

# ATMACA Determination of HMI Requirements

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## Abstract

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This document defines the functional requirements for various types of HMI solutions within the ATMACA project. These requirements serve as the foundation for the design, development, and validation of each interface, ensuring consistent interaction models and operational coherence across the air traffic management ecosystem.

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# ATMACA

AIR TRAFFIC MANAGEMENT AND COMMUNICATION OVER ATN/IPS

# ATMACA

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# 1 Introduction

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## 1.1 Purpose of the document

This plan aims to provide a comprehensive view of the various functionalities of the Human-Machine Interfaces (HMI) within the ATMACA system, organized according to their specific roles and operational purposes. Each interface is tailored to support intuitive user interaction, enhance operational efficiency, and maintain clear situational awareness across different mission scenarios.

## 1.2 Scope

This document outlines the different requirements for the main HMI solutions within the ATMACA system. It establishes the scope, objectives, and operational roles of each interface, providing a structured basis for design, development, and validation activities. The content serves as a reference for ensuring consistency across HMI implementations, alignment with operational needs, and compliance with applicable standards in Air Traffic Management (ATM).

## 1.3 Background

The ATMACA project is grounded in the broader SESAR (Single European Sky ATM Research) initiative, which aims to modernize and harmonize air traffic management across Europe. ATMACA builds on SESAR's vision by focusing on digital communication, automation, and enhanced human-machine collaboration in both civil and military ATM environments. The project leverages technological enablers such as Controller-Pilot Data Link Communications (CPDLC) and trajectory-based operations to improve safety, efficiency, and interoperability. Similar SESAR projects, like PJ16 – “U-space and ATM Integration,” have also explored advanced HMI solutions to support situational awareness and decision-making in complex traffic scenarios. ATMACA continues this trajectory by addressing the unique requirements of integrated ATM services in diverse operational domains.

## 1.4 Glossary of terms

Term	Definition	Source of the definition
Air traffic	The movement of aircraft in the air and on the surface of an aerodrome	EUROCONTROL ATM Lexicon
Air traffic controller	A person who provides air traffic control service	ICAO Doc 4444
Air traffic management	A service provided to regulate and control air traffic in order to ensure its safe and efficient flow	EUROCONTROL ATM Lexicon
Automatic Dependent	Means a means by which aircraft, aerodrome vehicles and other objects can automatically transmit or receive, or transmit and receive data	Easy Access Rules for ATM-ANS (Regulation 2017/373)

Surveillance Broadcast	such as identification, position and additional data, as appropriate, in a broadcast mode via a data link.	
Controller-Pilot Data Link Communications	A means of communication between air traffic controller and pilot, using data link for ATC communications	Easy Access Rules for ATM-ANS (Regulation 2017/373)
Coordinated Universal Time	The time standard used for all air navigation purposes, based on the International System of Units (SI). It is a uniform time scale determined by the International Bureau of Weights and Measures (BIPM) and is synchronized with Universal Time (UT1) by means of leap seconds to account for Earth's irregular rotation.	ICAO Annex 2
Flight Information Region	An airspace of defined dimensions within which flight information service and alerting service are provided.	ICAO Annex 11
Human Machine Interface	Encompasses all hardware and software components that allow the human operator to interact with the air traffic management system, including visual displays, input devices, and control panels.	ICAO Doc 9880
Meteorological Aerodrome Report	A routine aviation weather report issued at regular intervals (typically every hour), providing observed meteorological conditions at an aerodrome.	ICAO Annex 3
Notice to Airmen	A notice containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.	ICAO Annex 15
Significant Meteorological information	Is a concise statement of occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations.	ICAO Annex 3
Terminal Aerodrome Forecast	A concise statement of the expected meteorological conditions at an aerodrome for a specified period (usually 24 or 30 hours), used for flight planning and operations.	ICAO Annex 3

Very high frequency	The portion of the radio frequency spectrum between 30 MHz and 300 MHz, used extensively in aviation for communication and navigation purposes. In air traffic management, VHF is primarily used for voice communication between pilots and air traffic controllers due to its favourable propagation characteristics, allowing reliable line-of-sight transmission.	ICAO Annex 10
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**Table 1: glossary of terms**

## 1.5 List of acronyms

Term	Definition
A/C	Aircraft
ADS-B	Automatic Dependent Surveillance–Broadcast
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATIS (D-ATIS)	Digital Automatic Terminal Information Service
ATMACA	AIR TRAFFIC MANAGEMENT AND COMMUNICATION OVER ATN/IPS
ATM	Air traffic management
ATN	Aeronautical Telecommunication Network
ATN/IPS	Aeronautical Telecommunication Network using Internet Protocol Suite
CDA	Connected Data Application
CPDLC	Controller–Pilot Data Link Communications
CPU	Central Processing Unit
FIR	Flight Information Region
FL	Flight Level
GRO	Green Route Operations
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
METAR	Meteorological Aerodrome Report

NDA	Non-connected Data Application
NOTAM	Notice To Airmission
SESAR	Single European sky ATM research
SESAR 3 JU	SESAR 3 Joint Undertaking
SIGMET	Significant Meteorological Information
TAF	Terminal Aerodrome Forecast
UI	User Interface
UTC	Coordinated Universal Time
UX	User Experience
VHF	Very High Frequency

**Table 2: list of acronyms**

## 2 Functional requirements

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This section defines the functional requirements proposed for the SESAR ATMACA solution across the various HMIs. It specifies the essential capabilities and behaviours each interface must support to ensure efficient, safe, and seamless interaction between users and ATM systems. These requirements address the specific operational needs of tower controllers, radar operators, pilots, and system supervisors. By clearly outlining the expected functions, this section provides the foundation for design, development, and validation activities that will support the overall SESAR objectives.

Due to the extensive number of detailed requirements defined for each HMI solution, they have been grouped into key functional categories to provide a clearer and more structured understanding of the system's capabilities. The complete list of specific requirements is specified in Annex 1 of this document. Below is a summary of the main categories as well as representative requirements applicable to each one.

The requirements may be subject to slight modifications and adjustments during the design phase, based on technical constraints and feedback from end users.

### 2.1 ATC Tower HMI

The Air Traffic Control (ATC) Tower HMI serves as the primary interface between air traffic controllers and the digital systems that oversee airport surface movements and airspace operations. It is designed to facilitate rapid, precise, and intuitive decision-making by integrating real-time flight data, communication tools, and situational awareness elements into a cohesive and user-friendly environment. The interface supports key operational tasks such as flight list management, message exchange, and dynamic visualization of airport layouts, enabling controllers to maintain full situational control. Additionally, the Tower HMI enables smooth coordination with adjacent ATC sectors, ensuring continuous and safe traffic flow. Tailored to the workflows of different tower roles—including Ground, Delivery, and Tower Control—the system emphasizes clarity, operational efficiency, and safety, while allowing scalability and customization to adapt to varying airport sizes and complexities.

#### 2.1.1 User Authentication and Session Management

This category covers requirements related to user access, login/logout handling, user and organization identification, and overall session status management.

- Input fields for username and password.
- Display “Connected” status after successful login.
- Show the organization selector on the login screen (user + org identification).
- Display role availability and assignment logic depending on controlling/monitoring roles.
- Send messages when role conflicts occur, allow role handoff or denial.
- The system shall provide the capability for the user to sign in and sign out of the session.
- Display current Universal Time Coordinated (UTC) time.

## 2.1.2 Role and function selection

Includes features to show, select, and manage functions, sectors, and user roles within the system to ensure proper control and clear operational status visibility.

- Indicate if no sector or function is associated or no role is active after login.
- Allow users to select available functions/sectors.
- Allow role selection depending on control status (controlling vs monitoring).
- Allow the same user to select multiple roles (monitoring + controlling).
- Display assigned function/sector and active role (controlling, monitoring, mirroring).
- Allow sector filters for multiple roles (e.g., Ground and Delivery).

## 2.1.3 Airspace and communication context

Focuses on presenting critical airspace details, communication data, and system alerts to support safe and efficient operations.

- Display airspace info: Facility, Area, FIR, Country.
- Display communication info: Primary/Backup VHF, Host, Realm.
- Display adjacent ATC units with status, communication data, and interaction options.
- Include a “transfer to” dropdown to hand off the flight to another sector, such as delivery, tower or approach.
- Provide a free-text input field to send unstructured, generic messages to a selected adjacent ATC unit.

## 2.1.4 Flight and messaging management

Covers interaction with active flights, message handling, alerts, and communication management with aircraft.

- Collapsible/expandable display of sections (Status & Function, Airspace Info, Runway Details).
- Display active runway info with real-time status synced with NOTAM and wind data.
- Display active flight groups with status indicators, badges, and counts.
- Auto-expand message pane on new messages; allow message interaction and status updates in real time.
- Support for managing large numbers of flights (20–50+ aircraft) with clear focus control.
- Instant messaging dialog linked to flights with structured message templates and free text input.
- Real-time updates of flight details (gate, runway, routing, squawk, altitude).

## 2.1.5 Runway and weather information management

Includes presentation of runway status, conditions, and real-time weather data to assist operational decision-making.

- Show active runway information with real-time updates.
- Display wind and METAR/TAF data with manual refresh and tooltips.

- Show runway condition according to ICAO with caution icons for NOTAMs.
- Support contamination measurement (Runway Condition Range).
- Bottom panel anchored with weather, runway, and NOTAM summaries.
- Expandable panel for advanced operational settings.

### **2.1.6 Map and visualization tools**

Focuses on the graphical display of aircraft and airport infrastructure, supporting situational awareness through interactive maps.

- Real-time, color-coded airport map with aircraft icons, taxiway routes, NOTAM overlays, zoom, pan, and centre functions.
- Tooltip previews on aircraft icons with flight and message status info.
- Dynamic updates of aircraft icons based on message states and alerts.
- Collapse/expand functionality for workspace optimization.

### **2.1.7 Operational alerts and system-level information**

This category focuses on enhancing situational awareness and operational control through clear, real-time system alerts and centralized management panels.

- Display system-level alerts via the alert icon.
- A pane with operational summaries: weather, runway, NOTAM, system updates, with clear colour coding for status (green (normal), orange (needs attention), red (critical issue)).
- Unified Operational Settings Panel with multi-tab interface for runway operations, service feeds, permissions, and audit history.
- Real-time updates of panel status with color-coded indicators and alert icons.
- Expand/collapse behaviour to maximize workspace and ensure situational awareness.
- Access control by role for sensitive operational settings.

### **2.1.8 Interface interaction and usability**

Incorporates features designed to enhance controller efficiency, such as intelligent text suggestions, message search capabilities, visual indicators within message history, color-coded commands, shortcut buttons, and a highly responsive user interface.

- Consistent UI/UX with expandable sections, clear save/cancel actions, and low distraction hierarchy.
- Use of color-coded indicators and icons for quick status recognition.
- Keyboard shortcuts for sending messages.
- Logging of all sent messages and configuration changes with timestamps and user IDs.
- Smooth integration and consistent interaction patterns across all HMI components.

## 2.2 ATC Radar HMI

The **ATC Radar Control HMI** is specifically designed to support en-route and approach air traffic control operations by providing a real-time, radar-centric environment for effective aircraft surveillance, communication, and coordination. This interface integrates comprehensive flight data management, dynamic radar visualization with trajectory and weather overlays, and streamlined tools for conflict detection and resolution. It facilitates seamless coordination with adjacent ATC sectors and ensures continuous monitoring of system health and airspace conditions. With features such as context-aware alerts, customizable displays, and quick access to operational controls, the Radar HMI enhances situational awareness and supports effective traffic flow management in complex and high-density environments.

### 2.2.1 User and session management

This category includes requirements related to system access and session control, such as login authentication, user role assignment, sector allocation, and status indications (e.g., connection status, user ID, active role visibility).

- The HMI shall start with a Login Page.
- The login page shall verify user authorization and load the relevant ATC working position.
- The HMI shall display:
  - User login status,
  - Assigned sector/function,
  - Active role and allow role toggling in multi-sector mode.
- The HMI shall show a "Connected" status after successful login.
- The HMI shall indicate when no role or sector is associated.
- The HMI shall provide sign-out and change password controls.

### 2.2.2 Overall HMI layout and display structure

Covers the general interface design, including the layout of different panes (Top, Bottom, Left, Right, Centre), information displayed in each section, and dynamic behaviours such as collapsible views, real-time indicators, and visual alerts.

- The HMI shall be organized in Top, Bottom, Left, Right, and Centre panes.
- The HMI shows:
  - Controller's name, UTC time, facility/area/FIR/country,
  - Radar mode, login status, and role info.
  - It can be collapsed into a slim strip with key indicators.
- The HMI shows:
  - Surveillance and comm feed status (e.g., CPDLC, ADS-B),
  - Dynamic NOTAM and flow restriction alerts.
- The HMI shows the aircraft list.

- The HMI shows adjacent ATC units with facility name, sector, FIR and VHF frequency as well as handover options.
- The HMI displays messaging board.

### 2.2.3 Aircraft list and flight management

Encompasses how aircraft are displayed and managed: categorized flight lists (e.g., expected, under control, transferred), sorting/filtering mechanisms, colour coding, priority logic, and user customization (e.g., drag-and-drop reordering).

- Aircraft shall be categorized as:
  - Under Control, Expected Incoming, recently transferred.
- Labels shall be identified by:
  - Colour (under control),
  - Transparency (expected),
  - Colour & 2-min visibility (transferred).
- Flight list features:
  - Drag-and-drop reordering and custom sorting.
  - Flashing for 10 seconds after a new message is received.
  - Yellow colour for pending label typing.
  - Selected aircraft highlighted with a rectangle frame.
  - Flights ordered by latest first by default.
  - Filter by sector (All, Approach, En-route).
  - Flashing label for last A/C transmitting until clicked.

### 2.2.4 ATCO-pilot messaging and communication

Defines the messaging interface for communication between controllers and pilots sent/received message alignment, communication history, typing area with predictive suggestions, message status (read/cancelled), and integration of common ATC phraseology.

- Clicking on aircraft opens a Communication Page.
- Message window shows:
  - Call sign, chronological message history (oldest to newest),
  - Sent messages on right, received on left.
- Allows:
  - Free text or predefined commands,
  - Dropdowns triggered by keywords like climb, turn, etc.
  - Spell correction, Enter-to-send, message cancellation.
- Shows read status of messages.

- Emergency button sends special alert to pilot.
- Messaging tab is the main tab.
- Messages are separated by sector transitions.
- Includes search bar and highlighting of keywords like Descend, Contact, etc.
- Constant quick-access buttons: Roger, Affirm, Negative, Stand-by.

### **2.2.5 Aircraft transfer and handover procedures**

Covers procedures for transferring aircraft between ATC units: access to handover menus, filtering of suitable receiving units based on flight trajectory, execution of handovers, and post-transfer visibility rules.

- Handover is initiated by right-clicking on the under-control aircraft label.
- The system shall show a list of available handover ATC units.
- Filtered list based on flight trajectory with best match on top.
- Handover is completed automatically after ATCO confirmation.
- Adjacent ATC unit panel shows:
  - Facility, sector, FIR, frequency, and status (online/offline).
  - Status icons (online, pending and offline).
  - Emergency button is fixed and always visible

### **2.2.6 Surveillance and communication system status**

Details the monitoring of system feeds such as ADS-B, CPDLC, Voice, and Radar. Includes status indicators, real-time updates, and connection health, both for surveillance and communication channels.

- The HMI displays:
  - Status of ADS-B, Radar, CPDLC, voice systems.
  - Visual indicators for airspace restrictions, NOTAMs, and flow constraints.
  - Alert icons for NOTAMs.
- The HMI allows:
  - Frequency availability check.
  - Inter-sector connection validation

### **2.2.7 Service settings and system configuration**

Covers the settings panel, allowing controllers to manage data sync intervals, adjust the Green Route Optimization (GRO) engine, configure surveillance feeds, and perform diagnostic or infrastructure related tasks.

- Service Settings Pane shows:
  - Sync health and status of surveillance/communication feeds.

- Real-time CPDLC/voice channel info.
- Status of the GRO engine with server and data source.
- Allows:
  - Configuring GRO, restarting engine, reconnecting, and manual override.
  - Adjusting sync frequency and look-ahead time.
  - Toggle GRO's auto-suggest mode.
  - Support for eco-routing, diagnostics, and infrastructure monitoring.

### 2.2.8 Radar display and traffic interaction

Describes how the radar map visualizes aircraft trajectories, sector boundaries, restricted zones, and weather layers. It also includes support for quick actions such as heading or altitude changes, waypoint selection, and conflict resolution tools.

- The HMI may display a real-time radar map with:
  - Callsign, heading, FL, speed, route.
  - Vector lines, sector/FIR boundaries, restricted zones, WX layers.
- User can:
  - Click aircraft for quick actions (direct-to, FL/heading changes),
  - Toggle visual layers: weather, range rings, NOTAM zones.

### 2.2.9 User interaction and usability enhancements

Includes features that improve controller efficiency: smart text suggestions, message search functionality, visual cues in messaging history, color-coded commands, quick access buttons, and overall interface responsiveness.

- Aircraft label for last message received should blink until clicked.
- Highlighting of key ATC terms in message threads.
- Dropdown suggestions based on typed commands.
- Customization of flight list sorting by drag-and-drop or callsign/time.
- Auto-expansion of Top/Bottom panes upon critical events or alerts.
- Quick-access buttons and clear visual hierarchy in all panes.
- Use of colour, font, alignment, and icons for usability and readability.

## 2.3 Flight Deck HMI

The **Flight Deck HMI** is designed to offer pilots a unified and context-aware operational environment that enhances interaction with digital services and situational information. This interface consolidates critical flight data, service notifications, and real-time alerts into an integrated platform that supports efficient decision-making and communication throughout all flight phases. By providing a flexible and intuitive user experience, the Flight Deck HMI helps pilots maintain situational awareness and manage operational tasks effectively in both surface and airborne conditions.

### 2.3.1 Authentication and User Context Management

This section defines the functionalities related to user authentication, session management, and the visualization of the user's operational context. It ensures secure access control and clear assignment of roles, sectors, and responsibilities within the HMI.

- The HMI shall display current and next data authority (CDA/NDA), including their VHF frequencies, CPDLC logon status, and activation.
- A compact CDA/NDA Info Block shall provide real-time datalink connectivity context.
- The HMI shall show real-time flight info, including aircraft ID, FIR, runway, QNH, wind, and temperature.
- The panes can be collapsed to show only critical context (e.g., UTC, Flight ID, CPDLC status).
- Auto-expand behaviour is triggered by changes in CPDLC/VHF connectivity or data authority.

### 2.3.2 Interface Layout and Dynamic Pane Behaviour

Describes the general visual structure of the Flight Deck HMI, including the spatial organization of interface components and their dynamic behaviours. It focuses on adaptability, visibility, and user control over pane interactions.

- The HMI layout consists of Top, Centre, Left, Right panes with flexible behaviour based on phase.
- The HMI shall reallocate space dynamically, e.g., hiding the airport map in airborne phase to expand the service view.
- The HMI can display services in a scrollable list or full-screen overlay, based on interaction.
- The HMI supports a "Disable auto-expand" function during briefings or high-focus scenarios.
- The HMI shall present a simplified screen layout to reduce cognitive workload.
- The HMI shall prioritize pop-ups by colour, urgency, and module.

### 2.3.3 Digital ATM Services List Display and Interaction

This category covers the presentation and interaction of digital ATM services in the Pilot HMI, including dynamic status updates, phase-dependent information, and user navigation to detailed service interfaces. It ensures that pilots can access relevant information efficiently and safely during all flight phases.

- The HMI shows the list of digital ATM services (D-ATIS, D-STARTUP, D-TAXI, etc.) with color-coded phase status.
- Services in the list are dynamically updated based on current flight phase (preflight, taxi, airborne, etc.).
- A countdown timer is shown for NDA FIR entry.
- Pilots can click any service in one pane to open its full interface in another pane.
- Incompatible CPDLC aircraft will show a clear note, e.g., "EDUU CPDLC not supported."

### 2.3.4 ATCO–pilot messaging interface

Defines the layout and behaviour of the communication module between air traffic controllers and pilots. It includes message formatting, history tracking, alignment, and usability enhancements to support accurate and fast communication.

- The CPDLC Inbox shows chronological message history, distinguishing uplinks and downlinks with visual formatting.
- Each uplink shows response buttons (WILCO, STANDBY, UNABLE, NEGATIVE).
- Pilots can compose structured messages via a Message Type Selector with dropdown fields.
- Message previews are available before transmission.
- Messages with high urgency (e.g., "Go Around") are displayed with special visuals and sound alerts.
- If no pilot response within 20 seconds, Auto STANDBY may be sent.
- Status tracking of messages (e.g., "Awaiting ATC Response") is displayed live.

### 2.3.5 Coordination and handover workflow

Details the features related to inter-sector or inter-unit coordination. This section addresses the logic, interface, and steps required to execute aircraft handovers in a structured and traceable manner.

- The HMI shows CDA/NDA transitions and countdowns, enhancing awareness for handoff planning.
- The HMI supports dynamic service activation based on FIR transitions and aircraft phase.
- The CPDLC activation state is clearly indicated during handover windows.

### 2.3.6 System Feed Monitoring and Communication Status

Focuses on the visualization and status reporting of surveillance and communication systems. It ensures real-time monitoring of data feeds, highlighting loss of connectivity or degradation in system performance.

- One uses color-coded indicators (green/yellow/red) to show data authority and connectivity status.
- Tooltips on icons (CDA/NDA, connectivity) provide extended metadata, such as handoff time or FIR crossing.
- The HMI lists service states with icons for fast awareness.
- The HMI includes a "Silence updates" option for non-critical changes (e.g., trivial METARs).
- A "Revert to voice" option is available for emergency fallback.

### 2.3.7 System configuration and diagnostics panel

Includes tools and interfaces for configuring system parameters and accessing diagnostic information. This section supports the pilots and technical staff in adjusting operational settings and monitoring system health.

- The HMI serves as a consolidated hub for all digital ATM services, dynamically adjusting based on flight context.
- Services can be grouped (e.g., Pushback, Taxi, Startup) or decoupled based on operational needs.
- The HMI refreshes automatically on uplink/downlink to ensure synchronization.
- Inactive services can be hidden to reduce visual clutter.

### 2.3.8 Enhanced usability and input assistance

Encompasses usability features intended to streamline pilot interaction with the system. It includes predictive input tools, visual guidance, command shortcuts, and other functions that reduce workload and improve efficiency.

Services and messages are color-coded for quick recognition:

- The HMI shall highlight critical keywords (e.g., "CLSD", "NOT USABLE") in NOTAMs with colour.
- The HMI shall auto-hide blocked/unavailable services to reduce distraction.
- Optional tooltips and logbook info appear on icons (e.g., flight phase).
- The interface includes:
  - Auto-filtering NOTAMs by relevance and time,
  - Arrival Flow Graph, and
  - Weather overlays with crosswind/tailwind warnings.
- METAR/TAF/SIGMET data is decoded for readability and can be transferred to EFB or performance modules.
- The HMI shall auto-transfer landing and in-block times to the EFB Flight Log.

## 2.4 ATM Management Station HMI

The **ATM Management Station HMI** serves as the central interface for supervising, configuring, and maintaining the distributed components of the ATMACA air traffic communication network. Designed for supervisory roles such as system administrators and technical coordinators, it provides a modular and role-oriented environment that ensures operational integrity and synchronization across the system. This interface supports real-time monitoring, configuration management, and administrative control over networked nodes and services. By offering a centralized and structured approach, the Management Station HMI plays a key role in maintaining system consistency, supporting incident management, and ensuring overall network resilience in dynamic ATM environments.

### 2.4.1 Authentication and User Management

This category includes all requirements related to system access, user handling, roles, and session control. It focuses on security and identity management, including user creation, editing, role and sector assignments, as well as authentication and authorization mechanisms.

- The SIGN IN pane shall allow users to enter username and password and select their role after login.

- The HMI shall indicate when no sector or role has been assigned after login.
- The HMI shall allow supervisors to manage user accounts and forcibly log out sessions if required.
- The HMI shall support local authentication servers per facility and delegate authorization to the ATM Server.
- Roles shall include additional details clarifying the user's operational responsibilities (e.g., monitoring, ground).

## 2.4.2 User Interface and Status Visualization

This groups of requirements define how the interface presents information to the user, including display of connection status, active roles, function selection, and clear presentation of operational and diagnostic information.

- The HMI shall display node attributes including identity, role, assigned airspace, and backup configuration.
- The dashboard shall offer real-time performance and diagnostic info such as CPU usage, heartbeat, and uptime.
- The Node Table shall be searchable and filterable, showing role, hostname, and online status.
- The HMI shall automatically display periodic heartbeat signals to confirm node availability.

## 2.4.3 Node Management and Visualization

This includes administration of system nodes, their configuration, operational status, performance metrics, and synchronization of topology and data. It covers both visualization and manual control of node-related information.

- The dashboard shall support adding, editing, and deleting nodes with access control.
- Operators shall be able to manually fetch diagnostic and performance data from nodes.
- The HMI shall visually indicate backup nodes and allow configuration of backup status.

## 2.4.4 System Topology Management (FIR, Areas, Facilities, Sectors)

This category covers the definition, editing, and management of the hierarchical and geographical structure of the system, including FIRs, areas, facilities, and sectors. It also includes mechanisms to ensure integrity, consistency, and coordination among these entities.

- The HMI shall support creation and visualization of FIRs, Areas, Facilities, and Sectors with spatial mapping.
- Each topology element (FIR, Area, Facility, Sector) shall include unique IDs and hierarchical relationships.
- The HMI shall allow adjacency mapping and filtering for sectors and areas to support coordination and handovers.
- Export functions shall allow backup and synchronization of the topology database to the ATM Server.

## 2.4.5 Data Synchronization and Control

Contains requirements related to manual and automatic synchronization of data between system components, ensuring that certain sensitive or diagnostic data are not transmitted, and providing support for secure synchronization processes.

- The HMI shall enable manual synchronization of node topology (roles, assignments) to the ATM Server.
- Synchronization flows shall include preview, confirmation, and visual indicators.
- Diagnostic data (e.g., CPU usage) shall be excluded from sync payloads to reduce system load.
- A visualization of the sync flow shall link the Management Station, ATM Server, and mapping cache.

## 3 References

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### 3.1 Reference documents

- [1] ICAO ANNEX 3 – Meteorological Service for International Air Navigation – 21<sup>st</sup> edition
- [2] ICAO ANNEX 10 – Aeronautical Telecommunications – 8<sup>th</sup> edition
- [3] ICAO ANNEX 15 - Aeronautical Information Services - 16<sup>th</sup> edition
- [4] EUROCONTROL ATM Lexicon
- [5] ICAO 4444 - Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM) - 15<sup>th</sup> edition
- [6] ICAO 9880 - Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols – 3<sup>rd</sup> edition
- [7] Commission Implementing Regulation (EU) 2017/373, 01/03/2017
- [8] SESAR Solution, PJ.14-W2-107 “Future Satellite Communications Datalink
- [9] SESAR Solution, PJ.14-02-06 “AeroMACS Integrated with ATN, Digital Voice, and Multilink”
- [10] EUROCONTROL Data Link Implementation Guidance

## 4 Annex 1

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For further details, refer to the document "ATMACA TASK 5.1", where all applicable requirements for each HMI solution are specified, including their priority for the initial design.