

# **Software Requirements Specification**

## **SKYRADAR Air Traffic Control System**

**Version 1.0**

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### **Document Information**

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Version	Date	Author	Description
1.0	2025-12-16	Engineering Team	Initial SRS document with 8 core safety requirements

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## 1. Introduction

### 1.1 Purpose

This Software Requirements Specification (SRS) document defines the functional and non-functional requirements for the SKYRADAR Air Traffic Control System. The document is intended to serve as a contractual agreement between stakeholders and the development team, ensuring all safety-critical and operational requirements are clearly specified and verifiable.

The SKYRADAR system provides advanced air traffic management capabilities including conflict detection, terrain awareness, airspace compliance monitoring, and automated traffic flow optimization for modern Air Traffic Control (ATC) operations.

### 1.2 Document Conventions

This document follows IEEE 830-1998 standard formatting conventions:

- **Requirement Priority Levels:**
  - HIGH: Safety-critical requirements (Safety impact = true)
  - MEDIUM: Operational efficiency requirements (Safety impact = false)
- **Requirement Identifiers:** Format SKYRADAR- [SUBSYSTEM] - [NNN]
- **Verification Methods:**
  - Test: Formal testing procedures
  - RL: Requirements Level verification
- **Derivation Status:**
  - Partially: Requirements partially derived from parent specifications
- **Typography:**
  - CSP: = Configuration System Parameter
  - VSP: = Variable System Parameter

- **Bold** = Key terms and headings
- *Italics* = References to external documents

### 1.3 Intended Audience

This document is intended for:

- **System Engineers:** Overall system architecture and integration
- **Software Developers:** Implementation of safety-critical algorithms
- **Test Engineers:** Verification and validation planning
- **Safety Assessors:** Safety case development and certification
- **Air Traffic Controllers:** Operational concept validation
- **Regulatory Authorities:** Certification and compliance review
- **Project Managers:** Planning and resource allocation

### 1.4 Product Scope

SKYRADAR is a next-generation Air Traffic Control automation system designed to enhance safety and efficiency in terminal and en-route airspace operations. The system provides:

**Primary Benefits:** - Enhanced separation assurance through multi-layered conflict detection - Improved terrain clearance monitoring for approach/departure operations - Automated traffic flow optimization for arrivals and departures - Advanced navigation performance monitoring for precision procedures - Real-time compliance monitoring for specialized airspace operations

**Key Objectives:** - Reduce controller workload through intelligent automation - Improve safety margins through predictive alerting - Optimize airspace capacity through dynamic sequencing - Support advanced procedures (RNP, CPDLC, Time-Based Separation) - Ensure compliance with international aviation standards (ICAO, FAA, EASA)

### 1.5 References

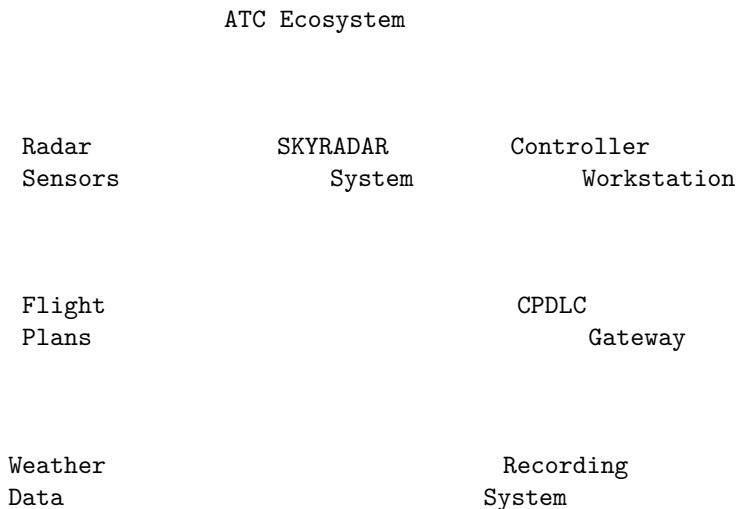
Reference ID	Document	Version
SSS	ATCS System Specification	REQ-005855 to REQ-007585
ICAO-PANS-ATM	ICAO Procedures for Air Navigation Services - Air Traffic Management	Doc 4444
ICAO-Annex11	ICAO Annex 11 - Air Traffic Services	Amendment 51
EUROCAE-ED87	Minimum Aviation System Performance Standards for STCA	ED-87C

Reference ID	Document	Version
RTCA-DO-318	Minimum Operational Performance Standards for RVSM	DO-318
FAA-JO-7110	FAA Air Traffic Control Procedures	Order 7110.65Z

## 2. Overall Description

### 2.1 Product Perspective

SKYRADAR operates as a core component within a larger Air Traffic Control ecosystem:



**External Interfaces:** - Surveillance data from primary/secondary radar and ADS-B - Flight plan data from Flight Data Processing System - Meteorological data from weather information systems - Controller inputs via Human-Machine Interface (HMI) - CPDLC messages via data link gateway

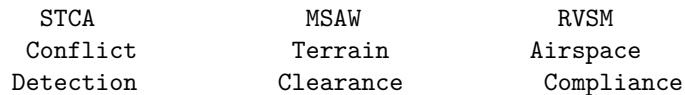
### 2.2 Product Features

The SKYRADAR system provides eight major feature categories:

Feature Category	Description	Safety Critical
<b>STCA</b> - Short Term Conflict Alert	Detects and alerts potential aircraft conflicts with specialized logic for parallel approaches	No
<b>MSAW</b> - Minimum Safe Altitude Warning	Monitors terrain clearance during approach/departure phases	Yes
<b>RVSM</b> - Reduced Vertical Separation	Ensures aircraft compliance with RVSM approval requirements	Yes
<b>AMAN</b> - Arrival Manager	Optimizes arrival sequences using time-based separation	No
<b>Wake Vortex</b>	Monitors dynamic wake turbulence separation based on atmospheric conditions	Yes
<b>RNP</b> - Required Navigation Performance	Validates containment within RNP approach procedures	Yes
<b>CPDLC</b> - Controller-Pilot Data Link	Manages timeout and reversion for data link clearances	Yes
<b>DMAN</b> - Departure Manager	Monitors compliance with departure slot allocations	No

#### Feature Interaction Diagram:

Surveillance  
Track Data



**Alert Manager  
(Prioritization)**

**Controller  
Display**

### 2.3 User Classes and Characteristics

User Class	Description	Technical Expertise	Usage Frequency
<b>Air Traffic Controllers</b>	Primary operators who use alerts to maintain separation and safety	Medium (ATC trained)	Continuous
<b>Supervisors</b>	Monitor system status and override parameters	High (Senior controllers)	Intermittent
<b>System Engineers</b>	Configure parameters (CSP/VSP) and monitor performance	Very High (Engineering)	Daily (maintenance)
<b>Safety Analysts</b>	Review alert logs and safety metrics	High (Safety domain)	Weekly/Monthly
<b>Maintenance Technicians</b>	Perform system health checks and diagnostics	High (Technical)	As needed

## 2.4 Operating Environment

**Hardware Platform:** - Fault-tolerant server architecture with redundancy  
- Real-time processing capabilities (<100ms latency) - Minimum 32GB RAM, multi-core processors (8+ cores) - Redundant network interfaces (1Gbps+)

**Software Environment:** - Real-time operating system (e.g., VxWorks, Linux RT) - Database system for configuration and historical data - Network protocols: ASTERIX, ICAO AIDC, CPDLC ATN

**Operational Environment:** - 24/7/365 availability requirement - Temperature-controlled server room (18-24°C) - UPS backup power (minimum 30 minutes) - Geographic redundancy for disaster recovery

## 2.5 Design and Implementation Constraints

**Regulatory Constraints:** - Must comply with ICAO Standards and Recommended Practices (SARPs) - Must meet EUROCAE ED-87C STCA performance standards - Must satisfy DO-178C software development assurance level (DAL-B for safety-critical functions)

**Technical Constraints:** - Maximum alert latency: 2 seconds from track update to alert display - Minimum alert accuracy: 95% detection rate, <5% false alert rate - System availability: 99.999% uptime requirement

**Operational Constraints:** - Must integrate with existing ATC infrastructure - Must support incremental deployment and rollback - Must maintain compatibility with legacy flight plan formats

## 2.6 Assumptions and Dependencies

**Assumptions:** 1. Surveillance data quality meets minimum ICAO standards 2. Flight plan data is available and updated in real-time 3. Controllers are trained on SKYRADAR alert interpretation 4. Meteorological data is available with <5 minute update rate 5. Aircraft transponder data includes Mode S capabilities

**Dependencies:** 1. Radar surveillance system provides track updates at 4-5 second intervals 2. Flight Data Processing System provides current flight plan data 3. Weather information system provides wind, temperature, humidity data 4. Aeronautical database provides runway, airspace, and procedure definitions 5. Time synchronization via NTP or GPS for accurate time-based operations

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## 3. System Features

This section provides a high-level summary of the eight major system features. Detailed functional requirements are specified in Section 4.

### **3.1 Short Term Conflict Alert (STCA)**

Detects potential conflicts between aircraft and provides early warning to controllers. Includes specialized logic for suppressing nuisance alerts during parallel approach operations with Normal Operating Zones (NOZ) and No Transgression Zones (NTZ).

**Priority:** MEDIUM **Safety Impact:** False (operational efficiency)

### **3.2 Minimum Safe Altitude Warning (MSAW)**

Monitors aircraft altitude relative to terrain and obstacles during critical phases of flight (approach and departure). Generates alerts when aircraft descend below minimum safe altitude thresholds.

**Priority:** HIGH **Safety Impact:** True (terrain collision prevention)

### **3.3 RVSM Non-Approval Alert**

Monitors aircraft operating in Reduced Vertical Separation Minimum (RVSM) airspace to ensure only RVSM-approved aircraft operate at RVSM flight levels. Alerts controllers when non-approved aircraft enter RVSM airspace.

**Priority:** HIGH **Safety Impact:** True (vertical separation assurance)

### **3.4 Arrival Manager (AMAN)**

Optimizes arrival sequences by calculating time-based separation and adjusting aircraft positions within the arrival flow. Helps maximize runway throughput while maintaining required separation standards.

**Priority:** MEDIUM **Safety Impact:** False (flow optimization)

### **3.5 Wake Vortex Separation Monitoring**

Monitors separation between aircraft pairs considering wake turbulence categories and atmospheric conditions. Uses dynamic separation minima based on real-time weather data (crosswind, temperature, humidity).

**Priority:** HIGH **Safety Impact:** True (wake turbulence encounter prevention)

### **3.6 RNP Approach Containment Monitoring**

Validates that aircraft executing RNP (Required Navigation Performance) approaches remain within the defined containment area. Alerts when lateral deviation exceeds twice the RNP value for the procedure.

**Priority:** HIGH **Safety Impact:** True (obstacle clearance during precision approaches)

### **3.7 CPDLC Message Timeout and Reversion**

Monitors Controller-Pilot Data Link Communications (CPDLC) message acknowledgments and triggers voice communication reversion when safety-critical messages are not acknowledged within timeout thresholds.

**Priority:** HIGH **Safety Impact:** True (clearance delivery assurance)

### **3.8 Departure Manager (DMAN)**

Monitors departure slot compliance by comparing actual take-off times with assigned Target Take-Off Times (TTOT). Helps controllers maintain departure flow efficiency and comply with flow management restrictions.

**Priority:** MEDIUM **Safety Impact:** False (departure flow optimization)

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## **4. Functional Requirements**

### **4.1 Conflict Detection and Resolution**

#### **4.1.1 STCA - Suppression During Parallel Approaches Requirement**

**ID:** SKYRADAR-STCA-041 **Parent Requirement:** ATCS-SSS-REQ-005855

**Derivation Status:** Partially **Safety Impact:** No **Verification Method:**

Test **Verification Level:** RL

#### **Requirement Statement:**

SKYRADAR shall flag STCA conflicts as suppressed for tracks located in NOZ if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The associated NTZ area is active	System State
2	The status of the NTZ areas manager is equal to OPERATIONAL	System State
3	The heading gap between each aircraft and the runway axis is lower than MAX_DELTA_HEADING	CSP
4	The current distance between the aircraft is kept above MinimalDistance (safety distance)	VSP

Condition #	Condition Description	Parameter Type
5	Each track is located within a different NOZ associated with an offline defined “parallel approach pair” of runways	Configuration
6	The “parallel approach pair” is in INDEPENDENT mode	System State
7	STCA_PARALLEL_APP_FPL_FlagsOKtaFLAG is false OR the runway of each track’s coupled FPL (if assigned) matches the runway linked to the NOZ where the track is located	

**Rationale:** Alert inhibition on approach with NOZ and NTZ Areas prevents nuisance alerts during normal parallel approach operations while maintaining safety through geometric and procedural checks.

**SDS Rules Reference:** HLR\_10 [cmats\_snp] Partial derivation shall be avoided

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#### 4.2 Terrain and Altitude Monitoring

##### 4.2.1 MSAW - Minimum Safe Altitude Warning Generation Requirement ID: SKYRADAR-MSAW-025 Parent Requirement: ATCS-SSS-

REQ-006142 Derivation Status: Partially Safety Impact: Yes Verification

Method: Test Verification Level: RL

##### Requirement Statement:

SKYRADAR shall generate MSAW (Minimum Safe Altitude Warning) alerts for tracks if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The MSAW system status is equal to OPERATIONAL	System State
2	The track altitude is below the MSA (Minimum Safe Altitude) threshold defined for the current sector	Database/Track
3	The track is in APPROACH or DEPARTURE flight phase	Track State

Condition #	Condition Description	Parameter Type
4	The track vertical speed indicates descent or level flight (not climbing above MIN_CLIMB_RATE)	VSP/Track
5	The track is located within a monitored airspace zone where MSAW is active	Configuration
6	The track has valid altitude data with quality indicator equal to HIGH or MEDIUM	Track Quality
7	MSAW_EMERGENCY_OVERRIDE is false OR the track's transponder squawk code is NOT in emergency range (7500, 7600, 7700)	VSP/Track

**Rationale:** Terrain clearance monitoring for approach and departure operations prevents controlled flight into terrain (CFIT) by alerting controllers when aircraft descend below safe altitudes.

**SDS Rules Reference:** HLR\_15 [cmats\_snp] Partial derivation shall be avoided

**Performance Requirements:** - Alert generation latency: <2 seconds - MSA threshold accuracy: ±50 feet - False alert rate: <3% of total alerts

#### 4.3 Airspace Compliance Monitoring

**4.3.1 RVSM - Non-Approval Alert Generation Requirement ID:** SKYRADAR-RVSM-033 **Parent Requirement:** ATCS-SSS-REQ-006500  
**Derivation Status:** Partially **Safety Impact:** Yes **Verification Method:** Test **Verification Level:** RL

##### Requirement Statement:

SKYRADAR shall generate RVSM (Reduced Vertical Separation Minimum) Non-Approval alerts for tracks if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The RVSM monitoring system status is equal to OPERATIONAL	System State

Condition #	Condition Description	Parameter Type
2	The track flight level is within RVSM airspace range (between RVSM_MIN_FL and RVSM_MAX_FL)	CSP/Track
3	The track RVSM approval status indicator is set to NOT_APPROVED or UNKNOWN	Track Data
4	The track altitude source quality indicator is equal to HIGH or MEDIUM	Track Quality
5	The track is located within an RVSM designated airspace zone where monitoring is active	Configuration
6	The track flight plan indicates IFR (Instrument Flight Rules) operation	Flight Plan
7	RVSM_EMERGENCY_EXCEPTION/Track is false OR the track's transponder squawk code is NOT in emergency range (7500, 7600, 7700)	

**Rationale:** RVSM compliance monitoring for flight operations in reduced vertical separation airspace ensures that only properly equipped and approved aircraft operate in RVSM airspace, maintaining the safety case for 1000ft vertical separation.

**SDS Rules Reference:** HLR\_12 [cmats\_snp] Partial derivation shall be avoided

#### RVSM Airspace Characteristics:

Parameter	Typical Value	Notes
RVSM_MIN_FL	FL290	29,000 feet
RVSM_MAX_FL	FL410	41,000 feet
Standard Vertical Separation	1000 feet	Within RVSM airspace
Non-RVSM Separation	2000 feet	Below FL290 or above FL410

#### 4.4 Traffic Flow Management

**4.4.1 AMAN - Time-Based Arrival Sequencing Requirement ID:** SKYRADAR-ARR-044   **Parent Requirement:** ATCS-SSS-REQ-007125  
**Derivation Status:** Partially Safety Impact: No Verification Method:  
Test Verification Level: RL

##### Requirement Statement:

SKYRADAR shall generate an alert for arrival sequence optimization issues when ONE OR MORE of the following conditions are NOT satisfied:

Condition #	Condition Description	Parameter Type
1	The AMAN (Arrival Manager) system status is equal to OPERATIONAL	System State
2	The track is in ARRIVAL flight phase with valid time-to-threshold prediction	Track State
3	The track is located within the Extended Terminal Maneuvering Area (E-TMA) boundary defined for the arrival airport	Configuration
4	The calculated arrival delay is greater than AMAN_MIN_DELAY_THRESHOLD (typically 120 seconds)	CSP/Calculation
5	The track has an assigned arrival runway with active AMAN sequencing enabled	Configuration
6	The potential sequence position change would not violate minimum time-based separation with preceding or following traffic (TBS_MIN_SEPARATION_TIME)	VSP/Safety Check

**Alert Logic:** - **When ALL conditions are satisfied:** No alert is generated. SKYRADAR automatically adjusts arrival sequence positions for optimal flow management. - **When ONE OR MORE conditions are NOT satisfied:** An alert is generated to inform controllers that automatic arrival sequencing cannot be applied, requiring manual intervention.

**Rationale:** Automated arrival sequencing with time-based separation for traffic flow optimization improves runway throughput and reduces delay while main-

taining safety separation. Alerts notify controllers when conditions prevent automatic optimization, ensuring awareness of manual intervention requirements.

**SDS Rules Reference:** HLR\_18 [cmats\_snp] Partial derivation shall be avoided

**AMAN Performance Targets:**

Metric	Target Value
Delay Reduction	15-30% compared to manual sequencing
Sequence Stability	<2 position changes per flight
Throughput Improvement	5-10% increased runway acceptance rate

## 4.5 Separation Assurance

### 4.5.1 Wake Vortex - Dynamic Separation Monitoring Requirement

**ID:** SKYRADAR-WV-045 **Parent Requirement:** ATCS-SSS-REQ-007240

**Derivation Status:** Partially **Safety Impact:** Yes **Verification Method:**

Test **Verification Level:** RL

**Requirement Statement:**

SKYRADAR shall generate wake vortex separation infringement alerts for track pairs if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The wake vortex monitoring system status is equal to OPERATIONAL	System State
2	Both tracks are in APPROACH or DEPARTURE flight phase on the same runway or parallel runways separated by less than WV_PARALLEL_RWY_DISTANCE (typically 760 meters)	CSP/Track
3	The leading aircraft wake turbulence category is HEAVY or SUPER and the following aircraft category is at least two categories lower (per ICAO RECAT standards)	Track Data

Condition #	Condition Description	Parameter Type
4	The measured separation distance between the two tracks is below the dynamic wake vortex separation minimum calculated based on current meteorological conditions (crosswind, temperature, humidity from WEATHER_DATA_SOURCE)	VSP/Calculation
5	Both tracks have valid position and altitude data with quality indicator equal to HIGH	Track Quality
6	WV_TIME_BASED_MODE is true AND time-based separation is below WV_MIN_TIME_SEPARATION, OR flag is false AND distance-based separation is below WV_MIN_DISTANCE_SEPARATION	VSP/Flag
7	WV_EMERGENCY_OVERRIDE is false OR neither track's transponder squawk code is in emergency range (7500, 7600, 7700)	Flag/Track

**Rationale:** Dynamic wake turbulence separation reduction based on atmospheric conditions and aircraft characteristics allows for optimized separation standards while maintaining safety.

**SDS Rules Reference:** HLR\_22 [cmats\_snp] Partial derivation shall be avoided

#### ICAO RECAT Wake Turbulence Categories:

Category	Aircraft Examples	Wake Characteristic
SUPER (J)	A380	Extreme wake
HEAVY (H)	B747, B777, A330	Strong wake
UPPER MEDIUM (UM)	B767, A310	Moderate wake
LOWER MEDIUM (LM)	B737, A320	Light wake
SMALL (S)	Regional jets	Minimal wake

#### Dynamic Separation Matrix:

Leader → Follower	Strong Crosswind (>15kt)	Moderate Crosswind (5-15kt)	Light Crosswind (<5kt)
SUPER →	4 NM	5 NM	6 NM
HEAVY →	3 NM	4 NM	5 NM
MEDIUM →	4 NM	5 NM	6 NM
HEAVY → SMALL			

## 4.6 Navigation Performance Monitoring

**4.6.1 RNP - Approach Containment Validation Requirement ID:** SKYRADAR-RNP-046 **Parent Requirement:** ATCS-SSS-REQ-007355  
**Derivation Status:** Partially **Safety Impact:** Yes **Verification Method:** Test **Verification Level:** RL

### Requirement Statement:

SKYRADAR shall generate RNP (Required Navigation Performance) containment violation alerts for tracks if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The RNP monitoring system status is equal to OPERATIONAL	System State
2	The track is executing an RNP approach procedure with approach type indicator set to RNP or RNP_AR (Authorization Required)	Track/Procedure
3	The track flight plan indicates the aircraft RNP capability value is adequate for the published procedure (aircraft RNP procedure required RNP from RNP_PROCEDURE_DATABASE)	CSP/Flight Plan

Condition #	Condition Description	Parameter Type
4	The track lateral deviation from the published RNP approach path exceeds the RNP containment limit (deviation $> 2 \times$ RNP value for more than RNP_DEVIATION_TIME_THRESHOLD seconds)	VSP/Calculation
5	The track is located within the RNP procedure coverage volume defined in the approach chart (typically final approach segment beyond FAF)	Configuration
6	The track GNSS integrity status indicator is equal to AVAILABLE with horizontal protection level (HPL) less than the alert limit for the RNP value	Track Data
7	RNP_VISUAL_OVERRIDE is false OR the track has not reported visual conditions with the runway in sight to ATC	Flag/Track

**Rationale:** Monitoring of Required Navigation Performance approach path containment and precision for advanced procedure compliance ensures obstacle clearance in terminal areas with reduced obstacle clearance areas.

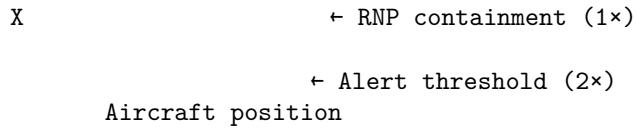
**SDS Rules Reference:** HLR\_25 [cmats\_snp] Partial derivation shall be avoided

#### RNP Approach Types:

RNP Type	Required RNP Value	Typical Application	Authorization
RNP	0.3 NM	Standard terminal approaches	Basic GNSS
APCH			
RNP AR	0.1 - 0.3 NM	Complex terrain airports	Special authorization
APCH			
RNP 0.1	0.1 NM	Precision-like approaches	Advanced authorization

#### Containment Monitoring:

## RNP Approach Path



## 4.7 Data Link Communications

**4.7.1 CPDLC - Message Timeout and Voice Reversion Requirement**  
ID: SKYRADAR-CPDLC-047 Parent Requirement: ATCS-SSS-REQ-007470 Derivation Status: Partially Safety Impact: Yes Verification Method: Test Verification Level: RL

### Requirement Statement:

SKYRADAR shall generate CPDLC message timeout alerts and trigger voice communication reversion for tracks if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The CPDLC system status is equal to OPERATIONAL	System State
2	The track has an active CPDLC connection with logon status set to CONNECTED and data authority is CURRENT	Track State
3	A CPDLC uplink message of type CLEARANCE or INSTRUCTION has been transmitted to the aircraft with message status equal to SENT	Message State
4	The elapsed time since message transmission exceeds the response timeout threshold (CPDLC_RESPONSE_TIMEOUT: typically 60s for clearances, 30s for time-critical instructions)	CSP/Timer

Condition #	Condition Description	Parameter Type
5	No CPDLC downlink response (WILCO, UNABLE, STANDBY, or ROGER) has been received from the aircraft for the pending message	Message State
6	The message criticality level is set to HIGH or SAFETY_CRITICAL requiring mandatory acknowledgment	Message Attribute
7	CPDLC_VOICE_BACKUP_ENABLE Configuration is true AND the controller position has active voice communication capability with frequency assigned to the track's current sector	Configuration

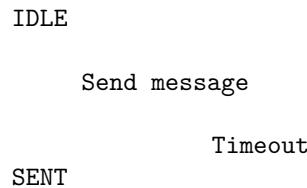
**Rationale:** Controller-Pilot Data Link Communications timeout monitoring and voice reversion alerting for safety-critical clearances ensures communication loop closure and prevents loss of clearance delivery.

**SDS Rules Reference:** HLR\_28 [cmats\_snp] Partial derivation shall be avoided

#### CPDLC Message Types and Timeouts:

Message Type	Criticality	Response Timeout	Voice Reversion
Altitude Clearance	SAFETY_CRITICAL	30 seconds	Mandatory
Heading Instruction	HIGH	30 seconds	Mandatory
Speed Instruction	HIGH	60 seconds	Mandatory
Route Clearance	MEDIUM	60 seconds	Optional
Information	LOW	N/A	Not required

#### Communication State Diagram:



Response received

ACKED

TIMEOUT

Trigger voice

VOICE  
REVERSION

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#### 4.8 Departure Management

**4.8.1 DMAN - Departure Slot Compliance Requirement ID:** SKYRADAR-DMAN-048 **Parent Requirement:** ATCS-SSS-REQ-007585  
**Derivation Status:** Partially **Safety Impact:** No **Verification Method:** Test **Verification Level:** RL

**Requirement Statement:**

SKYRADAR shall generate departure sequence slot violation alerts for tracks if ALL of the following conditions are met:

Condition #	Condition Description	Parameter Type
1	The DMAN (Departure Manager) system status is equal to OPERATIONAL	System State
2	The track has an assigned Target Take-Off Time (TTOT) with departure sequence position allocated by DMAN	Track Data
3	The track is in DEPARTURE_GROUND or DEPARTURE_TAXI flight phase with valid ground position data	Track State
4	The calculated actual take-off time prediction exceeds the assigned TTOT by more than DMAN_SLOT_TOLERANCE (typically ±5 minutes)	CSP/Calculation

Condition #	Condition Description	Parameter Type
5	The departure runway assigned to the track has active DMAN sequencing enabled with current departure demand exceeding DMAN_ACTIVATION_THRESHOLD (typically 8 departures per hour)	VSP/Configuration
6	The track departure route or initial departure fix matches one of the DMAN managed flow constraint points defined in DMAN_REGULATED_ROUTES	CSP/Flight Plan

**Rationale:** Automated departure sequence monitoring and Target Off-Block Time (TOBT) compliance for flow management optimization helps maintain airport departure capacity and comply with ATFM slots.

**SDS Rules Reference:** HLR\_31 [cmats\_snp] Partial derivation shall be avoided

#### DMAN Sequencing Parameters:

Parameter	Typical Value	Purpose
TTOT Tolerance	±5 minutes	Acceptable deviation window
Activation Threshold	8 departures/hour	Minimum traffic to enable DMAN
Sequence Update Interval	60 seconds	Frequency of TTOT recalculation
Maximum Delay Absorption	15 minutes	Maximum taxi delay allowed

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## 5. Non-Functional Requirements

### 5.1 Performance Requirements

Req ID	Description	Target Value	Measurement Method
NFR-001	Alert Generation Latency	<2 seconds	Time from track update to alert display
NFR-002	Track Processing Capacity	500 tracks simultaneous	Maximum concurrent aircraft
NFR-003	System Response Time	<500ms	User interface responsiveness
NFR-004	Database Query Performance	<100ms	Configuration parameter retrieval
NFR-005	Alert Update Rate	4-5 seconds	Synchronized with radar update rate

## 5.2 Safety Requirements

Req ID	Description	Target Value
NFR-101	Safety-Critical Alert Reliability	99.9% detection rate
NFR-102	False Alert Rate	<5% of total alerts
NFR-103	System Failure Detection Time	<10 seconds
NFR-104	Redundancy Switch-Over Time	<2 seconds
NFR-105	Data Integrity	100% (checksums and validation)

## 5.3 Reliability and Availability

Req ID	Description	Target Value
NFR-201	System Availability	99.999% uptime
NFR-202	Mean Time Between Failures (MTBF)	>8760 hours (1 year)
NFR-203	Mean Time To Repair (MTTR)	<30 minutes
NFR-204	Backup System Sync Time	<5 seconds

## 5.4 Maintainability

Req ID	Description	Requirement
NFR-301	Parameter Modification	Runtime configuration without system restart
NFR-302	Software Update Window	<4 hours for major updates
NFR-303	Diagnostic Logging	Comprehensive event logging with severity levels
NFR-304	Remote Monitoring	Web-based system health dashboard

## 5.5 Security Requirements

Req ID	Description	Requirement
NFR-401	Access Control	Role-based authentication (RBAC)
NFR-402	Audit Trail	All configuration changes logged
NFR-403	Data Encryption	TLS 1.3 for network communications
NFR-404	Password Policy	Minimum 12 characters, complexity requirements

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## 6. Appendices

### 6.1 Glossary of Terms

Term	Definition
<b>AMAN</b>	Arrival Manager - automated system for optimizing arrival sequences
<b>CPDLC</b>	Controller-Pilot Data Link Communications
<b>CSP</b>	Configuration System Parameter - offline configured parameter
<b>DMAN</b>	Departure Manager - automated system for departure sequencing
<b>E-TMA</b>	Extended Terminal Maneuvering Area
<b>FAF</b>	Final Approach Fix
<b>GNSS</b>	Global Navigation Satellite System
<b>HPL</b>	Horizontal Protection Level
<b>IFR</b>	Instrument Flight Rules
<b>MSAW</b>	Minimum Safe Altitude Warning
<b>NOZ</b>	Normal Operating Zone (parallel approaches)
<b>NTZ</b>	No Transgression Zone (parallel approaches)
<b>RECAT</b>	Reduced Wake Turbulence Separation
<b>RNP</b>	Required Navigation Performance
<b>RNP AR</b>	RNP Authorization Required
<b>RVSM</b>	Reduced Vertical Separation Minimum
<b>STCA</b>	Short Term Conflict Alert
<b>TBS</b>	Time-Based Separation
<b>TOBT</b>	Target Off-Block Time
<b>TTOT</b>	Target Take-Off Time
<b>VSP</b>	Variable System Parameter - runtime adjustable parameter

## 6.2 Acronyms

Acronym	Expansion
ADS-B	Automatic Dependent Surveillance-Broadcast
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
CFIT	Controlled Flight Into Terrain
DAL	Development Assurance Level
EASA	European Union Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FPL	Flight Plan
HMI	Human-Machine Interface
ICAO	International Civil Aviation Organization
MSA	Minimum Safe Altitude
NM	Nautical Mile
PANS-ATM	Procedures for Air Navigation Services - Air Traffic Management
RTCA	Radio Technical Commission for Aeronautics
SARPS	Standards and Recommended Practices
SRS	Software Requirements Specification

## 6.3 Requirements Traceability Matrix

SKYRADAR Req ID	Parent SSS Req	Feature Area	Safety Critical	Verification Status
SKYRADAR-STCA-041	ATCS-SSS-REQ-005855	Conflict Detection	No	Pending
SKYRADAR-MSAW-025	ATCS-SSS-REQ-006142	Terrain Monitoring	Yes	Pending
SKYRADAR-RVSM-033	ATCS-SSS-REQ-006500	Airspace Compliance	Yes	Pending
SKYRADAR-ARR-044	ATCS-SSS-REQ-007125	Flow Management	No	Pending
SKYRADAR-WV-045	ATCS-SSS-REQ-007240	Separation Assurance	Yes	Pending
SKYRADAR-RNP-046	ATCS-SSS-REQ-007355	Navigation Performance	Yes	Pending

SKYRADAR Req ID	Parent SSS Req	Feature Area	Safety Critical	Verification Status
SKYRADAR-CPDLC-047	ATCS-SSS-REQ-007470	Data Link	Yes	Pending
SKYRADAR-DMAN-048	ATCS-SSS-REQ-007585	Flow Management	No	Pending

## 6.4 Configuration Parameters Reference

### Configuration System Parameters (CSP)

Parameter Name	Type	Range	Default	Description
MAX_DELTA_HEADING	Float	0-45°	20°	Maximum heading deviation for parallel approach
RVSM_MIN_FL	Integer	0-999	290	RVSM airspace lower boundary (FL)
RVSM_MAX_FL	Integer	0-999	410	RVSM airspace upper boundary (FL)
AMAN_MIN_DELAY_TRIGGER_THRESHOLD	Float	0-1000s	120s	Minimum delay to trigger AMAN sequencing
WV_PARALLEL_RWY_DISTANCE	Float	0-2000m	760m	Max runway spacing for wake vortex monitoring
CPDLC_RESPONSE_TIMEOUT	Integer	10-300s	60s	CPDLC message acknowledgment timeout
DMAN_SLOT_TOLERANCE	Float	0-600s	300s	TTOT deviation tolerance ( $\pm 5$ minutes)

### Variable System Parameters (VSP)

Parameter Name	Type	Range	Default	Description
MinimalDistance	Float	0.5-10 NM	3.0 NM	Minimum safety distance (STCA)

Parameter Name	Type	Range	Default	Description
MIN_CLIMB_RATE	Integer	0-1000 ft/min	300 ft/min	Minimum climb rate threshold (MSAW)
TBS_MIN_SEPARATION	Negative TIME	60-240s	90s	Minimum time-based separation
WEATHER_DATA_SOURCE	MET/METAR/TAF			Weather data source selection
WV_MIN_TIME_SEPARATION	Positive TIME	60-180s	120s	Wake vortex minimum time separation
WV_MIN_DISTANCE_OF_SEPARATION	Positive DISTANCE	5 NM		Wake vortex minimum distance separation
RNP_DEVIATION_THRESHOLD	Positive TIME	15s		RNP deviation persistence time
DMAN_ACTIVATION_THRESHOLD	Positive TIME	20 hr	8/hr	Minimum departure rate for DMAN

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### Document Control

Attribute	Value
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*End of Software Requirements Specification*