

Key Advancements in QATAR'S CNS/ATM Infrastructure

for Enhanced Aviation Safety,
Surveillance, Operational Efficiency,
and Airspace Security

نقار اصقننن الفوالبن
Hamad International Airport
QATAR



ENHANCED
SAFETY



ADVANCED
SURVEILLANCE



OPERATIONAL
EFFICIENCY



AIRSPACE
SECURITY



FUTURE-READY
INFRASTRUCTURE

INTRODUCTION

- Qatar has made significant advancements in modern aviation infrastructure through the continuous enhancement of Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) systems.
- With the rapid growth of air traffic operations, increasing cybersecurity and airspace security challenges, and the emergence of advanced aviation technologies, the modernization of CNS/ATM infrastructure has become a strategic national priority.
- These initiatives collectively support Qatar's vision for a future-ready, resilient, and highly secure aviation environment aligned with ICAO global modernization objectives and the evolving demands of international air traffic operations.

This presentation highlights the few of the key technological advancements implemented across Qatar's aviation ecosystem to enhance aviation safety, surveillance performance, operational efficiency, resilience, and airspace security.

1. GNSS Interference Resilience: Mitigation of Jamming and Spoofing Threats in Aviation
2. Counter-Unmanned Aircraft Systems (C-UAS) : Operational Framework for Detection, Tracking, Identification & neutralization of micro to small Unmanned Aerial threats
3. Enhanced Flight Planning: Implementation of eFPL within the FF-ICE Framework for Collaborative ATM Operations
4. Advanced ATC Communications: Next-Generation Voice Communication System (VCS X10) - Architecture and Operational Capabilities
5. Surveillance Infrastructure Performance: Spotlight on Integrated MLAT/ADS-B Surveillance full Coverage at HIA and DIA Airports

GNSS Interference Resilience:

Mitigation of Jamming and Spoofing Threats in Aviation



JAMMING
Disrupting GNSS Signals



SPOOFING
Deceiving with False Signals



DETECT

Identify Threats



MITIGATE

Reduce Impact



ASSURE

Ensure Integrity



Strengthening GNSS Reliability.
Securing Aviation Operations.



MONITOR
Continuous Surveillance



ANALYZE
Advanced Analytics



RESPOND
Timely Alerts & Countermeasures



PROTECT
Reliable Navigation.
Safe Operations.



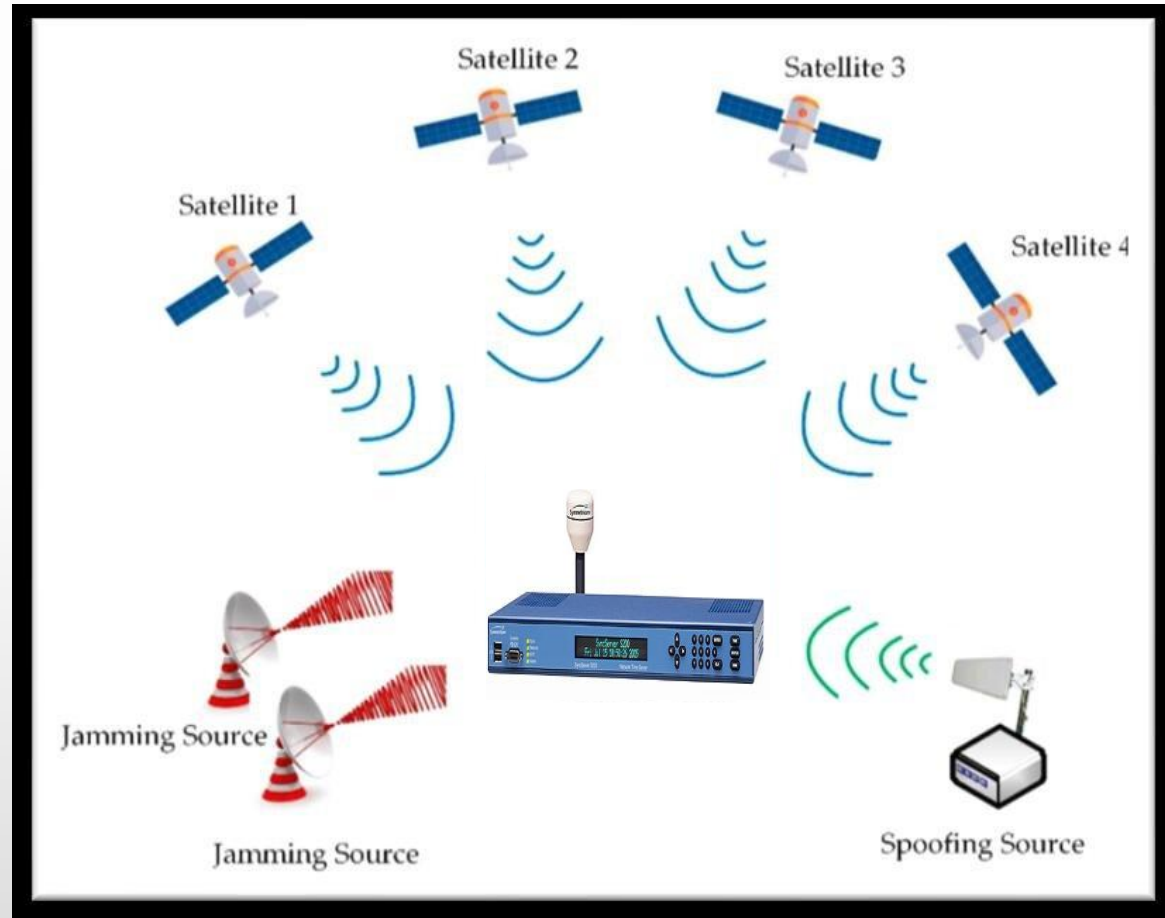
ICAO



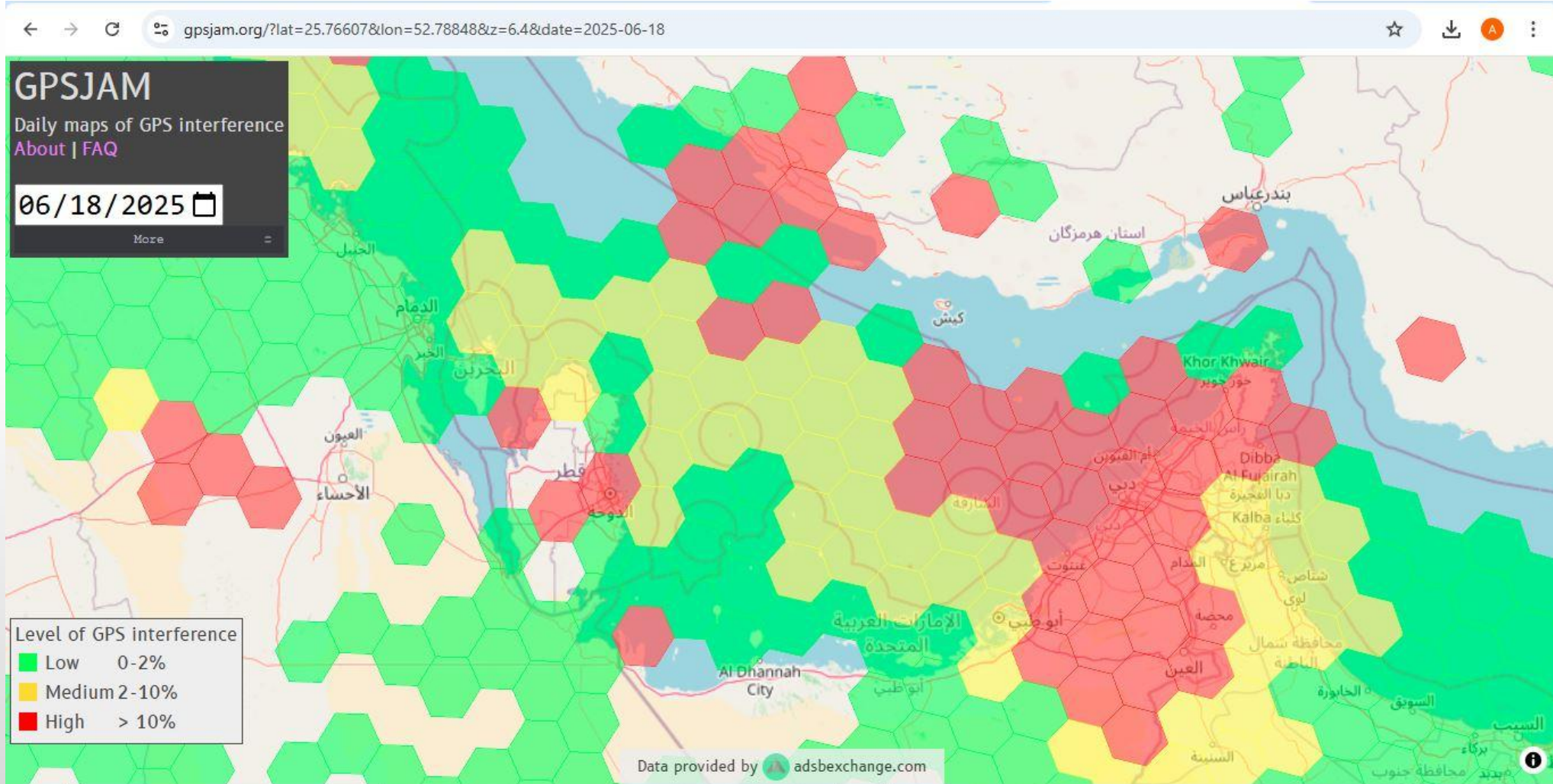
Summary Comparison

Aspect	GPS Jamming	GPS Spoofing
Definition	Blocking or overwhelming GPS signals	Sending fake GPS signals to mislead receivers
Objective	Deny GPS functionality (no signal, no data)	Deceive receiver with false position/time data
How it works	Emits noise/interference on GPS frequencies	Broadcasts counterfeit GPS signals mimicking satellites
Effect on GNSS	No GNSS fix or position	Wrong position, speed, or time shown
Detectability	Easily detectable (loss of signal)	Harder to detect (appears as a valid signal)

Overview of GNSS Jamming and Spoofing



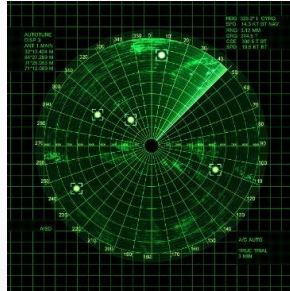
RECENT GPS JAMMING MAP



Global GNSS Constellations & Frequency

GNSS SATELITE	Country / Region	Constellation Name	Frequency Bands	Services
GPS	USA	NAVSTAR GPS	- L1 : 1575.42 MHz (C/A code, civilian) - L2 : 1227.60 MHz (military, L2C) - L5 : 1176.45 MHz (safety of life)	Civil, Military, Safety of Life
GLONASS	Russia	GLONASS	- L1 : 1602 MHz \pm FDMA offset (civilian) - L2 : 1246 MHz \pm offset - L3 : 1202.025 MHz (future)	Civil, Military
Galileo	European Union	Galileo	- E1 : 1575.42 MHz (civilian) - E5a : 1176.45 MHz (aviation) - E5b : 1207.14 MHz (open service) - E6 : 1278.75 MHz (commercial)	Open, Commercial, Encrypted
BeiDou	China	BeiDou Navigation System	- B1I : 1561.098 MHz - B1C : 1575.42 MHz - B2a : 1176.45 MHz - B2b : 1207.14 MHz - B3I : 1268.52 MHz	Civil, Military, Encrypted
NavIC	India	IRNSS / NavIC	- L5 : 1176.45 MHz - S-band : 2492.028 MHz (regional use)	Regional, Civil & Military
QZSS	Japan	QZSS	- L1 : 1575.42 MHz - L2C : 1227.60 MHz - L5 : 1176.45 MHz - L6 : 1278.75 MHz	Regional, augmentation of GPS

AVIATION'S GROWING DEPENDENCE ON GNSS



- Precise time sync: radar stations, ATC, airports.



- GNSS used in ADS-B, MLAT and navigation.



- UTM Server

- Even short outages can impact aviation safety.

CURRENT THREAT LANDSCAPE

- Increase in GPS jamming and spoofing incidents.

- Low-cost devices can disrupt civil aviation GNSS.

- Documented disruptions in Europe, Middle East, maritime zones.

RISKS IN QATAR'S AVIATION ECOSYSTEM

- Strategic location near conflict zones

- Exposure to maritime jamming threats.

- GNSS Dependency for ATC and future UTM systems.

**Ground based Monitoring & detection of GPS/GNSS
jamming/spoofing events**

&

**Protection of Critical CNS infrastructure from any GNSS
Jamming/interference threats.**

(Protect GNSS signals With Multi layer measures)

Protect GNSS signals With Multi layer measures

GNSS Resilience— Hardware Layer

Mitigation at the GNSS antenna side

- **Antenna Level (CRPA):** Controlled Reception Pattern Antenna (CRPA) units are the primary hardware defense. They use multiple antenna elements to create "nulls" in the direction of a jammer, effectively "turning off" reception from the interference source.

Mitigation at GNSS receiver side

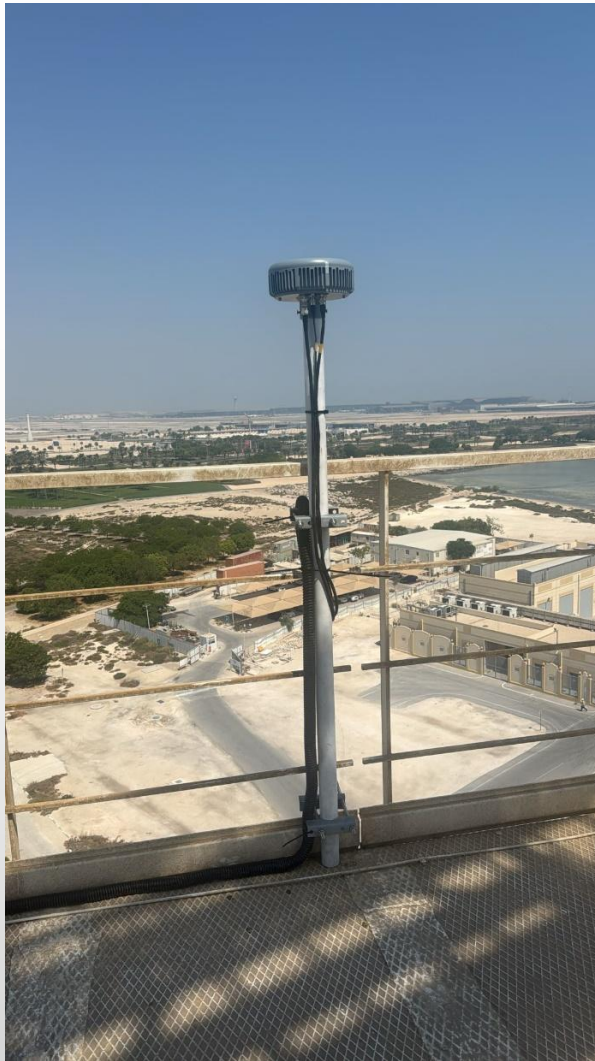
- **Multi-Constellation/Multiband GNSS receivers:** Modern GNSS receivers have the physical RF front-end capacity to track multiple satellite systems (GPS, Galileo, BeiDou, GLONASS) across several frequencies (L1, L2, L5).

GNSS Resilience – Software Layer

Signal Processing and Anti-Jamming & Anti-Spoofing Algorithms : Software filters, such as adaptive notch filters ,pulse blanking etc. to identify and excise specific types of jamming signals within the digital stream.

SITE PICTURES OF DEPLOYMENT IN QCAA CNS INFRASTRUCTURE

HMI pictures (no Jamming)



TUAL CRPA GUI

Settings | NMEA GPS Map | GNSS Satellites | GPS Resolution | TUAL GNSS PVT Map | NAV SAT | Version: 1.19.2

Ethernet Connection | IP: All CRPA | Start Dump | Stop Dump | Start Play | Stop Play

Serial Connection | Start Dump | Stop Dump

Serial Ports: Port Name: COM3 | Refresh Ports | Connect | Disconnect | Std | NMEA | Long

Network Interfaces: Realtek PCIe GbE Family Controller, Microsoft, Microsoft

Open | Not Listening

Jammer Suppression	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Suppr.	2	0	2	3	
Jammer Type	No Jammer	No Jammer	No Jammer	No Jammer	MHz
Diff Time	1,003	996	995	994	msec

CRPA Version: 1.1591.0.0.0
Status: No Error

Temperature: 27.2 °C

Position NMEA GGA / NAV PVT

Time		UTC
Latitude		°
Longitude		°
Alt. hMSL		m
Quality		

Jammer Level	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Antenna 1	-3	-4	-5	-5	
Antenna 2	-4	-5	-6	-5	
Antenna 3	-2	-5	-7	-1	
Antenna 4	-2	-5	-8	-1	

RSSI	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
RSSI 1	-93	-99	-99	-96	
RSSI 2	-95	-100	-101	-95	
RSSI 3	-93	-100	-102	-92	
RSSI 4	-93	-99	-103	-92	

Position Precision NMEA GSA

DOP: Fair, Moderate, Good, Excellent

101°F Sunny | Search | 12:49 PM 8/31/2025

HMI pictures (taken from 28th Feb 2026)

The screenshot displays the TUAL CRPA GUI interface. The top menu includes Settings, NMEA GPS Map, GNSS Satellites, GPS Resolution, TUAL GNSS PVT Map, and NAV SAT. The version is 1.20.2.

Ethernet Connection: IP: All CRPA. Buttons: Start Dump, Stop Dump, Start Play, Stop Play. Network Interfaces list includes rtpcap://\Device\NPF_{998E08DB-7205-4D38-A894-0534E8A1201B} and three Microsoft entries. An **Open** button is present, and the status is **Not Listening**.

Serial Connection: Serial Ports: Port Name COM3, Baud Rate 4,125,000 bps. Buttons: Refresh Ports, Connect, Disconnect. Receive options: Std (selected), NMEA, Long.

Jammer Suppression:

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Suppr.	8	2	6	8	
Jammer Type	Pulse %3 1563.5	Pulse %3 1237.4	No Jammer	Pulse %3 1563.2	MHz
Diff Time	972	1,019	988	1,004	msec

CRPA Version: 1.1591.0.0.0
Status: No Error

Temperature: 27.2 °C

Position NMEA GGA / NAV PVT:

Time	
Latitude	
Longitude	
Alt. hMSL	
Quality	

Jammer Level:

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Antenna 1	5	4	1	4	
Antenna 2	2	5	-1	6	
Antenna 3	8	0	0	4	
Antenna 4	2	4	-6	4	

RSSI:

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS
RSSI 1	-87	-91	-95	-87
RSSI 2	-89	-90	-96	-85
RSSI 3	-83	-95	-95	-88
RSSI 4	-89	-90	-100	-87

Position Precision NMEA GSA:

DOP	HDOP	PDOP	VDOP
Fair	~20	~20	~20
Moderate	~10	~10	~10
Good	~5	~5	~5
Excellent	~2	~2	~2

System tray: 78°F Sunny, Search, Windows icons, 1:42 PM 2/28/2026.

HMI pictures (taken from 28th Feb 2026)

The screenshot displays the TUAL CRPA GUI interface, which is used for monitoring and controlling GPS jammer suppression. The interface includes several panels and data displays:

- Settings and Connection:** Includes options for NMEA GPS Map, GNSS Satellites, GPS Resolution, TUAL GNSS PVT Map, and NAV SAT. It also shows Ethernet and Serial Connection settings.
- Network Interfaces:** Lists network interfaces, with the selected one being `ipcap://Device\NPF_{998E08DB-7205-4D38-A894-0534E8A1201B}`. A status bar indicates "Open" and "Not Listening".
- Jammer Suppression:** Displays suppression levels for different jammer types across four antennas.

Antenna	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Antenna 1	6	2	0	4	
Antenna 2	3	4	-1	7	
Antenna 3	9	1	-1	4	
Antenna 4	4	6	-6	4	
- Jammer Level:** Shows jammer levels for four antennas.

Antenna	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	dB
Antenna 1	6	2	0	4	
Antenna 2	3	4	-1	7	
Antenna 3	9	1	-1	4	
Antenna 4	4	6	-6	4	
- RSSI:** Shows Received Signal Strength Indication (RSSI) for four antennas.

RSSI	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS
RSSI 1	-85	-93	-95	-87
RSSI 2	-88	-91	-96	-84
RSSI 3	-82	-94	-95	-87
RSSI 4	-87	-90	-100	-86
- CRPA Version and Status:** Shows CRPA Version 1.1591.0.0.0 and Status "No Error".
- Temperature:** A vertical temperature gauge showing a reading of 27.2°C.
- Position NMEA GGA / NAV PVT:** Displays position data including Time, Latitude, Longitude, Alt. hMSL, and Quality.
- Position Precision NMEA GSA:** A graph showing DOP (Horizontal, Positioning, Vertical) values. The current DOP is 27.2, which is categorized as "Fair".

The Windows taskbar at the bottom shows the system time as 1:40 PM on 2/28/2026, with a weather forecast of 78°F Sunny.

HMI pictures (taken from 8th Mar 2026)

TUAL CRPA GUI (Version: 1.20.2)

Settings: NMEA GPS Map, GNSS Satellites, GPS Resolution, TUAL GNSS PVT Map, NAV SAT

Connection: Ethernet Connection (IP: All CRPA) | Serial Connection (Port: COM3, Baud Rate: 4,125,000 bps)

Network Interfaces: `rpcap://\Device\NPF_{998E08DB-7205-4D38-A894-0534E8A1201B}`

Serial Connection: Port Name: COM3, Baud Rate: 4,125,000 bps. Status: Not Listening.

Jammer Suppression

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	
Suppr.	15	4	14	16	dB
Jammer Type	Pulse %5 1563.8	Pulse %3 1238.4	Pulse %3 1603.5	Pulse %3 1574.0	MHz
Diff Time	1,007	973	990	988	msec

CRPA Version: 1.1591.0.0.0
Status: No Error

Temperature: 21.1 °C

Position NMEA GGA / NAV PVT

Time: 4:21 TC
Latitude: _____
Longitude: _____
Alt. hMSL: _____
Quality: _____

Jammer Level

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS	
Antenna 1	9	6	14	11	dB
Antenna 2	17	2	5	14	dB
Antenna 3	16	-2	3	15	dB
Antenna 4	8	2	-1	14	dB

RSSI

	GPS L1 BDS	L2 G2 Comb.	GL G1	GPS L1 BDS
RSSI 1	-81	-89	-80	-82
RSSI 2	-74	-93	-90	-76
RSSI 3	-75	-98	-91	-75
RSSI 4	-82	-93	-96	-78

Position Precision NMEA GSA

DOP: HDOP, PDOP, VDOP. Levels: Fair, Moderate, Good, Excellent.

System tray: 71°F, Light rain, Search, 9:41 AM, 3/8/2026

Protection against GNSS Resilience using CRPA

Controlled Reception Pattern Antenna (CRPA) technology is the "gold standard" for protecting GNSS signals by using spatial diversity to differentiate between real satellites and interference.

Unlike standard GNSS antennas which has a single antenna that receive signals from all directions, a CRPA works by using multiple small antenna elements together with a digital signal processor to electronically shape the antenna reception pattern and suppress interference/jammers while still receiving genuine GNSS satellite signals.

Main Purpose

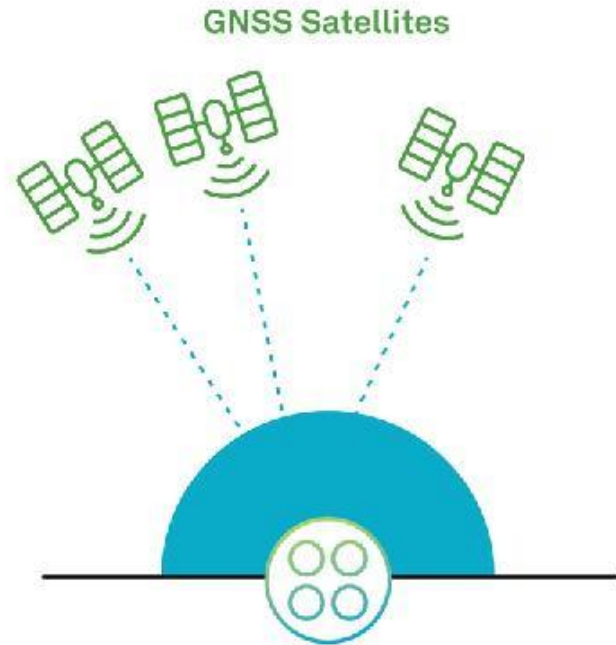
The unit protects critical GNSS-based systems by:

- Detecting interference sources
- Suppressing reception of interference signals
- Preserving authentic satellite signals
- Maintaining reliable Positioning, Navigation & Timing (PNT)

How CRPA Works

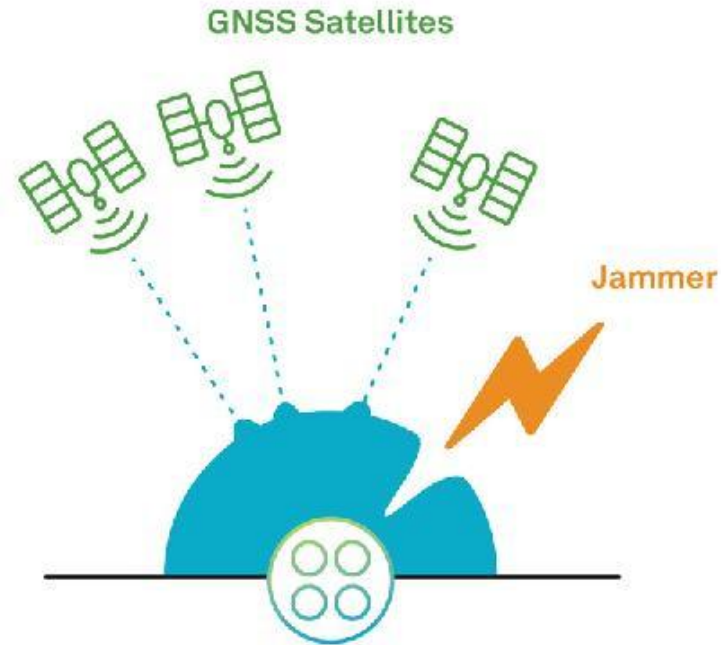
A CRPA system consists of a multi-element antenna array (typically 4 to 16 elements) and an antenna electronics (AE) unit. It uses two primary signal processing techniques

- ❖ **Null-Steering:** The system detects the direction of an interference source and electronically creates a "null" (a blind spot) in its reception pattern toward that specific direction. This can suppress jammers by **30–65 dB**.
- ❖ **Beamforming (Beam-Steering):** The system simultaneously amplifies the gain in the direction of legitimate satellites, increasing the signal-to-noise ratio to maintain a position lock even in high-interference environments



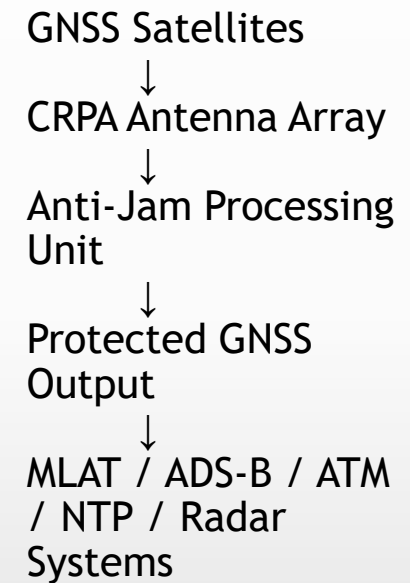
No Jammer

Near-hemispherical gain pattern of a CRPA antenna.



Jammer Attack

CRPA antenna forms a null in the direction of jammer and beams of gain are steered at satellites.



CRPA Elements	Approx Jammer Nulls
4-element	3 jammers
7-element	6 jammers
16-element	15 jammers

Key Benefits vs. Standard Antennas

- ❖ **Resilience:** It is significantly more effective than software-only filters because it blocks the interference physically before it enters the receiver.
- ❖ **Anti-Spoofing:** Because spoofers usually transmit multiple fake satellite signals from a single ground source, CRPA systems can detect this single-point origin and block the entire spoofing source.
- ❖ **Dynamic Adaptation:** The system constantly re-evaluates the signal environment, adjusting its nulls and beams in real-time as the aircraft or the jammer moves.

Main Components

1. CRPA Antenna

- Multi-element antenna array
- Receives GNSS signals from multiple directions
- Detects direction of interference

2. Anti-Jam Processor

- Core electronic unit performing:
- Adaptive beamforming
- Null steering
- Interference suppression
- Signal filtering algorithms

3. GNSS Receiver Interface

Provides protected GNSS signals to:

- MLAT sensors synchronization
- ADS-B systems
- Timing servers
- ATM systems
- NAVIGATION equipment
- Defence equipment

4. Monitoring & Control Interface

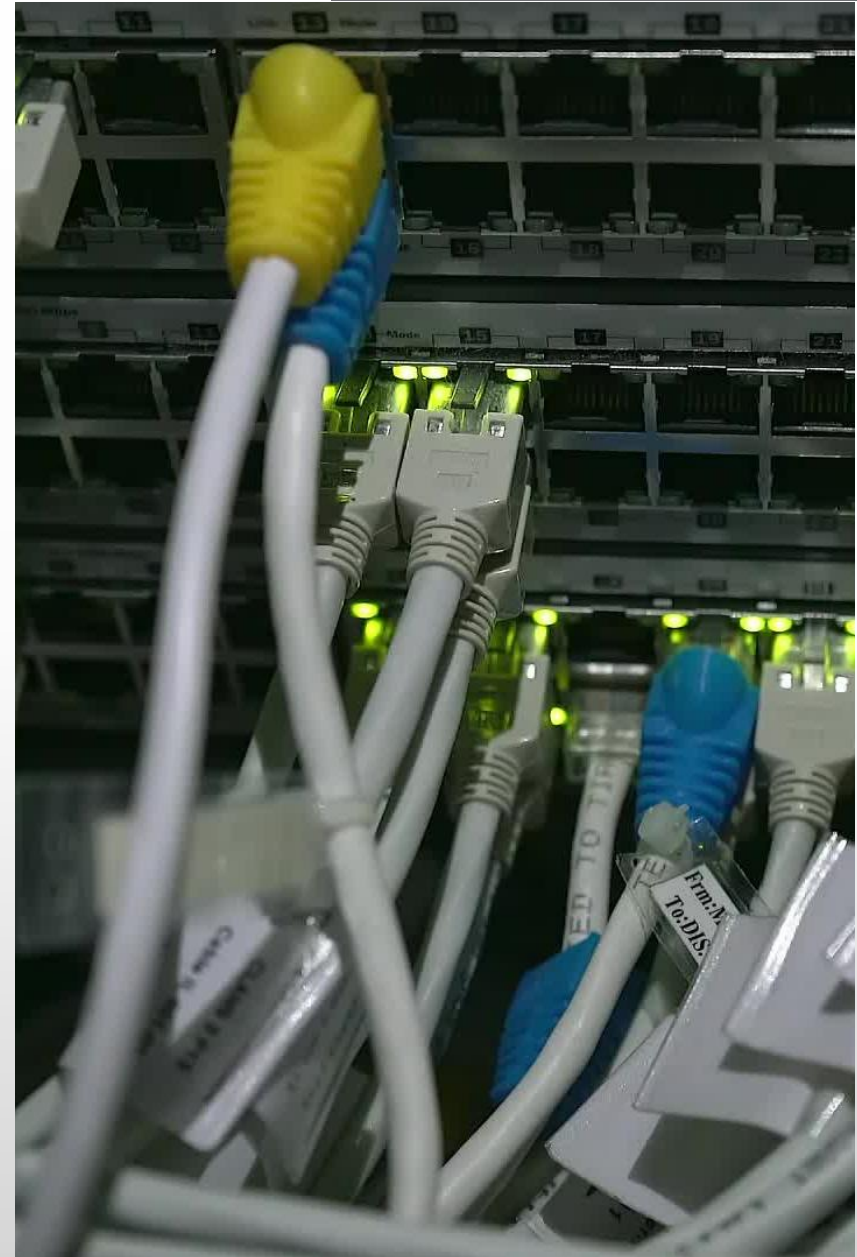
- Jam levels & alarms in multi bands & constellation
- RF monitoring
- System status
- Event logging
- Performance visualization

Key Functionalities

1. Anti-Jamming & spoofing (Adaptive Nulling & Beamforming)
2. Multi-Constellation Support & Multi-Frequency Support. It covers all constellations and its bands
3. Real-Time detailed Monitoring of RF interference in each bands/constellations and providing alarms

INTEGRATION WITH CNS SYSTEMS

- Compatible with ATC time servers, MLAT & ADS-B ground stations.
- Works with standard PTP/NTP infrastructure.
- Scalable for protection of other GNSS dependent navigation & surveillance equipment.





COUNTER-UNMANNED AIRCRAFT SYSTEMS (C-UAS)

Operational Framework for
Detection, Tracking, Identification & neutralization of micro to small
Unmanned Aerial Threats/Drones
in Airport environment



DETECTION



TRACKING



IDENTIFICATION



NEUTRALIZATION



ENHANCE AIRPORT
SAFETY & SECURITY



REAL-TIME SITUATIONAL
AWARENESS



RAPID RESPONSE
& MITIGATION



PROTECT PASSENGERS,
ASSETS & OPERATIONS

C-UAS

An adaptable system of integrated units for detection, tracking, identification and defeat of micro to small UAS's, that is controlled by a unified C2 System and operates in complicated environments, in all weather conditions, at all times of day.



End-to-End Solution

- Detection – The DTOA Sensors and Radar detect targets in bound
- Tracking– Once a target has been detected, the optical system can track the target
- Identification – After the target has been locked and tracked, the operator can change the identification of it in the C2
- Defeat– By decision of the operator, the RF Jammer disrupts the target and the threat is eliminated

System Components

Radar



Jammer



DTOA Sensor



EOS

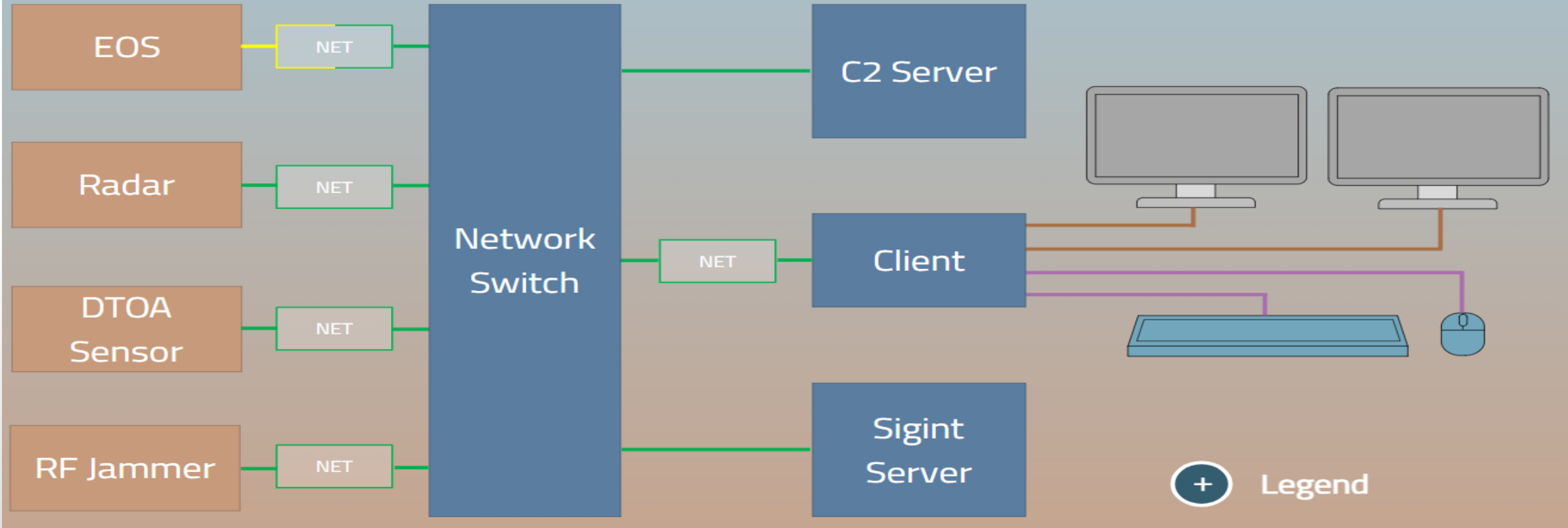


Command Area

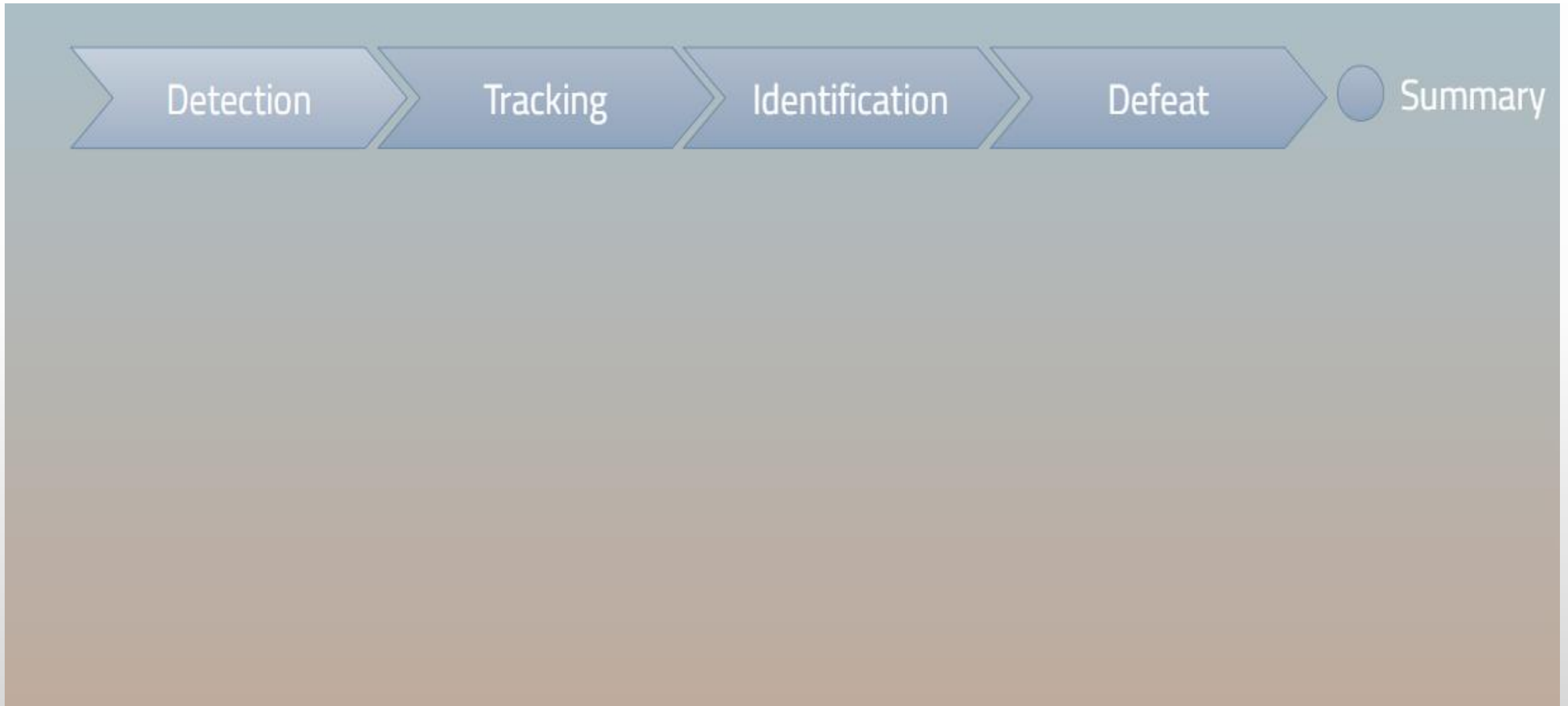


OPERATION PROCESS - EXPLAINED

Block Diagram



OPERATION PROCESS - EXPLAINED



OPERATION PROCESS - EXPLAINED

Detection

Tracking

Identification

Defeat

Summary

Detection & Scanning

- The DTOA Sensor scans, detects and analyzes use of wireless communications in the Defended Asset's vicinity and alerts the operator
- The Radar, at the same time, scans the area and detects all targets in its coverage range



OPERATION PROCESS - EXPLAINED

Detection

Tracking

Identification

Defeat

Summary

Tracking

- The C2 displays the targets on a tactical map
- By an operator choice, the is EOS enslaved to a target
- The C2 transfers target data to the EOS and redirects it to the target location
- Optical tracking is done manually once the operator locks the EOS on the target



OPERATION PROCESS - EXPLAINED



Identification

In the C2, the operator can provide a target with identification after he determined the threat level of it

OPERATION PROCESS - EXPLAINED

Detection

Tracking

Identification

Defeat

Summary

Defeat

- Jamming activation command is manually sent by the operator through the C2
- Disables the drone's communication with its controller and/or its GPS capabilities, essentially neutralizing the threat



Detection

Tracking

Identification

Defeat




Summary

Summary

- The C2 interfaces the sub-systems, assists in calibration and displays a deployment map
- The DTOA Sensors provide early alerts and, alongside the Radar, detects potential threats
- The EOS visually tracks the target
- The RF Jammer neutralizes the target





TOPIC	COVERAGE
Detection 1	Based on DToA (military combat proven) high end Rf Protocol type analyzer Cover more protocols than DJI and updated to new protocols frequently – cannot be bypassed range 3d location
Detection 2	High end RPS 82 Radar up to 7km detection for micro UAV
Detection 3	Combat proven High end optical large lens sensor (day and night)
Defeat neutralization	Combat proven Omni/directional Jammers , operator can choose if to block specific frequency, GNSS or communication only – or all together
C2	Web based, can be shared with cell phones or any other platform. Can accommodate Multiple sensors effectors and users!



LOCATION OF SENSORS AT HIA + DIA (GOOGLE EARTH IMAGE)



SUMMARY TABLE OF SENSORS AT HIA & DIA

ANTI DRONE SYSTEM - HIA/DIA					
SL. NO	NAME OF THE EQUIPMENT	TOTAL QUANTITY	INSTALLED LOCATION		FUNCTION
			HIA	DIA	
1	RF/SIGINT SENSOR	20	13	7	A DTOA SENSOR IS USED TO IDENTIFY UNAUTHORIZED FREQUENCIES AND TYPE OF OPERATION IN ITS VICINITY. DTOA SENSOR DETERMINES THE LOCATION OF A SIGNAL SOURCE (SUCH AS A DRONE OR ITS REMOTE CONTROLLER) BY MEASURING THE DIFFERENCE IN THE TIME IT TAKES FOR THE SAME RF SIGNAL TO REACH MULTIPLE SENSORS.
2	RADAR	2	1	1	RADAR, WHICH STANDS FOR RADIO DETECTION AND RANGING, IS AN OBJECT-DETECTION SYSTEM THAT USES RADIO WAVES TO DETERMINE THE RANGE, ANGLE, AND VELOCITY OF TARGETS. AT BOTH HIA AND DIA, ONE RADAR UNIT HAS BEEN INSTALLED AT EACH AIRPORT TO PROVIDE COMPREHENSIVE AIRSPACE COVERAGE AND CONTINUOUS MONITORING.
3	ELECTRO OPTICAL SENSOR	2	1	1	THE SYSTEM IS A MULTI-SENSOR SOLUTION ENABLING REAL-TIME, LONG-RANGE TARGET DETECTION AND IDENTIFICATION UNDER BOTH DAY AND NIGHT CONDITIONS. AT HIA AND DIA, ONE UNIT HAS BEEN INSTALLED AT EACH LOCATION TO PROVIDE CONTINUOUS AIRSPACE MONITORING AND SITUATIONAL AWARENESS.
4	JAMMER	4	2	2	THE JAMMING SYSTEM DISRUPTS SPECIFIC FREQUENCIES UNDER OPERATOR CONTROL VIA THE COMMAND AND CONTROL (C2) PLATFORM AND CAN SIMULTANEOUSLY BLOCK ALL PRE-DEFINED FREQUENCY BANDS. IT EMPLOYS TWO JAMMING TECHNIQUES—OMNIDIRECTIONAL AND DIRECTIONAL—TO EFFECTIVELY NEUTRALIZE THREATS. AT BOTH HIA AND DIA, TWO UNITS OF EACH TYPE HAVE BEEN DEPLOYED TO ENSURE COMPREHENSIVE COVERAGE.

COVERAGE DIAGRAM FOR HIA & DIA




HMI PICTURES OF HIA & DIA



HMI PICTURES OF HIA & DIA


MAINTENANCE

EOS 1 / 2




Active
Disconnected

JAMMER 3 / 4




Active
Not Active

RADAR 0 / 2




Not Active
Disconnected

SIGINT 17 / 20



Active
Semi Active
Disconnected

SYSTEM 12 / 12



Active

ALERTS

Time	Code	Source	Unit	Amount	Description
15:25 03.03.2026	JCU023	Jammer	Jammer Old Radar	999	Band 5750: TX power is below spec
15:25 03.03.2026	JCU027	Jammer	Jammer Old Radar	999	Band 5750: general failure
15:25 03.03.2026	SEN019	Sigint	ss_01_pole	999	Changed to ignore
15:25 03.03.2026	SEN019	Sigint	rct_b_tsu	999	Changed to ignore
15:25 03.03.2026	RAD024	Radar	RADAR	999	Communication with GPS receiver is down
15:25 03.03.2026	RAD025	Radar	RADAR	999	Excessive radar position and/or alignment deviation
15:25 03.03.2026	SYS008	System	Old_Radar_Tower_Radar	999	No Connection with Radar B sensor

CLEAR ALL

COMM. TO SERVICES - 11

- Data DB
- EOS Service
- External Api
- Jammer Service
- Logs DB
- Map Service
- Radar Type B Service
- SA Service
- Sigint Algorithm
- Sigint Service
- VOD

DISCONNECTED DEVICES (FOR THE LAST 1Y) - 3

Dev.	Name	Last Connection
	ss_04A	14:52 28.02.2026
	Old_Radar_Tower_Radar	01:07 09.02.2026
	VCU	17:13 17.02.2026

COMPONENTS OUT OF SYNC

Sev.	Name	Delay (ms)
------	------	------------

Radar – Target Detection

- Detects, classifies and tracks aerial objects
- Features MHR technology using Track-While-Scan (TWS)
- Provides velocity, direction and altitude of detected tracks
- Performs target initial classification supporting micro-doppler



7 KM

UAS DETECTION
RANGE

3.3-3.4 GHz

FREQUENCY
RANGE

4000 W

MAX POWER
CONSUMPTION

DTOA Sensor

- A radio frequency receiver that monitors and analyzes frequencies within a sector of 360°
- Based on differential time of arrival technology that enables pinpointing targets location according to time calculations

70Mhz-6Ghz
FREQUENCIES
RANGE

360°
AZIMUTH
RANGE



EOS – Tracking and Classification

- Electro Optic-Sensor – enables real-time long range, day/night target identification
- Enables target investigation, optical tracking
- Power and video conversions are performed using a Front Converter Box (FCB)
- Consists of two sensors: **CCD & FLIR**

360°

AZIMUTH
RANGE

1 rad/sec

TURNING
SPEED

-10°-(+70°)

ELEVATION
RANGE



RF Jammer

- Enables soft neutralization of the threat
- Transmits a blocking signal at the relevant frequencies
- Selection between directional or omni jamming
- 5 Jamming frequencies:
 - 433 Mhz
 - 900 Mhz
 - 1.6 Ghz – GPS
 - 2.4 Ghz
 - 5.8 Ghz



ENHANCED FLIGHT PLANNING:

Implementation of eFPL within
the FF-ICE Framework for
Collaborative ATM Operations



IMPROVED
COLLABORATION



GREATER
EFFICIENCY



ENHANCED
SAFETY



FUTURE-READY
ATM

QCAA AIM AND FLIGHT DATA MANAGEMENT

Capabilities



Highlights

SWIM connectivity

- Data set distribution
- EAD interface

Digital NOTAM

- Data originator portal
- Compliant with digital NOTAM event specification
- Distribution via SWIM

AIM data management

- AIXM 5 based
- Data set production

Initial flight processing

- 4D trajectory modelling using BADA 3 data
- AIXM 5 data driven validation
- FPL2012 baseline, eFPL upgrade planned

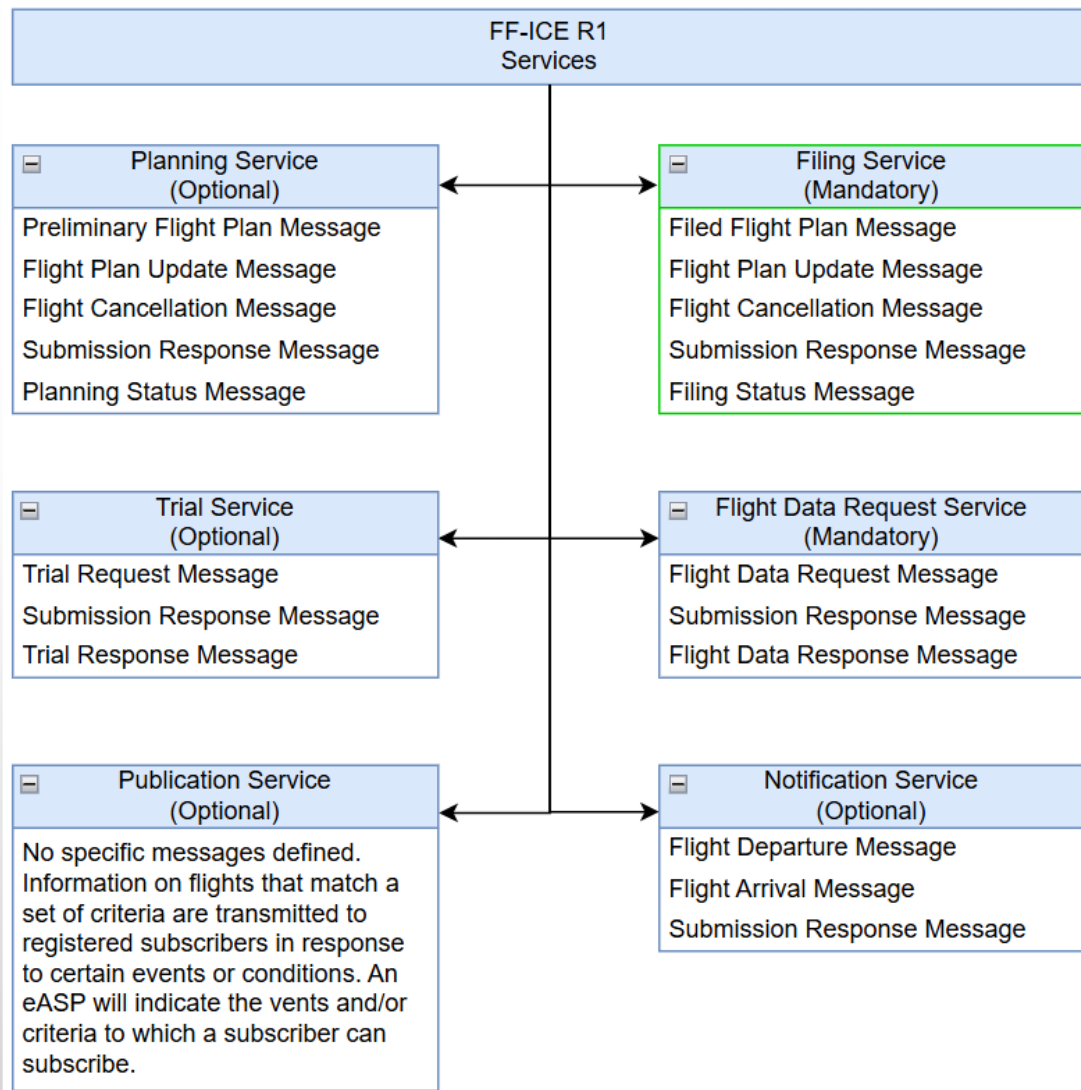
eFPL IMPLEMENTATION IN QCAA AIM INFRASTRUCTURE

- We are currently working on the extension of the existing AIM system of QCAA to support Enhanced Flight Plan (eFPL) operations based on the Flight and Flow Information for a Collaborative Environment (ICAO FF-ICE/R1) concept, through a phased implementation approach.
- eFPL transforms the traditional static flight plan messaging model into a rich, collaborative, and service-oriented digital information exchange framework, enabling more efficient, flexible, and future-ready ATM operations.

FPL2012 = Traditional ATM flight plan messaging

eFPL = Next-generation digital collaborative flight planning within SWIM/FF-ICE architecture

eFPL IMPLEMENTATION IN QCAA AIM INFRASTRUCTURE



What is eFPL?

eFPL is part of the:

- FF-ICE framework
- SWIM-based digital ATM ecosystem

It uses:

- FIXM data model
- Web services/API architecture
- Rich structured data exchange
- Instead of simple text messages as in FPL2012, eFPL contains:
 - Detailed trajectory information
 - Operational intent
 - Collaborative flow information
 - Extended metadata

Aspect	eFPL (Enhanced Flight Plan)	FPL2012
Full Form	Enhanced Flight Plan	ICAO Flight Plan 2012
Framework	FF-ICE (Flight & Flow Information for a Collaborative Environment)	Traditional ICAO flight plan format
Communication Method	SWIM/API-based digital services	AFTN/AMHS message-based
Data Format	Structured digital data (FIXM/XML/JSON)	Fixed text message format
Information Richness	Rich and extensible data model	Limited predefined fields
Trajectory Information	Supports 4D trajectory information	Limited trajectory representation
Collaboration	Enables collaborative ATM operations	Mainly point-to-point filing
Flexibility	Highly extensible and scalable	Rigid message structure
Real-Time Updates	Dynamic service-based updates	Static message exchange
Validation	Advanced digital validation	Traditional syntax validation
Interoperability	SWIM-compliant interoperability	Legacy ATS interoperability
Future Readiness	Designed for future ATM modernization	Legacy operational standard
Data Exchange	Service-oriented architecture (SOA)	Message routing architecture
Integration Capability	Easy integration with ATFM/DCB/UTM/SWIM	Limited integration capability
Human Readability	Primarily machine-readable	Human-readable ATS message
Underlying Standard	FIXM + FF-ICE	ICAO Doc 4444 FPL2012

MAIN OPERATIONAL ADVANTAGES OF eFPL

1. RICHER FLIGHT INFORMATION

eFPL can include:

- 4D trajectories
- Dynamic operational constraints
- Flow management information
- Collaborative decision-making data
- FPL2012 is limited to fixed ATS fields.

2. BETTER ATM COLLABORATION

eFPL supports:

- Airlines
- ANSPs
- Eurocontrol
- ATFM systems
- SWIM services

All exchanging synchronized digital information.

3. DYNAMIC UPDATES

eFPL supports:

- Filing updates
- Status tracking
- Interactive acknowledgements
- Real-time responses
- instead of simple static message transmission.

4. FUTURE ATM READINESS

eFPL is designed for:

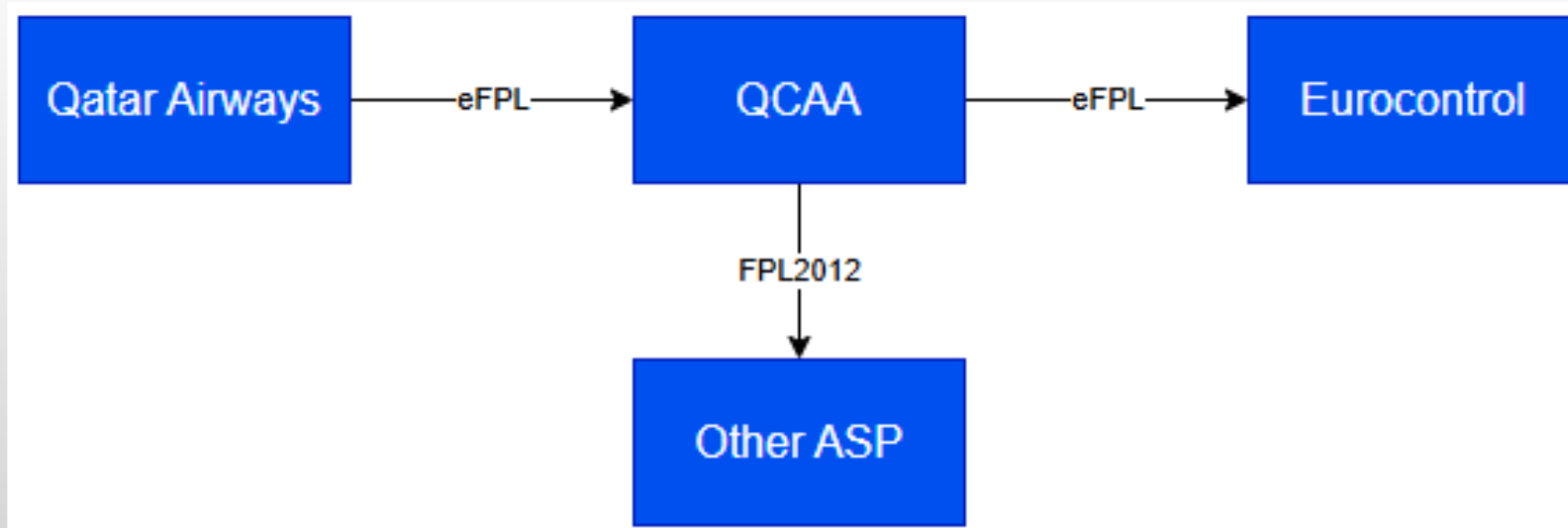
- Trajectory-Based Operations (TBO)
- SWIM
- Digital ATM
- Collaborative ATM
- AI/automation-enabled ATM

OBJECTIVES PLANNED IN PHASE 1 APPROACH;

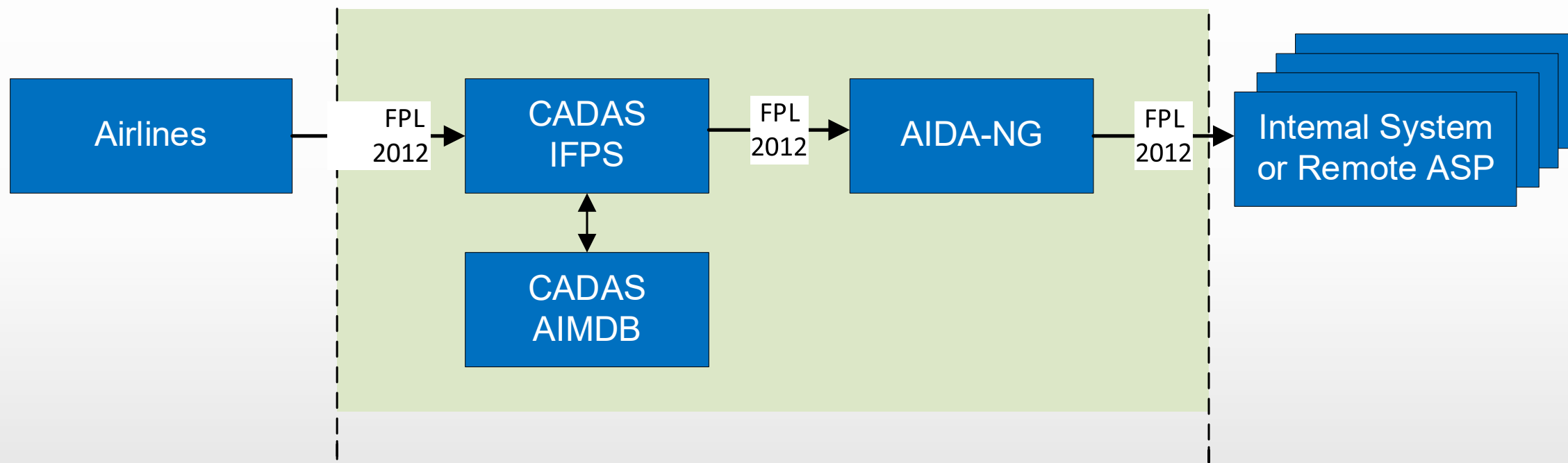
- Enable QCAA to receive flight plans as FF-ICE/R1 compliant eFPL messages from Qatar Airways for Europe destination

Note: all other AUs shall continue to send the flight plans as FPL2012

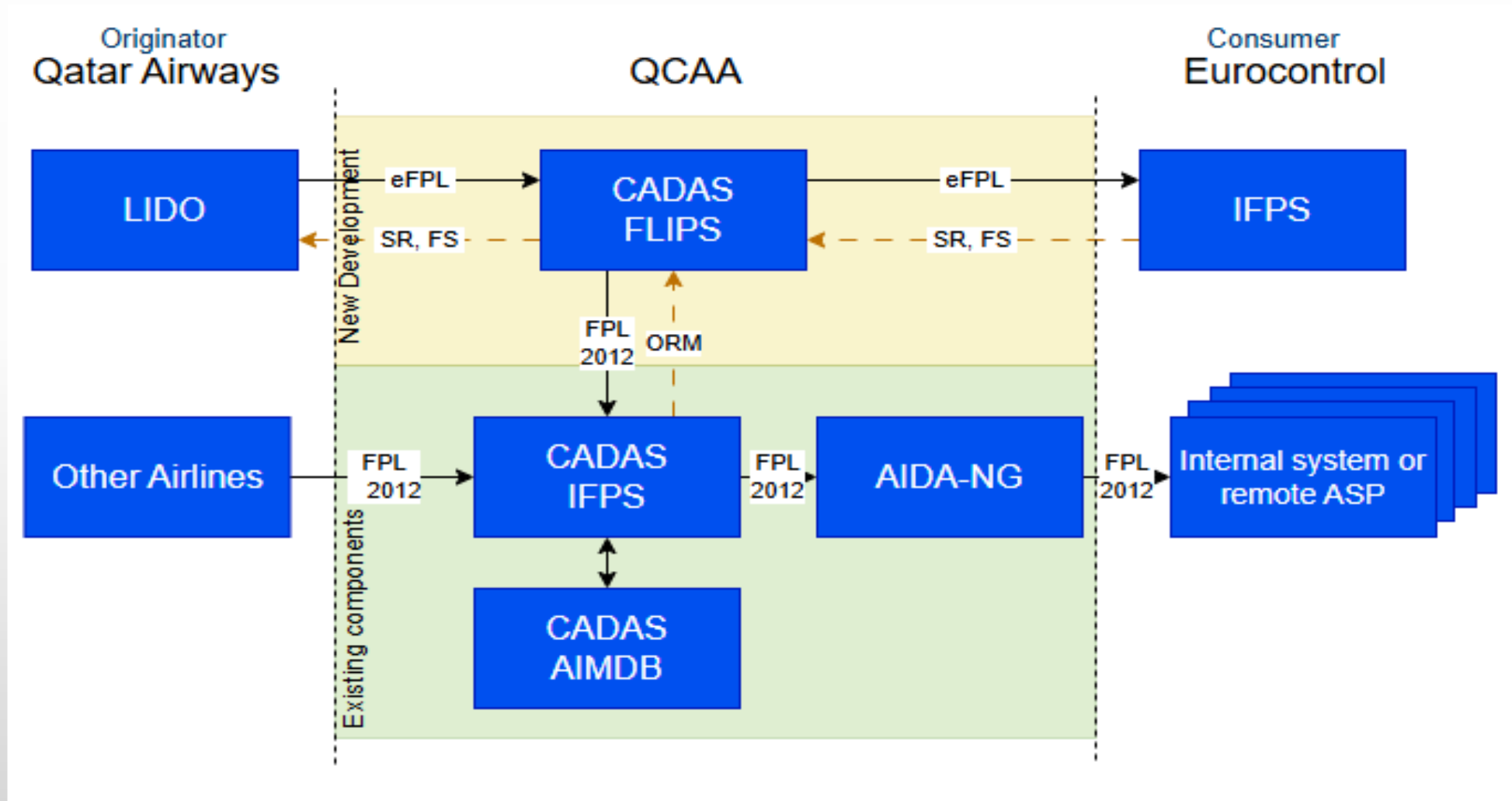
- After validations of received eFPLs from Qatar airways , eFPL for flights to Europe shall be distributed to Eurocontrol's IFPS
- The distribution to all other ASPs (not supported with FF-ICE/SWIM services) shall be as conventional AFTN formatted FPL2012 via AMHS/AFTN network . CADAS converts the eFPL to FPL2012 for distribution to other ASPs
- The FPL originator, Qatar Airways, will receive the appropriate FF-ICE response messages to their filing request sent to CADAS-FLIPS.



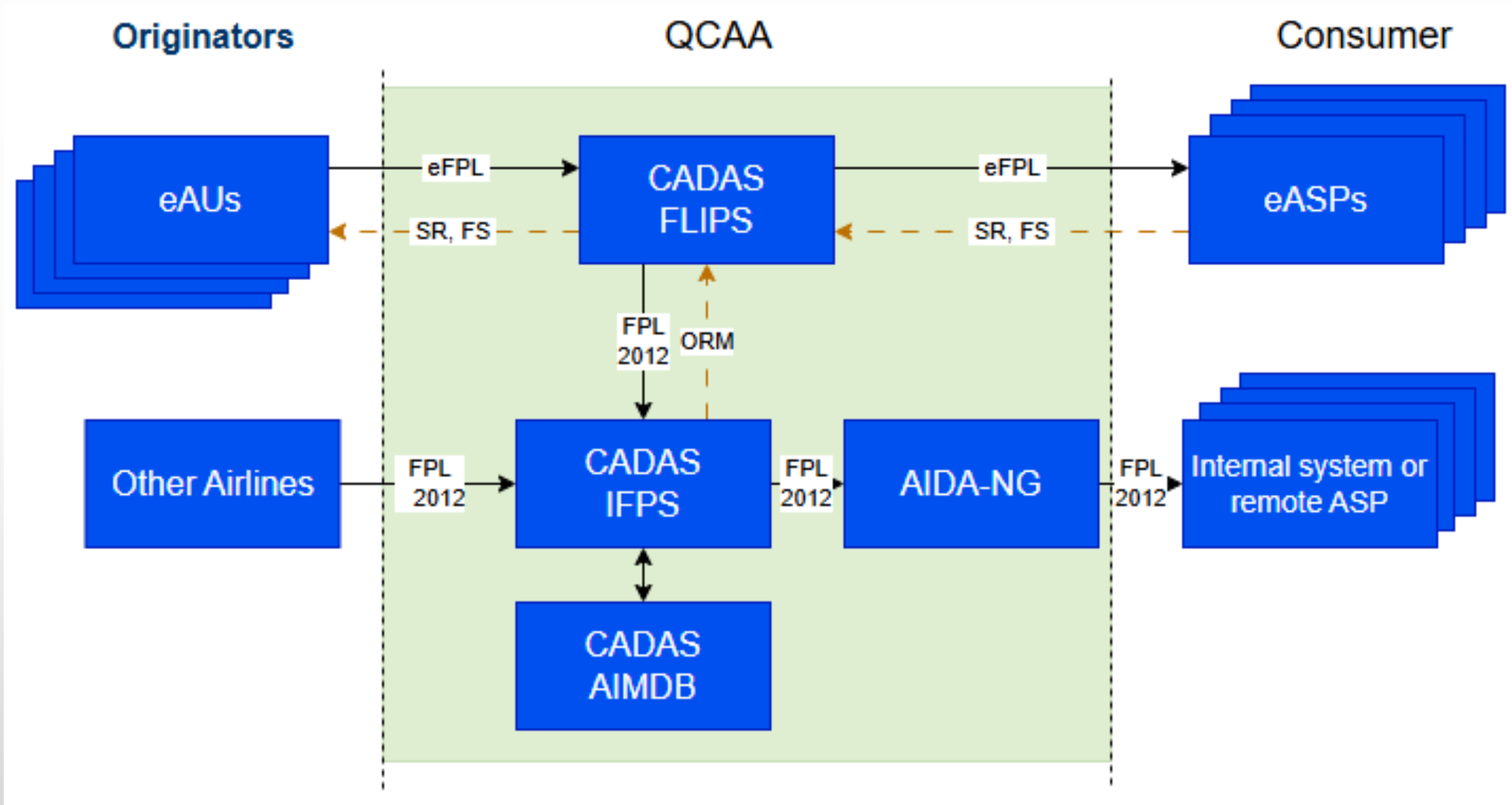
CURRENT SETUP WITHOUT FF/ICE eFPL IMPLEMENTATION



NEW SETUP AFTER FF/ICE eFPL IMPLEMENTATION



FUTURE EXTENSIBILITY / SCALABILITY



FUTURE EXTENSIBILITY / SCALABILITY

- This phased implementation is focused on enabling FF-ICE/R1 compliant eFPL information exchange between Qatar Airways, Qatar Civil Aviation Authority, and EUROCONTROL.
- As the regional SWIM network has not yet been established, data exchange with remote Air Navigation Service Providers (ANSPs) who are not SWIM enabled to be conducted through conventional AFTN/AMHS messaging mechanisms.
- However, the proposed eFPL solution is designed with scalability and future interoperability in mind, making it well suited to support additional eFPL connections in the future. Once the regional SWIM network becomes available, remote connections can be progressively migrated from AFTN/AMHS to fully SWIM-based eFPL information exchange.



ADVANCED ATC COMMUNICATIONS

Next-Generation Voice Communication System (VCS X10) - Architecture and Operational Capabilities

INTRODUCTION

- ❑ QCAA is in the process of implementing the innovative, service-oriented Frequentis X10 Voice Communication System (VCS) at Qatar Air traffic control center (QATCC) for the ACC & Approach ATC control positions setting a benchmark for modernisation and efficiency in communication infrastructure and ensuring robust & reliable communication for air traffic controllers.
- ❑ The X10 system also supports future scalability, aligning with QCAA long-term goals for digital transformation in air traffic management.
 - **MAIN VCS WITH HMIS FOR ATCOS IN THE QATCC CONTROL ROOM.**
 - **BACKUP VCCS WITH CONNECTIVITY TO THE ATCO HMIS IN THE QATCC**

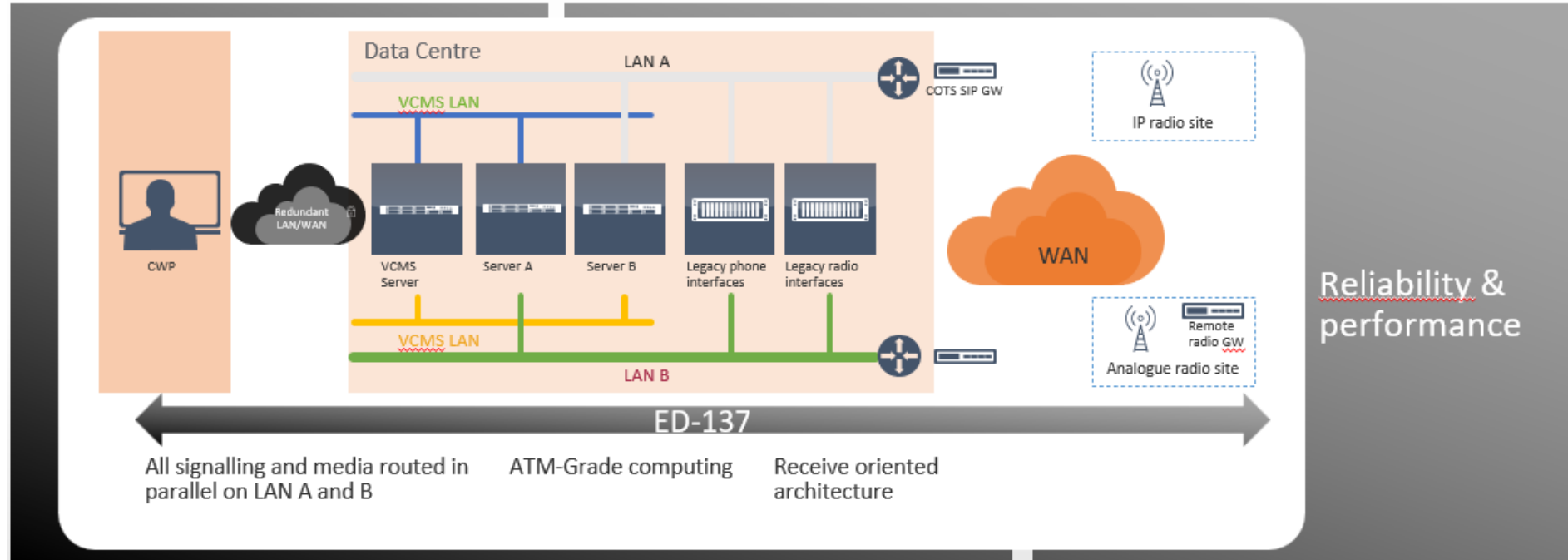
KEY FEATURES/BENEFITS OF X10 VCS

- **Completely software Service-oriented solution deployed on IT COTS hardware** : Designed for maximum interoperability, X10 supports deployment on customer-supplied COTS hardware or
- **Seamless switchover between Main & Backup X10 VCS system from the CWP** : With integrated support for dual operations, ATC communication can be mirrored in real time between main and backup systems, ensuring continuous availability.
- **Controller-centric HMI** : It offers flexible layout configurations, dark/light modes, and gesture-based controls while retaining familiar workflows, making the transition from older systems seamless and training-light.
- **Simplified system maintenance & updates** : Through X10 microservices architecture, Operators can deploy new features or security patches at container level via a secure browser interface, reducing system downtime and IT overhead.

- **Evergreen lifecycle** : Since the X10 VCS is deployed on IT COTS hardware and avoiding any proprietary hardware's, system has got evergreen life cycle support
- **Easy Integration with external systems** : Building on the power of the Frequentis MosaiX platform, the X10 streamlines integration with existing ATM systems and ensures readiness for future concepts like sector less flight, UTM integration, and dynamic airspace management.
- **Multi-Level redundancy** : It supports geographically redundant data centres, dual-path audio, and role-based resource sharing, giving air traffic controllers instant access to backup systems, even on the same screen.
- **ATM grade cyber security** : The platform supports encrypted IP communication, hardened software containers, and strict access control, all tailored to air traffic management environments. When combined with the Frequentis SBC, its unique security capabilities deliver an unparalleled level of protection.

SYSTEM OVERVIEW

DISTRIBUTED INTELLIGENCE AND PARALLEL OPERATING FOR UNRIVALLED RESILIENCE, RELIABILITY and safety

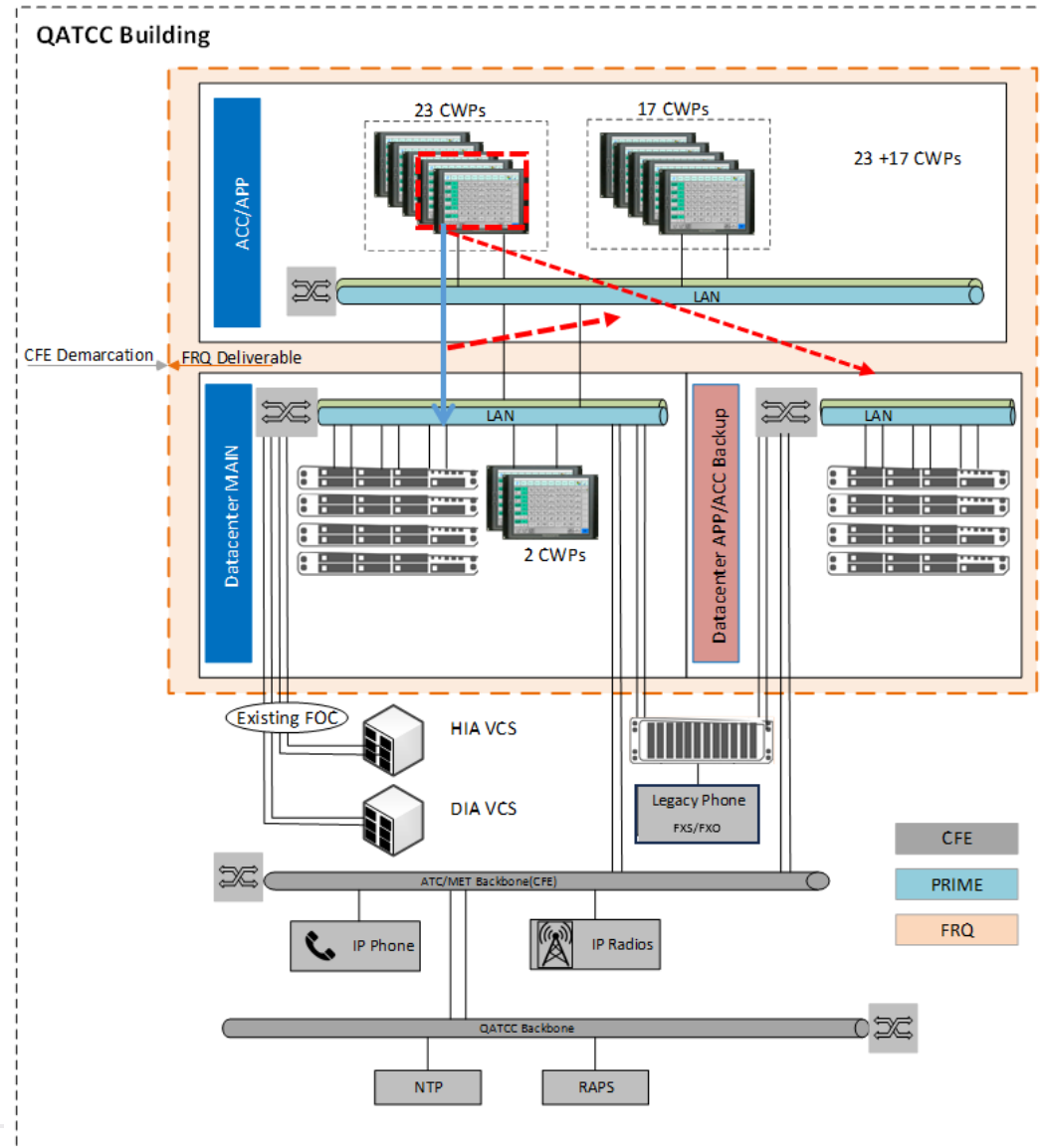


Both systems run continuously with equal priority

Faults in peripherals not affecting other system parts

Simple Network separation by duplication of audio

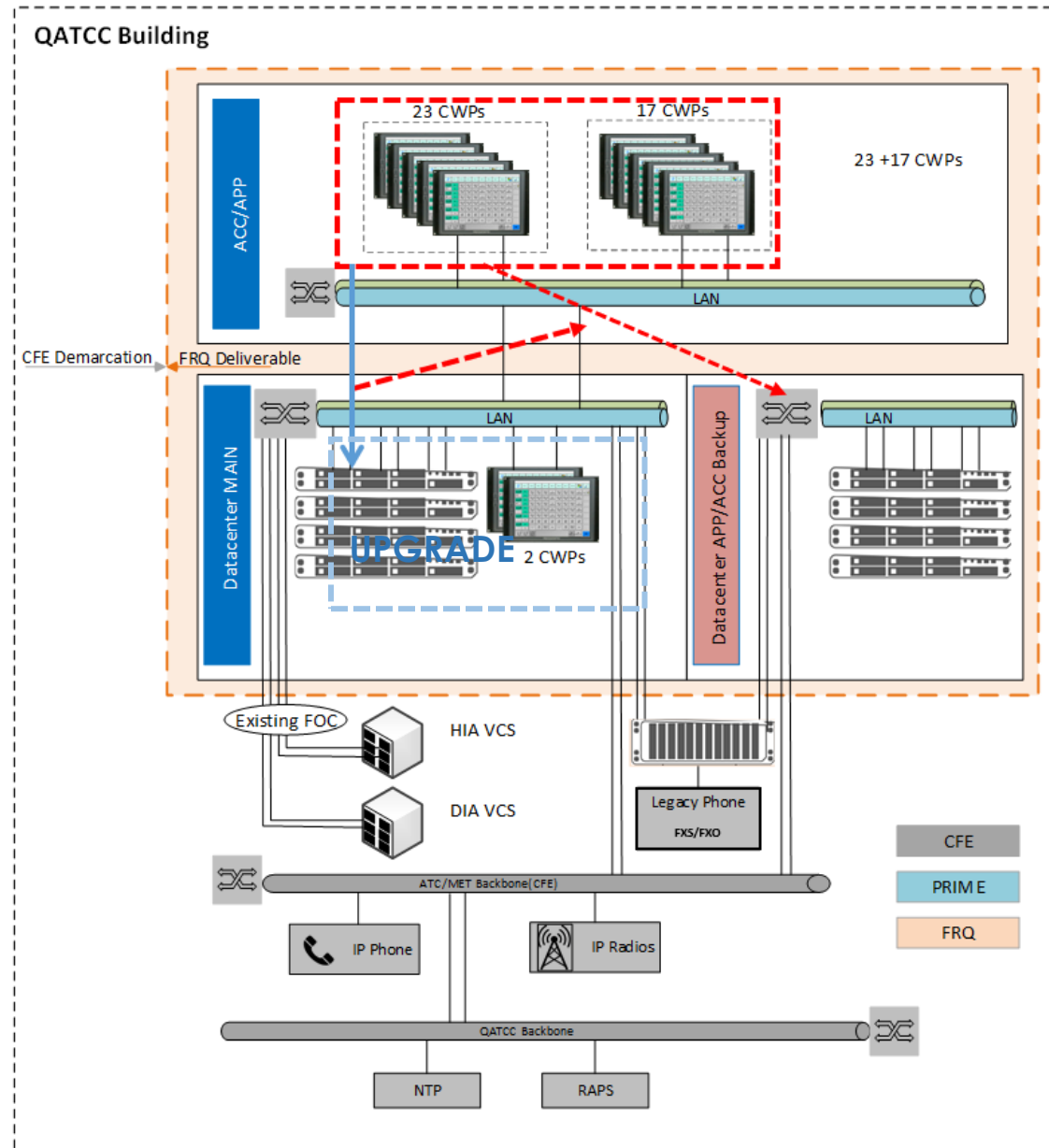
REDUNDANT SYSTEM ARCHITECTURE



REDUNDANT SYSTEM ARCHITECTURE

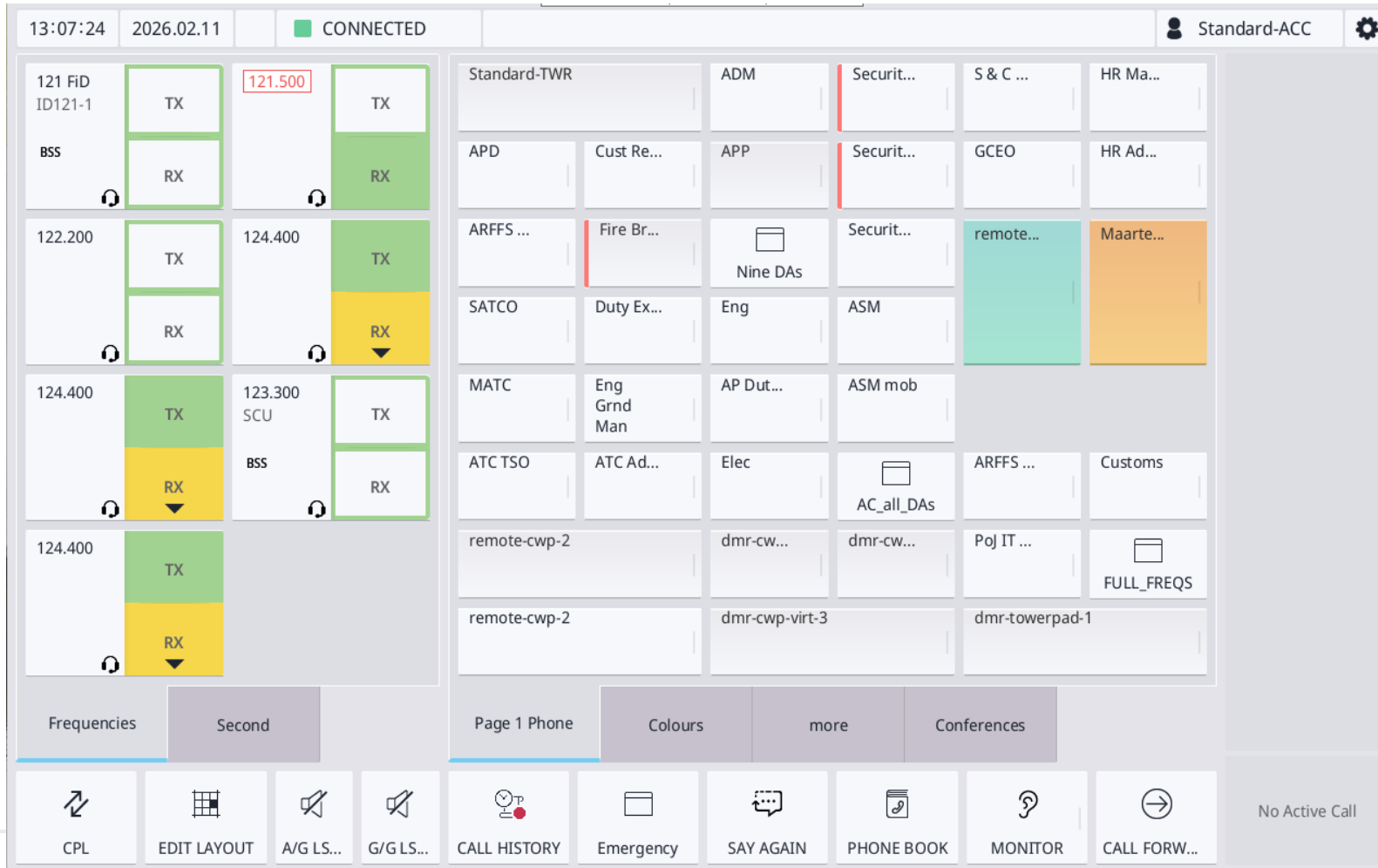
Use Case : System Upgrade (No outage)

- Complete Operational Switchover from Main to Ultimate Contingency Datacentre
- Upgrade of Main Datacentre
- Switchback to Main Datacentre
- Upgrade Ultimate Datacentre
- **No Operational Outage during Upgrades**



NEW CONTROLLER USER EXPERIENCE

- Designed with controllers to use gestures and context sensitivity



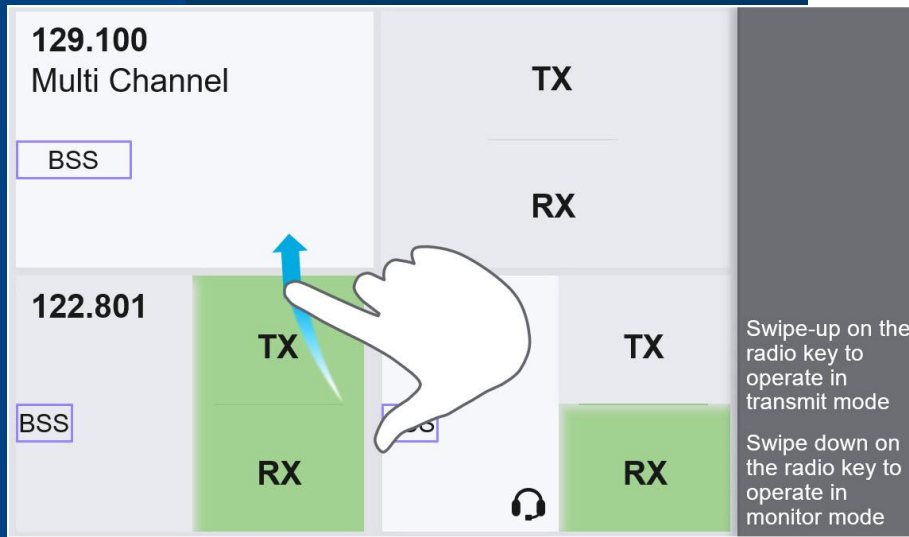
The screenshot displays a sophisticated ATC communication interface. At the top, a status bar shows the time (13:07:24), date (2026.02.11), connection status (CONNECTED), and user profile (Standard-ACC). The main workspace is a grid of buttons for various frequencies and call types, such as '121 FID ID121-1', 'BSS', '122.200', '124.400', '124.400', '123.300 SCU', and '124.400'. Each button includes TX (Transmit) and RX (Receive) indicators. A secondary grid on the right contains functional buttons like 'Standard-TWR', 'ADM', 'Securit...', 'S & C ...', 'HR Ma...', 'APD', 'Cust Re...', 'APP', 'Securit...', 'GCEO', 'HR Ad...', 'ARFFS ...', 'Fire Br...', 'Nine DAs', 'remote...', 'Maarte...', 'SATCO', 'Duty Ex...', 'Eng', 'ASM', 'MATC', 'Eng Grnd Man', 'AP Dut...', 'ASM mob', 'ATC TSO', 'ATC Ad...', 'Elec', 'AC_all_DAs', 'ARFFS ...', 'Customs', 'remote-cwp-2', 'dmr-cw...', 'dmr-cw...', 'PoJ IT ...', 'FULL_FREQS', 'remote-cwp-2', 'dmr-cwp-virt-3', and 'dmr-towerpad-1'. A bottom navigation bar features icons for 'CPL', 'EDIT LAYOUT', 'A/G LS...', 'G/G LS...', 'CALL HISTORY', 'Emergency', 'SAY AGAIN', 'PHONE BOOK', 'MONITOR', and 'CALL FORW...'. A 'No Active Call' indicator is present on the right side.



FOLLOW YOUR DEMAND - GESTURE CONTROL

CONTROLLER HMI

WITH INTUITIVE GESTURE CONTROLS

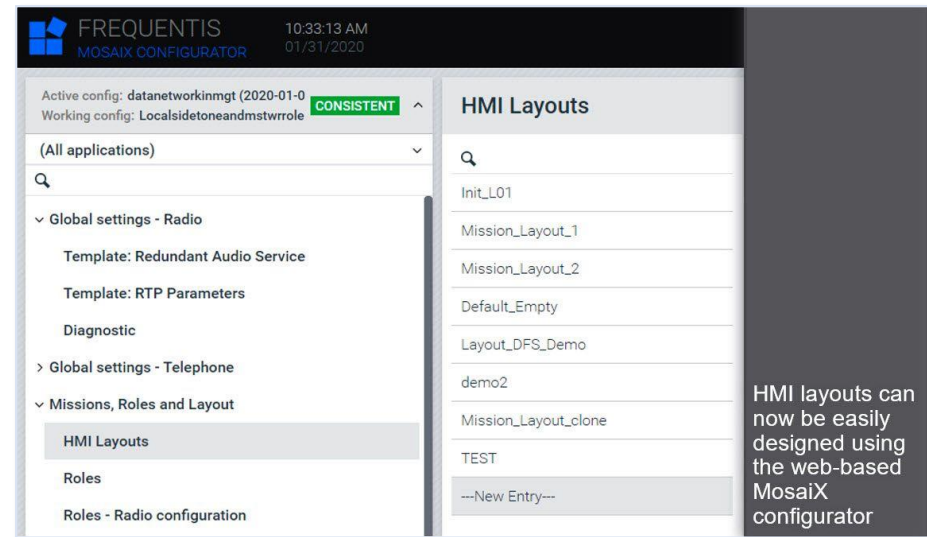


- Transmit & monitor mode
- Context sensitive menu normal call
- Context sensitive menu on-going call
- Customisable pop-up windows
- Checklists / emergency procedures

WEB-BASED GUI TOOL

DESIGN YOUR OWN HMI USING A WEB-BASED GUI

THE WORLDS MOST FLEXIBLE VCS-HMI CONFIGURATION



- MosaiX configurator
- Widget & grid design
- Drag & drop
- Drag & drop - functions menu
- Sub-grids & clones
- Result

NEW CONTROLLER USER EXPERIENCE

- Free Button Placement and Different Colour Schemes

The screenshot displays a user interface for ATC communications. At the top, a status bar shows the time (13:08:23), date (2026.02.11), connection status (CONNECTED), and user profile (Standard-ACC). The main area is a grid of buttons for different services and frequencies, such as APP, ARFFS, LIS Split, LIS One, Eng, Duty Ex..., Rest Ro..., dmr-cwp-3, Duty Ex..., LIS One, Police, CHRIS9, GCEO, MATC, Customs, ATC Lo..., remote-cwp-2, remote-cwp-1, APD, dmr-cwp-virt-3, ARFFS ..., GCEO, Fire Br..., Eng, Standard-TWR, and GCEO. The buttons are color-coded and arranged in a flexible layout. At the bottom, a navigation bar includes icons for CPL, EDIT LAYOUT, A/G LS..., G/G LS..., CALL HISTORY, Emergency, SAY AGAIN, PHONE BOOK, MONITOR, and CALL FORW... A 'No Active Call' indicator is visible on the right side.

[preliminary information]

User-centric design



For exceptional user experience

ACC

COLOR

TOWER

LSP SELECTION

EMERGENCY

SPLIT

15:17:31 | CONNECTED | 1 / 1 | cwp-srs-4 | PDM-GUI-ACC

118.000 APP BSS	TX RX	122.800 BSS	TX RX	123.700 BSS	TX RX	Ramona	Hutchinson	Wilder	
123.700 BSS	TX RX	118.000 APP BSS	TX RX	122.800 BSS	TX RX	Hunter	Reyes	Valeria	
129.100 Multi Cha... BSS	TX -5kHz RX -5kHz	TX RX	TX RX	118.000 APP BSS	TX RX	Esperanza	Dillard	Toni	
118.000 APP BSS	TX RX	122.800 BSS	TX RX	129.100 Multi Cha... BSS	TX RX	Craig	Madden	Mann	
						Foley	Le...	Kelly	Shelley
						Bullock	Barr	Buckley	
						Felicia	M...	cw...	Henson
						cwp-srs-1	cwp-srs-2	cwp-srs-3	

RADIOS | Backup | DIRECT ACCESS | Support | Procedures | PDM_role_TWR

CPL | Edit | AG LSP 1 off | GG LSP 1 off | LSP | Replay | Monitoring | Phone Book | Call history

FREQUENTIS

Surveillance Infrastructure Performance:

Spotlight on Integrated MLAT/ADS-B Surveillance full Coverage at HIA and DIA Airports



MLAT



ADS-B



HIA

Hamad International Airport
Doha



DIA

Doha International Airport
Doha



FULL
COVERAGE



SAFETY
ENHANCEMENT



PERFORMANCE
OPTIMIZATION



INTEGRATION
READY



COLLABORATION
DRIVEN



FUTURE
READY



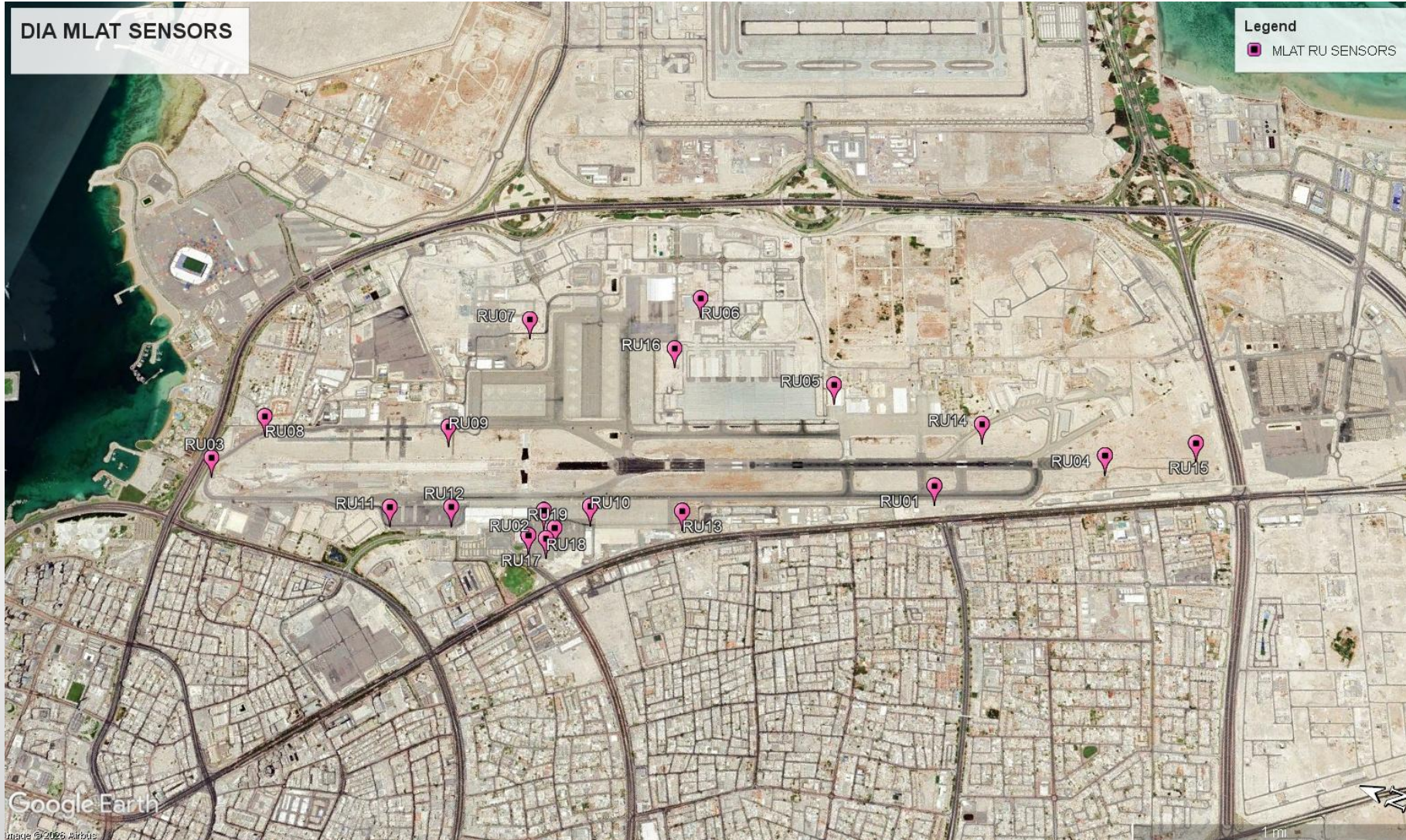
INTRODUCTION

- Multilateration system plays a vital part in HIA's Air traffic and Surface movement operations with most expanded coverage throughout HIA and DIA Airports.
- A total of 56 MLAT Sensors at HIA which make it as the single airport having largest number of eMLAT Sensors in the Middle East region and also 19 MLAT sensors in DIA contribute a major role in safe movements and setting a new standard to enhance aircraft and passenger safety.
- Saab Sensis MLAT System is an airport surface cooperative surveillance system consist of a central processing system and distributed set of ground sensors which provides accurate and reliable detection and tracking of Aircrafts and ground vehicles.
- The system is designed to provide surveillance of Mode S, Mode A, mode C and ADSB aircraft on the airport surface or on the final approach complying with the operational requirement of Qatar Civil Aviation authority to have 7.5m plot accuracy everywhere inside the runways and taxiways and 12meter plot accuracy at apron and stand area.

LOCATION OF MLAT SENSORS AT HIA (GOOGLE EARTH IMAGE)



LOCATION OF MLAT SENSORS AT DIA (GOOGLE EARTH IMAGE)



LOCATION OF MLAT SENSORS AT HIA + DIA (VIDEO)



7.5 M MLAT COVERAGE DIAGRAM AT HIA AIRPORT



12 M MLAT COVERAGE DIAGRAM AT HIA AIRPORT



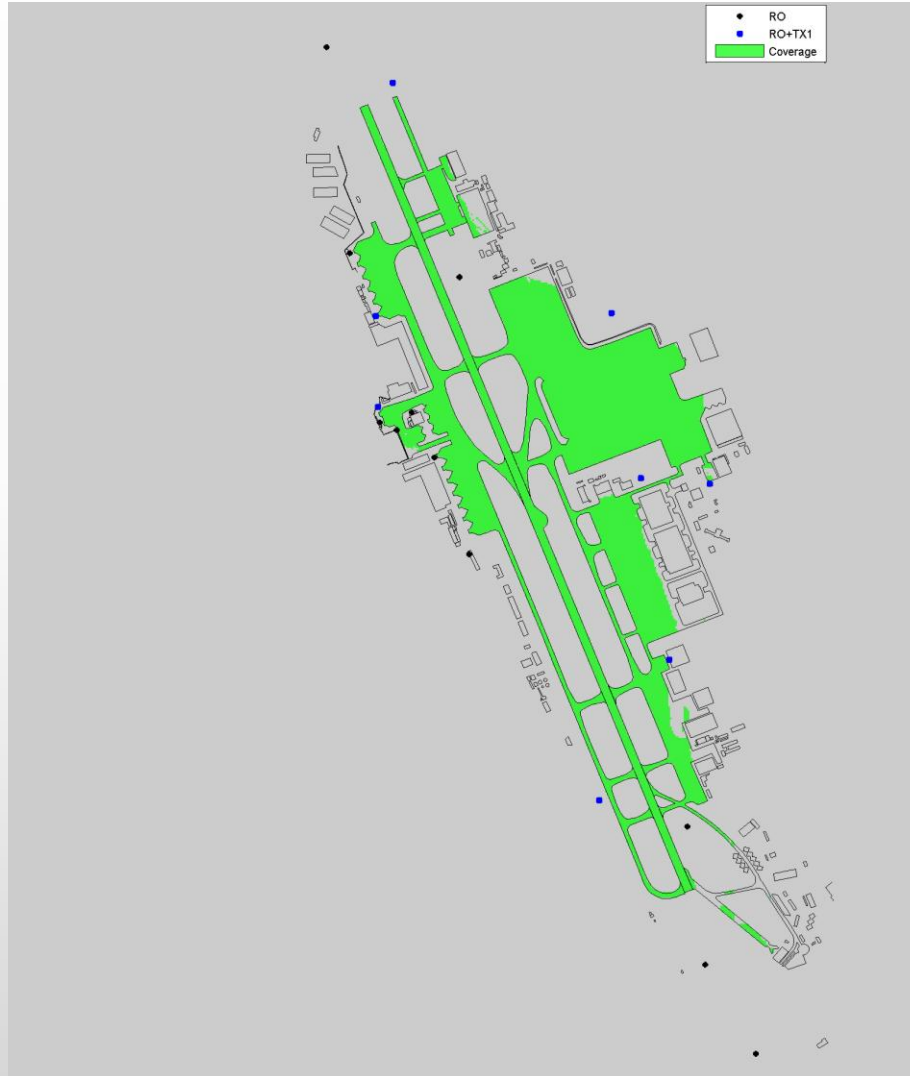
20 M MLAT COVERAGE DIAGRAM AT HIA AIRPORT



7.5 M MLAT COVERAGE DIAGRAM AT DIA AIRPORT



12 M MLAT COVERAGE DIAGRAM AT DIA AIRPORT



20 M MLAT COVERAGE DIAGRAM AT DIA AIRPORT

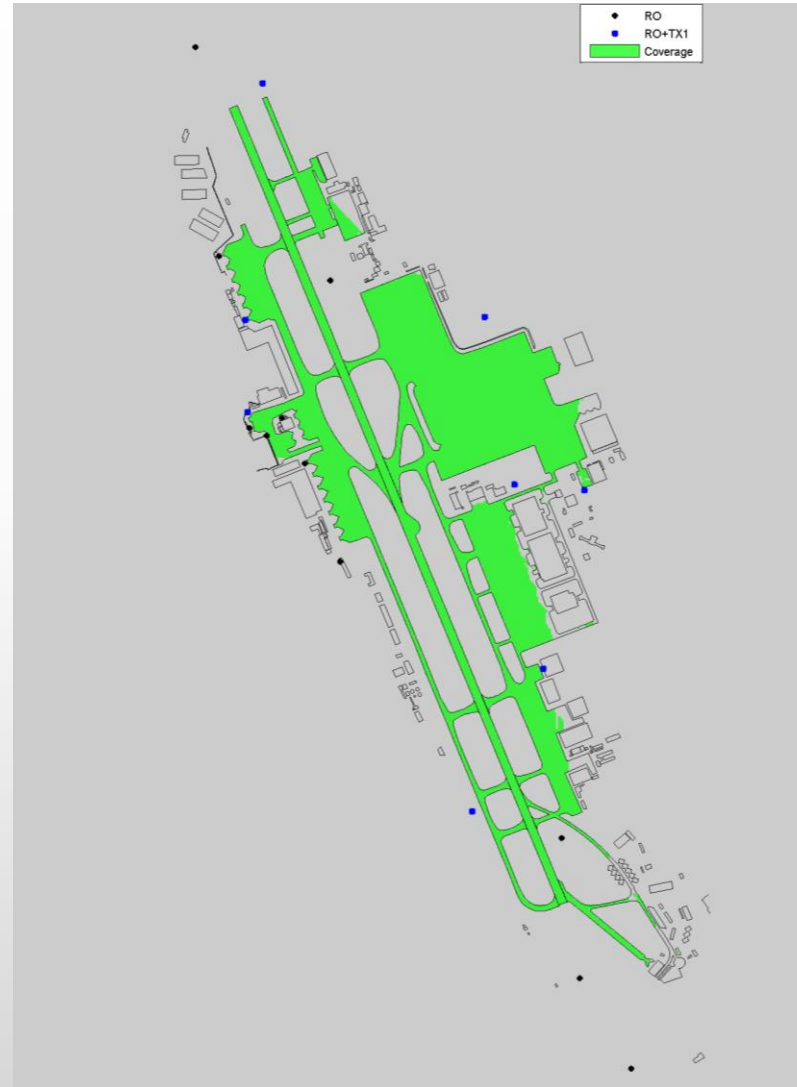


TABLE FOR QTY OF SENSORS

LOCATION	RO ONLY	RO + TX1
HIA	39	17
DIA	12	7

HIA MLAT					
RU NUMBER	RU LOCATION	RU TYPE	RU NUMBER	RU LOCATION	RU TYPE
RU01	LLZ 34 R	RO	RU29	N8 - QJET AREA C5310	RO
RU02	GP16 L	RO+TX1	RU30	N9 - VEHICLE WASHING AREA	RO+TX1
RU03	MLAT RU3	RO+TX1	RU31	N10 - MOTOR TRANSPORT WORKSHOP BUILDING- C4320	RO
RU04	SMR3	RO	RU32	N11 - FIRE STATION BUILDING-C3210	RO+TX1
RU05	GP34R	RO	RU33	N12 - PTC GATE A8	RO+TX1
RU06	LLZ16L	RO+TX1	RU34	N13 - ISOLATION AREA	RO
RU07	DVOR-DME	RO	RU35	N14 - ISOLATION AREA	RO+TX1
RU08	LLZ16R	RO	RU36	N15 - PTC GATE C12	RO
RU09	GP34L	RO+TX1	RU37	N16 - PTC GATE C13	RO
RU10	MLATRU10	RO	RU38	N17 - PTC GATE A4	RO
RU11	GP16R	RO	RU39	N18 - PTC GATE B2	RO+TX1
RU12	LLZ34L	RO	RU40	N19 - PTC GATE C2	RO
RU13	MET BLDG	RO	RU41	N20 - PTC GATE C3	RO
RU14	RX STATION	RO	RU42	N21 - PTC GATE A3	RO
RU15	ATCT	RO+TX1	RU43	N22 - PTC GATE B1	RO
RU16	ATCT-EAST	RO+TX1	RU44	N23 - NORTH DET.POND SUBSTATION	RO
RU17	EAST APRON CAB SOUTH	RO	RU45	N24 - HANGER A&B	RO
RU18	EAST APRON CAB NORTH	RO	RU46	N25 - GA HANGER	RO
RU19	WEST APRON CAB	RO	RU47	N26 - AIRFIELD JULIET APRON ELE. BUILDING	RO
RU20	ADS-B1 ASR SOUTH	RO	RU48	NEAR TIB NORTH BUILDING (W1)	RO
RU21	ADS-B2 ASR SOUTH	RO+TX1	RU49	HML 621 (W2)	RO
RU22	N1 - VDGS Q21	RO+TX1	RU50	HML 637B (W3)	RO+TX1
RU23	N2 - HANGER A	RO+TX1	RU51	NEAR PERIMETER FENCE (AREA 1) (W5)	RO+TX1
RU24	N3 - HANGER D	RO	RU52	NEAR ESSENTIAL SUB-STATION (AREA 4) (W8)	RO+TX1
RU25	N4 - HANGER C	RO	RU53	NEAR BY RUNWAY 16L HOLDING BAY (W9)	RO
RU26	N5 - HANGER B	RO	RU54	HML 628 (W10)	RO
RU27	N6 - QJET AREA C5160	RO	RU55	NEAR TAXIWAY R2 (AREA 1) (W11)	RO
RU28	N7 - GENERAL AVIATION TERMINAL	RO	RU56	NEAR PERIMETER FENCE (AREA 1) (W12)	RO

DIA MLAT		
RU NUMBER	RU LOCATION	RU Type
RU01	MET Watch Tower	RO+TX1
RU02	QAS Tower	RO
RU03	LLZ 33 Shelter	RO
RU04	LLZ 15 Shelter	RO
RU05	Qatar Airways Hangar	RO+TX1
RU06	ASR/SIRS Radar	RO+TX1
RU07	Tx Mast	RO+TX1
RU08	Rx5 MLAT shelter	RO+TX1
RU09	GP15 Shelter	RO
RU10	VDGS Pole, A12	RO
RU11	VDGS Pole, A1	RO
RU12	VDGS Pole, A6	RO+TX1
RU13	ATC Tower	RO
RU14	GP33 Shelter	RO
RU15	DVOR Shelter	RO
RU16	Rx Mast	RO
RU17	Next to Stand G3	RO+TX1
RU18	Police Gate 2	RO
RU19	CCTV Pole next to Police Gate 2	RO

Q&A



OPEN FOR DISCUSSION AND
TECHNICAL CLARIFICATION.



DEMO AND WORKSHOP
AVAILABLE ON REQUEST.