATENCY

F.1.1. TEST COVERAGE

This test will provide verification coverage for requirements R0012 and R0227.

F.1.2. TEST SETUP

An example test setup is shown in Figure 3.

The Unit Under Test (UUT) is configured to include a complete string of the RT system components and video processing elements used to capture the video images and present the video images on the RVP and SVP displays (all aspects of capture, encoding, decoding, processing, transmission, and display are to be incorporated in the UUT).

Test equipment required for this test consists of a Master Clock Input that is synchronized with a Master Clock Truth as well as a camera to capture the test results. As shown in Figure 3, an image of the time displayed by the Master Clock Input is captured by the RT system by placing it in view of the RVP or SVP camera. The video of the Master Clock Input's time is processed by the RT system and presented on the RT system RVP or SVP display, as shown in Figure 3. The Master Clock Truth's time, which is synchronized with the Master Clock Input, is placed adjacent to the RT system display such that both clocks' time are in view of a test equipment camera. A test equipment camera is used to capture two clock times displayed: the RVP or SVP, and the Master Clock Truth's time.

The Master Clock Input and Master Clock Truth are synchronized to within 0.005 seconds and capable of displaying the time with a minimum time resolution of 0.01 seconds.

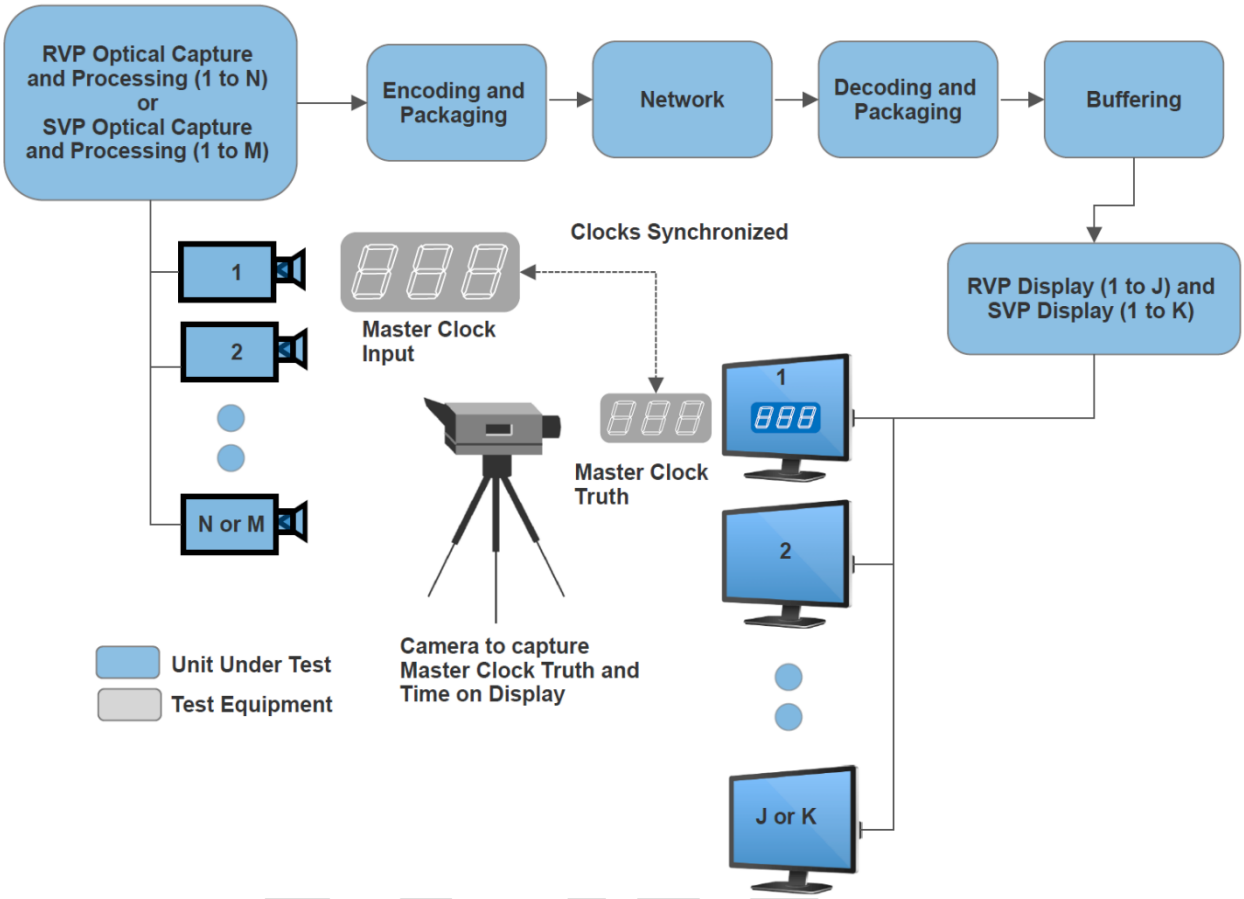

Figure 3 – Latency Test Setup

F.1.3. TEST CONDITIONS

1. The RT system mode is Operational Mode.
2. The RT system network traffic is operating at its highest expected bandwidth consumption. This can be accomplished by artificially loading the network with additional traffic, as necessary.
3. The RT system enables any software functionality that potentially causes an increase to video latency on the RVP or SVP (e.g., software light balancing, box and track, zooming, and/or supplemental information).

F.1.4. TEST METHOD

1. For each combination of RVP and SVP optical capture sensor and RVP and SVP display, repeat the following steps:

    a. Place a Master Clock Input in front of the optical sensor within its field of view.
    b. Place the Master Clock Truth near the appropriate RVP or SVP display so that the Master Clock Truth and the image of the Master Clock Input being displayed on the RVP or SVP can be captured with a camera.
    c. Randomly sample one percent of images of the Master Clock Truth and Master Clock Input being displayed for a minimum period of five minutes.

d. From the camera pictures, calculate the RVP and SVP latency by subtracting the time in the image of the Master Clock Input displayed on the RVP or SVP from the time in the image of the Master Clock Truth, then add the time interval between two consecutive video frames.

F.1.5. TEST ACCEPTANCE

The requirement is met if the maximum computed latency for each combination of RVP and SVP optical capture sensor and RVP and SVP display does not exceed one second.

F.2. INTEGRITY TIME-TO-ANNUNCIATE

F.2.1. TEST COVERAGE

This test will provide verification coverage for requirements R0073, R0074, R0177, R0312, and R0313.

Note: Recommend testing in conjunction with each integrity monitor contained within the RT system to obtain complete coverage of these requirements.

F.2.2. TEST SETUP

The UUT includes all the elements of the RT system necessary to simulate the faulted condition, resulting in an alarm condition (i.e., detection of the fault, generation of the ATC Alarm, and system mode transition to Degraded Mode).

The test setup requires test equipment sufficient to measure and record time between the faulted condition, alarm condition, and system mode annunciation to within 0.01 seconds.

F.2.3. TEST CONDITIONS

1. The RT system mode is Operational Mode prior to injecting the fault.
2. The RT system network traffic is operating at its highest expected bandwidth consumption, which potentially impacts the TTA latency. This can be accomplished by artificially loading the network with additional traffic, as necessary.
3. The RT system enables any software or system functionality that potentially causes an increase to TTA latency (e.g., software light balancing, box and track, zooming, and/or supplemental information).

F.2.4. TEST METHOD

For each RT system integrity monitor, perform the following:

1. Inject a fault that generates an out-of-tolerance condition resulting in HMI.
2. Record the time at which the HMI occurs (t_{HMI}).
3. Record the time at which the annunciation of the system transitions to Degraded Mode and the ATC Alarm presented to the Access Level 2 user occur (t_A).
4. Compute the TTA by differencing t_A and t_{HMI} (see Appendix E Time-to-Annunciate).

F.2.5. TEST ACCEPTANCE

The TTA requirement is met if the elapsed time between the occurrence of HMI and the ATC Alarm and system mode transition to Degraded Mode is less than or equal to one second ($t_A - t_{HMI} \leq 1$ second).

F.3. CONTINUITY REDUNDANCY SWITCHOVER

F.3.1. TEST COVERAGE

This test will provide verification coverage for requirements N0081 and R0083.

F.3.2. TEST SETUP

The UUT includes the components relevant to the test, as shown in Figure 4, including redundant elements and necessary monitoring components.

The test setup needs to account for the end-to-end time between when the active LRU is disabled (t_0) and the standby LRU is activated (t_1), as shown in Figure 4.

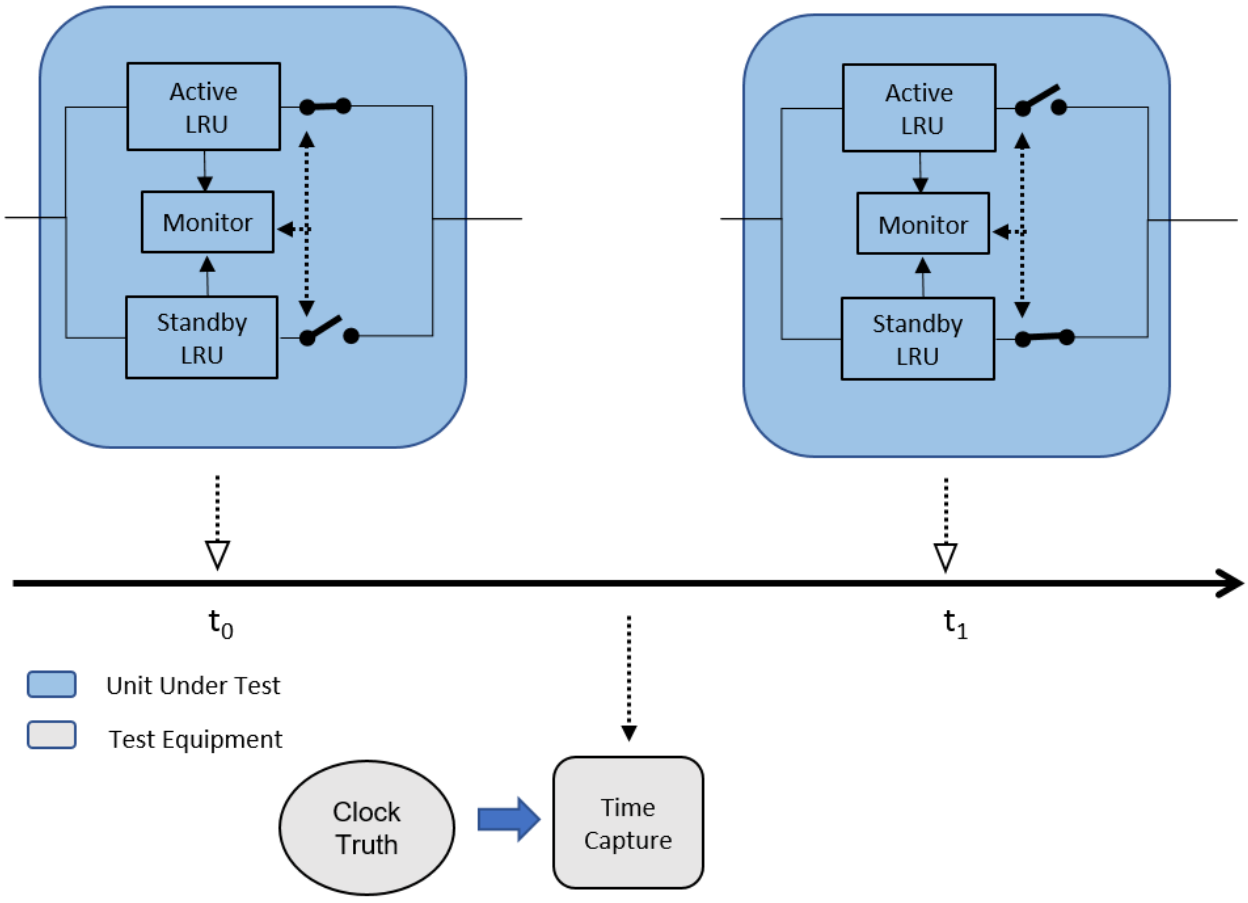

Figure 4 – Switchover Test Setup

F.3.3. TEST CONDITIONS

1. The RT system mode is Operational Mode.
2. The RT system network traffic is operating at its highest expected bandwidth consumption. This can be accomplished by artificially loading the network with additional traffic, as necessary.

3. The manufacturer will identify the redundant elements that are considered critical. The test is conducted for each type of identified elements (e.g., encoder, decoder, and display) and the associated monitor.

   Note: Critical failure, as identified in R0083, is defined in R0101.

F.3.4. TEST METHOD

A test is run for each type of redundant critical element and the associated monitor. Only one element needs to be tested if there are multiple critical elements of the same type (e.g., encoder). If multiple monitors exist for the same redundant critical element, each monitor is individually tested. For each switchover type, automatic and manual, perform the following:

1. Disable the active LRU, making it non-functional. This can be done by several different methods, including physically disconnecting the signals to or from the LRU.
2. For the manual switchover test, the test controller is to identify the presence(s) of the faulted condition(s) and activate the appropriate standby LRU. The test controller performing the procedure is expected to be trained, but is not an expert. The test controller is also expected to be unaware of when or what fault is being introduced.
3. Observe that the functionality of the standby LRU is enabled.
4. Record the time of loss of function of the active LRU (t_0), and the time of activation of the standby LRU (t_1).
5. Compute the recovery time by differencing t_1 and t_0.

F.3.5. TEST ACCEPTANCE

For the automatic switchover, the time to recover requirement is met if the elapsed time between when the active LRU is disabled and the standby LRU becomes functional is less than or equal to three seconds ($t_1 - t_0 \leq 3$ seconds).

For the manual switchover, the time to recover requirement is met if the elapsed time between when the active LRU is disabled and the standby LRU becomes functional is less than or equal to 30 seconds ($t_1 - t_0 \leq 30$ seconds).

F.4. R0333 RVP PERFORMANCE CAPABILITY

F.4.1. TEST COVERAGE

The RT system's RVP performance capability is comprised of a set of LOS values (see Table 8) identified in requirement R0333. The tests described within this document focus on using silhouette test patterns as targets for detection, recognition, and identification by an observer using the RVP.

F.4.2. TEST SETUP

The test setup described here applies to all RVP performance capability test cases. The UUT is configured to include a complete string of the RT system components and video processing elements used to capture the video image of the Object-of-Interest and present the video images on the RVP. Aspects of capture, encoding, decoding, processing, transmission, and display are to be incorporated into the UUT. Reductions in the system's complexity are possible for these verification tests, provided they do not adversely impact the test's usefulness to verify compliance. Examples include removing redundant components within the system or reducing the number of cameras and video screens utilized. The UUT configuration is justified if the configuration is a subset of the manufacturer's whole RT system configuration. Other considerations:

a. Test each camera type.
b. Test each RVP display type in combination with the different camera types.

The test setup is shown in Figure 5.

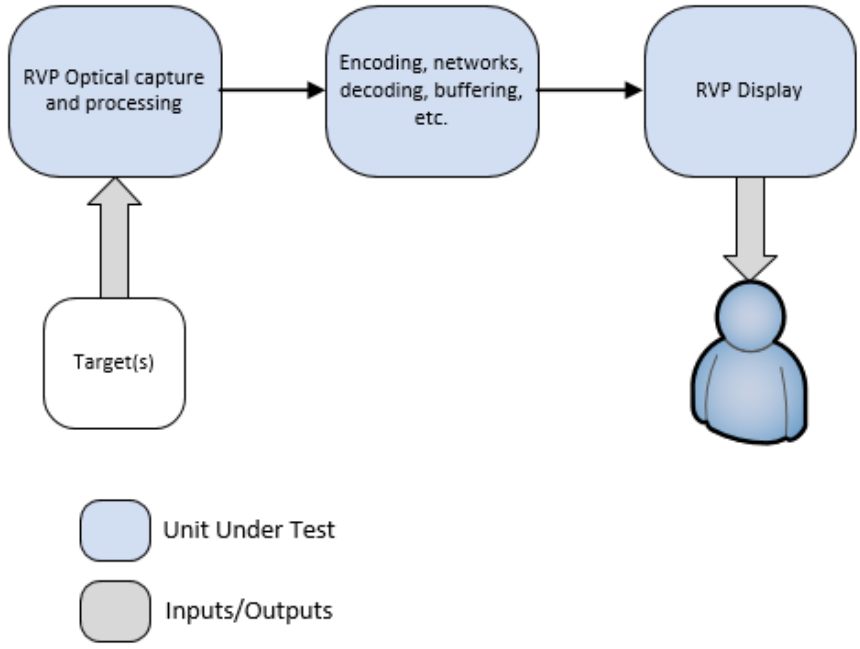

Figure 5 – RVP Performance Capability Test Setup

For the RVP-Primary Display, the observer is placed in front of the RVP at the maximum viewing distance between the RVP video wall and CWP, distance "f", specified by the manufacturer's system siting criteria, as shown in Figure 6.

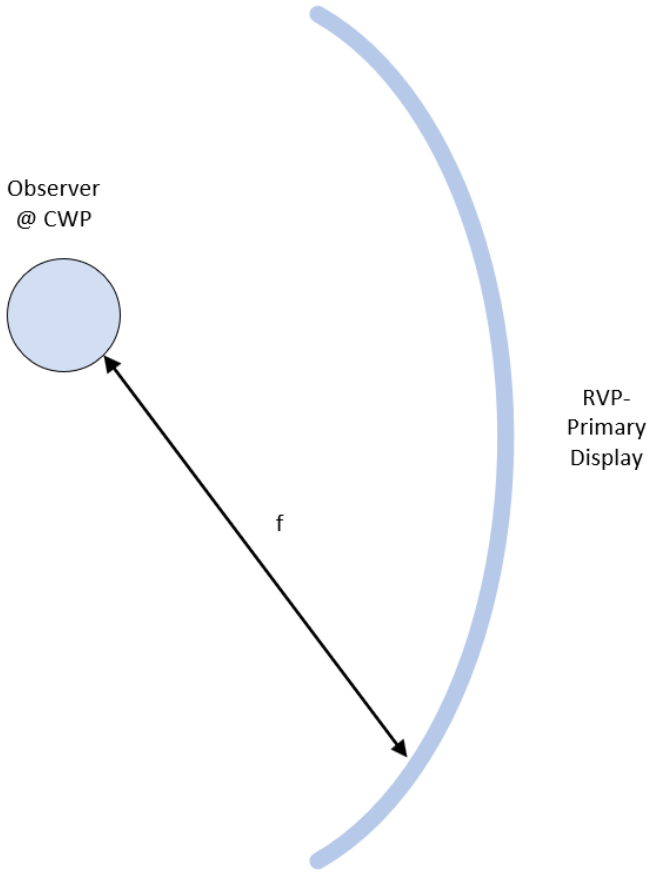

Figure 6 – Viewing Distance Test Setup

For the RVP-Secondary Display and the RVP-Tertiary Display, the observer is placed in front of the display at the maximum viewing distance between the observer and the RVP-Secondary Display(s) and RVP-Tertiary Display(s), specified by the manufacturer's system siting criteria.

The test targets are to be positioned parallel to the camera lens at the test distance determined by the test target scale derived from the LOS distance from the manufacturer's system siting criteria, as shown in Figure 7 and Figure 8.

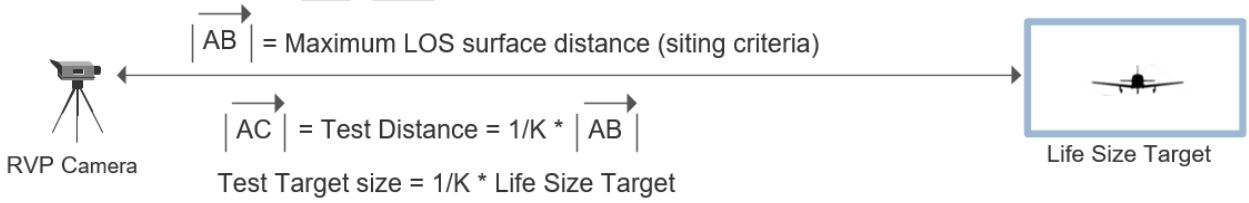

Figure 7 – Target Placement for Surface Performance Test Cases

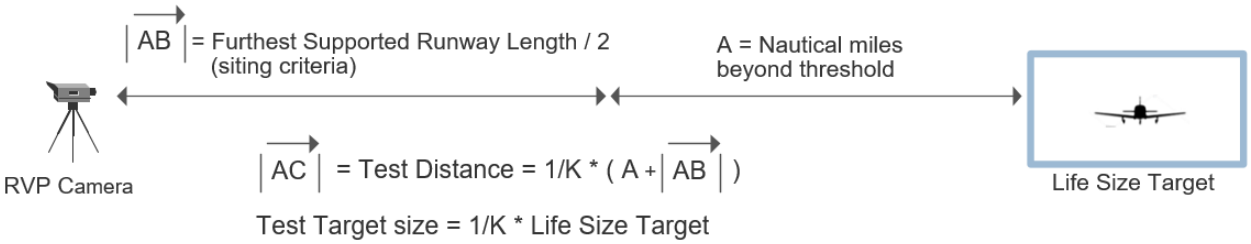

Figure 8 – Target Placement for Beyond End of Runway Test Cases

F.4.3. TEST CONDITIONS

The verification of the RVP performance capability requirements is to be tested under the conditions described in §§ 2.2.1.1.4. In addition, the following conditions apply:

1. Contrast: Object-of-Interest to background contrast is controlled by the color of the representation of the Object-of-Interest as a test pattern. A black silhouette against a white background as described in § F.4.4 is used.
2. The maximum LOS distance (distance from camera lens to test object) at which the test is conducted can be reduced, provided the full, life-size test pattern used for the target is scaled by the same ratio (e.g., reducing the LOS distance from 4,000 meters to 2,000 meters requires reducing the full, life-size test pattern size by 50%) and the camera is operationally performing as it would in an installed setting.

   Maximum LOS distance = $|\overrightarrow{AB}| = k|\overrightarrow{AC}|$

   where:
   - A = Location of RVP Camera
   - B = Location of full-scale target
   - C = Location of full-scale target scaled by 1/k

3. The RT system mode is Operational Mode.

F.4.4. TEST PATTERNS

The test cases outlined in this document will utilize silhouettes of aircraft, vehicles, and people as test patterns. The test pattern types are: Small Aircraft 1, Small Aircraft 2, Helicopter, Vehicle, and Person. The silhouettes are printed black against a white background. Each silhouette is centered on a white square with the length of each side equal to three times the width of the silhouette with the exception of the Person class silhouette. In the case of the Person class silhouette, the length of each side is equal to three times the height of the silhouette. Create a set of test pattern index cards containing each of the test patterns for use by the observer in identifying the individual test patterns. Test pattern images, suitable for use in the RVP performance capability tests, are supplied upon request.

F.4.5. LOS04, LOS05, LOS10, LOS11

This test will provide verification coverage for LOS04, LOS05, LOS10, and LOS11, as referenced in Table 8.

Test Method

1. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of four test patterns such that each test pattern occurs at least once in the sequence: Small Aircraft 1, Small Aircraft 2, Helicopter, and Vehicle.

   $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
   $X \sim U$ [Small Aircraft 1, Small Aircraft 2, Helicopter, Vehicle]

2. Provide the observer with a set of index cards for the four potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
3. Position the observer in front of the display screen at distance "f", see Figure 6.
4. For each of the nine targets in set F, repeat the following steps:

   a. Position the target in the center of the field of view of the RVP-Primary camera at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
   b. Notify the observer when the target is in place.
   c. Have the observer record the target's Object-of-Interest class, using test pattern index cards, from their observation of the test target on the display screen.

5. If the manufacturer implements an RVP-Secondary Display, then repeat steps 1 through 4 above with the RVP-Secondary camera.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly recognized each Object-of-Interest class (Small Aircraft or Vehicle) from the sequence of targets presented from the applicable camera(s).

F.4.6. LOS01, LOS07

This test will provide verification coverage for LOS01 and LOS07, as referenced in Table 8.

Test Method

1. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of test patterns such that each class of test pattern occurs at least once in the sequence: Vehicle, and Blank.

   $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
   $X \sim U$ [Vehicle, Blank]

2. Provide the observer with a set of index cards for the two potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
3. Position the observer in front of the display screen at distance "f", see Figure 6.
4. For each of the nine targets in set F, repeat the following steps:

   a. Position the target in the center of the field of view of the RVP-Primary camera at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
   b. Notify the observer when the target is in place.
   c. Have the observer record if their observation detects the presence of the test target on the display screen.

5. If the manufacturer implements an RVP-Secondary Display, then repeat steps 1 through 4 above with the RVP-Secondary camera.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly detected the presence or absence of a Vehicle class object from the sequence of targets presented from the applicable camera(s).

F.4.7. LOS02, LOS08

This test will provide verification coverage for LOS02 and LOS08, as referenced in Table 8.

Test Method

1. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of test patterns such that each class of test pattern occurs at least once in the sequence: Small Aircraft, Helicopter, and Blank.

   $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
   $X \sim U$ [Small Aircraft, Helicopter, Blank]

2. Provide the observer with a set of index cards for the two potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
3. Position the observer in front of the display screen at distance "f", see Figure 6.
4. For each of the nine targets in set F, repeat the following steps:

   a. Position the target in the center of the field of view of the RVP-Primary camera at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
   b. Notify the observer when the target is in place.
   c. Have the observer record if their observation detects the presence of the test target on the display screen.

5. If the manufacturer implements an RVP-Secondary Display, then repeat steps 1 through 4 above with the RVP-Secondary camera.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly detected the presence or absence of a Small Aircraft or Helicopter class object from the sequence of targets presented from the applicable camera(s).

F.4.8. LOS06, LOS12

This test will provide verification coverage for LOS06 and LOS12, as referenced in Table 8.

Test Method

1. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of three test patterns such that each test pattern occurs at least once in the sequence: Small Aircraft 1, Small Aircraft 2, and Helicopter.

   $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
   $X \sim U$ [Small Aircraft 1, Small Aircraft 2, Helicopter]

2. Provide the observer with a set of index cards for the three potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
3. Position the observer in front of the display screen at distance "f", see Figure 6.
4. For each of the nine targets in set F, repeat the following steps:

   a. Position the target in the center of the field of view of the RVP-Primary camera at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
   b. Notify the observer when the target is in place.
   c. Have the observer record the target's Object-of-Interest type, using test pattern index cards, from their observation of the test target on the display screen.

5. If the manufacturer implements an RVP-Secondary Display, then repeat steps 1 through 4 above with the RVP-Secondary camera.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly identified each Object-of-Interest type (Small Aircraft 1, Small Aircraft 2, or Helicopter) from the sequence of targets presented from the applicable camera(s).

F.4.9. LOS03, LOS09

This test will provide verification coverage for LOS03 and LOS09, as referenced in Table 8.

Test Method

1. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of test patterns such that each test pattern occurs at least once in the sequence: Person and Blank.

   $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
   $X \sim U$ [Person, Blank]

2. Provide the observer with a set of index cards for the four potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
3. Position the observer in front of the display screen at distance "f", see Figure 6.
4. For each of the nine targets in set F, repeat the following steps:

   a. Position the target in the center of the field of view of the RVP-Primary camera at the greatest supported distance defined by the manufacturer's system siting criteria for a point two nautical miles beyond the longest supported runway length, see Figure 7.
   b. Notify the observer when the target is in place.
   c. Have the observer record if their observation detects the presence of the test target on the display screen.

5. If the manufacturer implements an RVP-Secondary Display, then repeat steps 1 through 4 above with the RVP-Secondary camera.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly detected the presence or absence of the Person class object from the sequence of targets presented from the applicable camera(s).

F.4.10. LOS15

This test will provide verification coverage for LOS15, as referenced in Table 8.

Test Method

1. For each magnification enhancement employed by the manufacturer for the RVP-Tertiary Display (PTZ camera(s), software digital zoom, and short focal length binoculars), repeat the following steps:

    a. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of three test patterns such that each test pattern occurs at least once in the sequence: Small Aircraft 1, Small Aircraft 2, and Helicopter.

    $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
    $X \sim U$ [Small Aircraft 1, Small Aircraft 2, Helicopter]

    b. Provide the observer with a set of index cards for the three potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
    c. Position the observer in front of the display screen at distance "f", see Figure 6.
    d. For each of the nine targets in set F, repeat the following steps:

        i. Position the target in the center of the field of view of the applicable camera (associated with the magnification enhancement) at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
        ii. Notify the observer when the target is in place.
        iii. Have the observer record the target's Object-of-Interest class, using test pattern index cards, from their observation of the test target on the display screen using the magnification enhancement.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly identified each Object-of-Interest type (Small Aircraft 1, Small Aircraft 2, Helicopter) from the sequence of targets presented for each magnification enhancement employed.

F.4.11. LOS14

This test will provide verification coverage for LOS14, as referenced in Table 8.

Test Method

1. For each magnification enhancement employed by the manufacturer for the RVP-Tertiary Display (PTZ camera(s), software digital zoom, and short focal length binoculars), repeat the following steps:

    a. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of test patterns such that each test pattern occurs at least once in the sequence: Person and Blank.

    $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
    $X \sim U$ [Person, Blank]

    b. Provide the observer with a set of index cards for the four potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
    c. Position the observer in front of the display screen at distance "f", see Figure 6.
    d. For each of the nine targets in set F, repeat the following steps:

        i. Position the target in the center of the field of view of the applicable camera (associated with the magnification enhancement) at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
        ii. Notify the observer when the target is in place.
        iii. Have the observer record the target's Object-of-Interest class, using test pattern index cards, from their observation of the test target on the display screen using the magnification enhancement.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly detected the presence or absence of a Person class object from the sequence of targets presented for each magnification enhancement employed.

F.4.12. LOS13

This test will provide verification coverage for LOS13, as referenced in Table 8.

Test Method

1. For each magnification enhancement employed by the manufacturer for the RVP-Tertiary Display (PTZ camera(s), software digital zoom, and short focal length binoculars), repeat the following steps:

    a. Create set F, a set containing the sequence of nine targets randomly chosen from a uniform set of test patterns such that each test pattern occurs at least once in the sequence: Vehicle and Blank.

    $F = \{x_1, x_2...x_9 : x_i \text{ is a random selection of } X\}$
    $X \sim U$ [Vehicle, Blank]

    b. Provide the observer with a set of index cards for the two potential patterns in set F; however, do not reveal the sequence of targets in set F to the observer.
    c. Position the observer in front of the display screen at distance "f", see Figure 6.
    d. For each of the nine targets in set F, repeat the following steps:

        i. Position the target in the center of the field of view of the applicable camera (associated with the magnification enhancement) at the greatest supported distance defined by the manufacturer's system siting criteria, see Figure 7.
        ii. Notify the observer when the target is in place.
        iii. Have the observer record if their observation detects the presence of the test target on the display screen using the magnification enhancement.

Test Acceptance

The LOS requirement is satisfied when the observer's nine recorded observations of the target correctly detected the presence or absence of a Vehicle class object from the sequence of targets presented for each magnification enhancement employed.