PRISMA ATM Automation System

A modular ATM Automation Solution and Transition into a SWIM environment

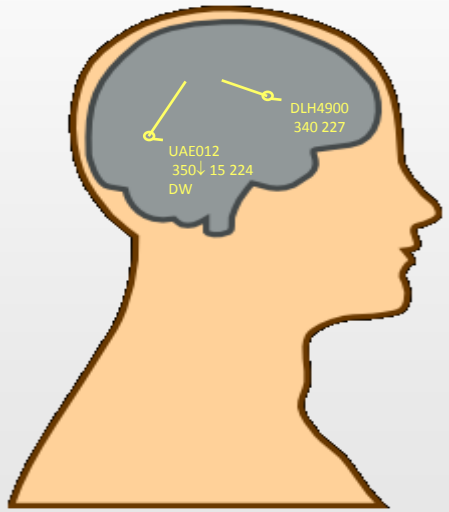
Werner Pitz

COMSOFT
dedicated to ATM

Evolution of ATM Systems

Conventional ATM System

- Conventional RDP and FDP systems
- Presenting real-time information to ATCO
- ATCO manually maintains information
- Traffic control is an active cognitive feat performed by the ATCO



Most conventional systems are isolated

- Local data processing
- Local Processing
- User input-driven and read-only system

ATM Systems are “replaced” …

- when maintenance becomes uneconomically
- when technology becomes obsolescent

Concept of Advanced ATM Systems

Men-Machine Cooperation

- ATCO focuses on actual decisions and demanding situations

Advanced ATM System autonomously takes over routine tasks

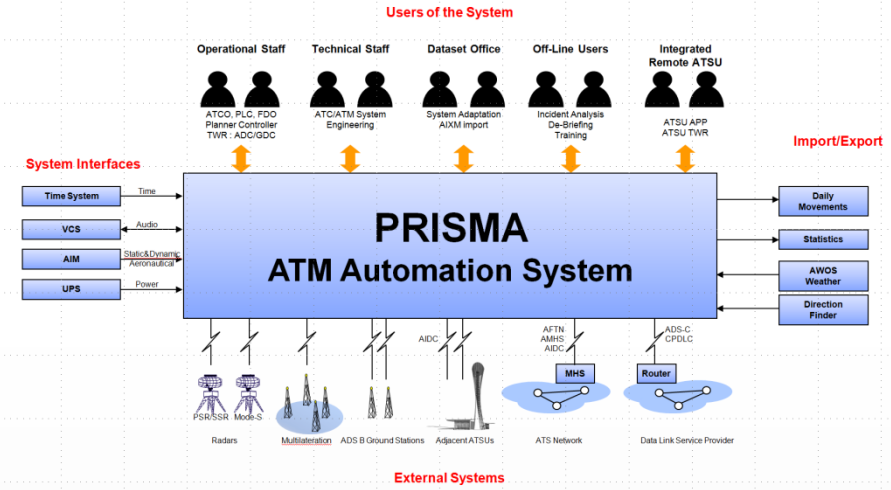
- Early online coordination and updates
- Updating flight profiles
- Integrated performance, complexity and safety monitoring

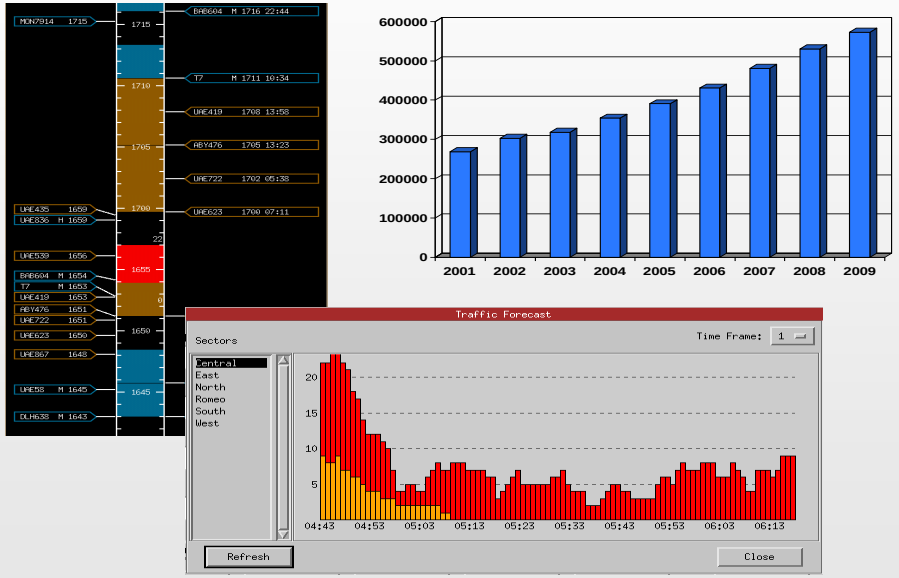
Advanced ATM System pro-actively supports decision making processes

- Optimal use of limited or constrained resources
- Manage the use of constrained resources (Runway/Flow)
- Interfaces with adjacent ATCUs and Aviation Industry Stakeholders

Support (automatic) CDM in cooperation with stakeholders

- Airport operation
- Airline operators





Characteristics of PRISMA ATM Automation Systems

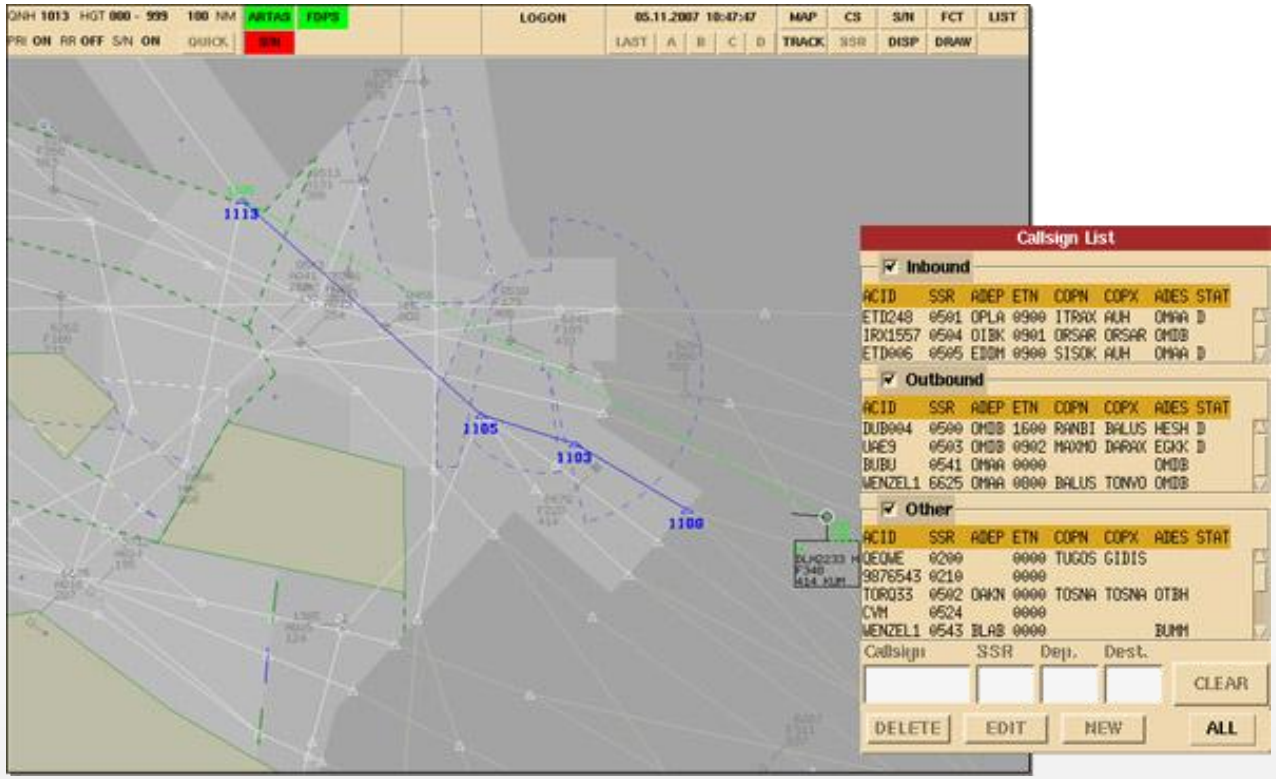
Operational Environment

- En-Route Control
- TMA Control
- APP Control
- Tower Control

Air Situation Picture

- PSR, SSR and Mode S radar
- Multilateration
- ADS-B
- ADS-C
- Non-Radar / Procedural (FPL Tracks)

Seamlessly supporting heterogeneous Emvironments



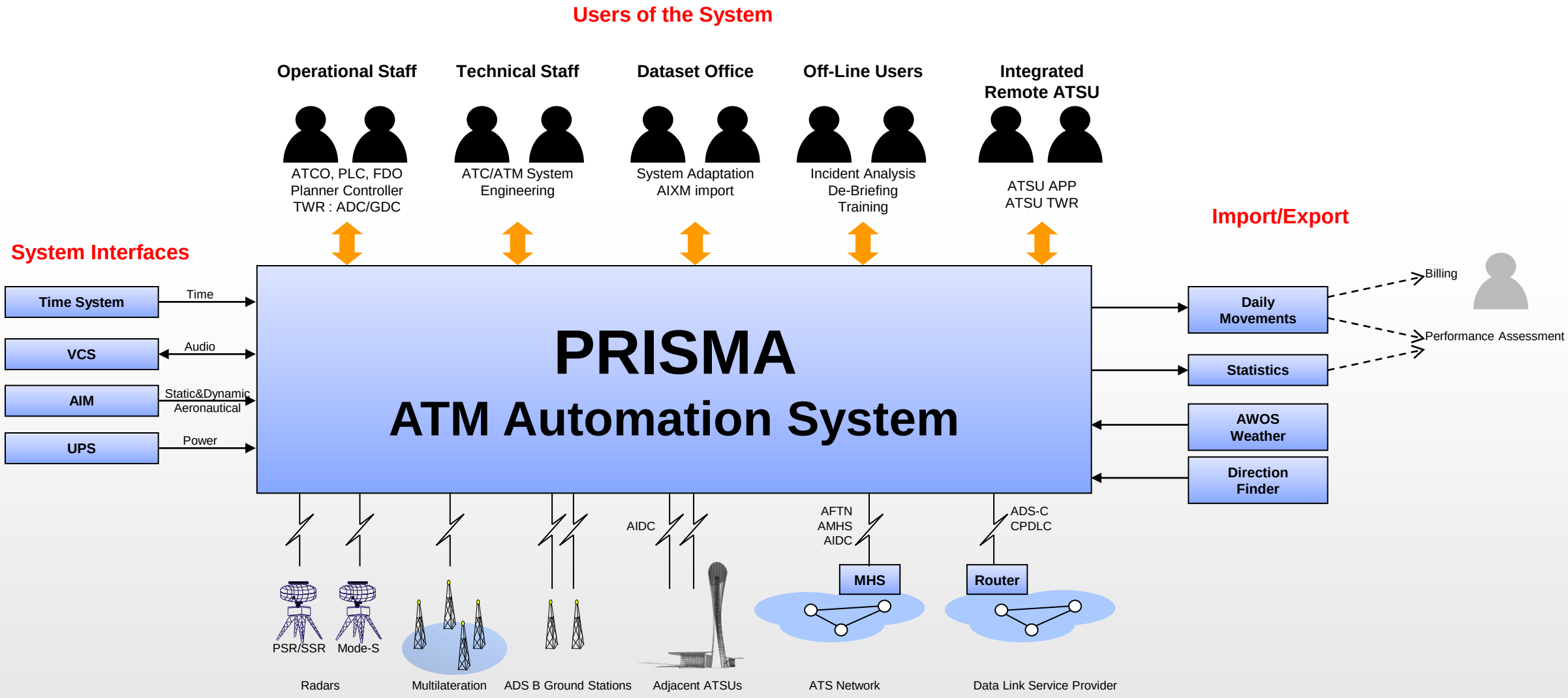
Flight Plan Processing

- Conventional Flight Strips
- Electronic Flight Strips
- Stripless Operation
- Heterogeneous Operation

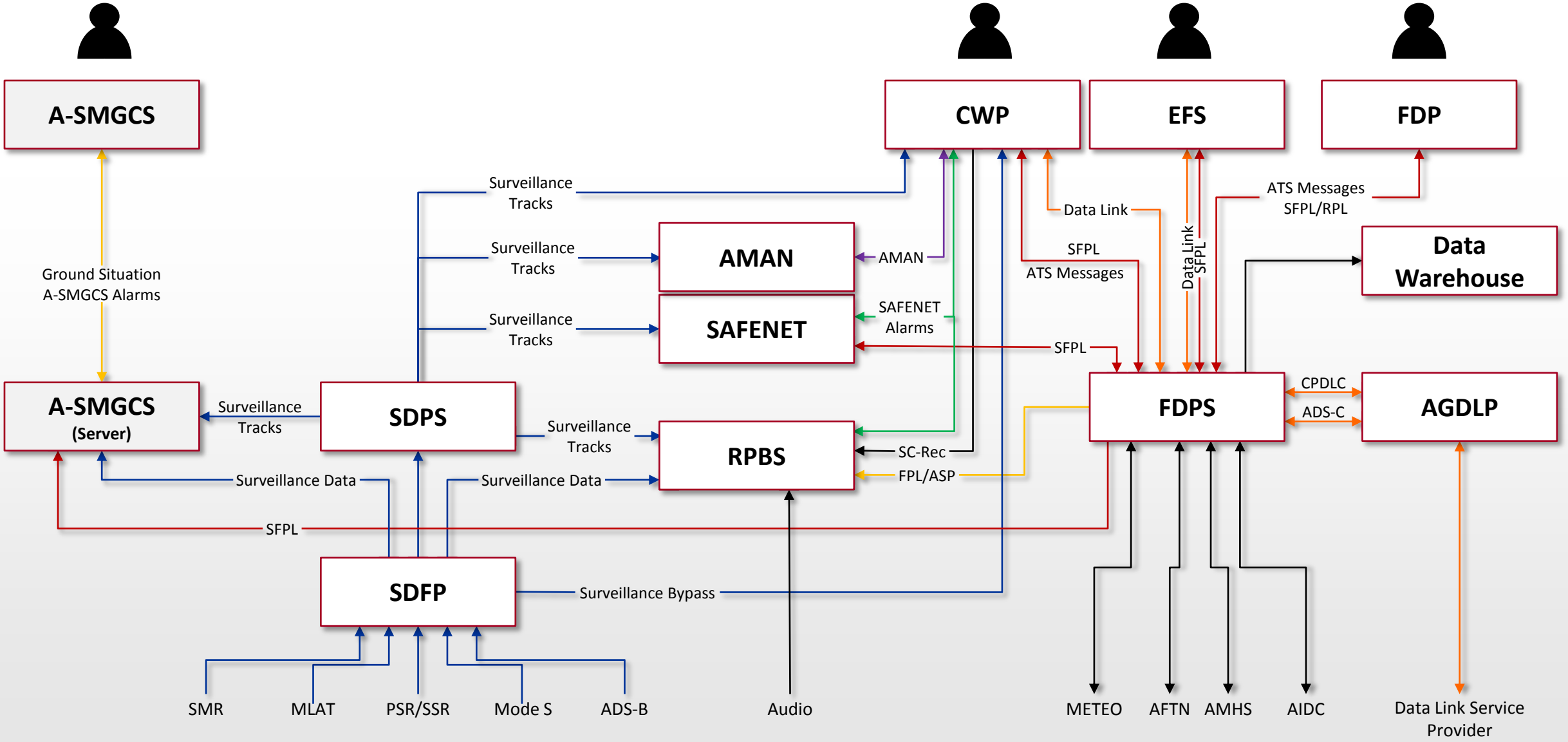
Enhanced Capabilities

- Multi Site Processing
- Integrated D-FLOW Management
- Integrated Arrival Manager

PRISMA System Boundaries



PRISMA Processing Chains (Data Flow)



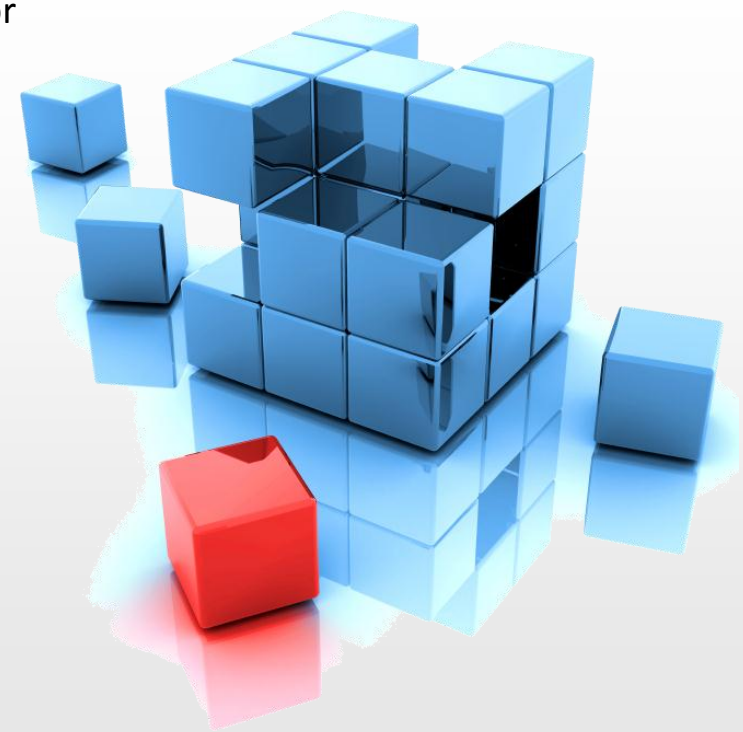
PRISMA Modularity

Functional Blocks
- SDFP - Surveillance Data Front End Processing
- SDPS - Surveillance Data Processing System
- FDPS - Flight Plan Data Processing System
- SAFENET - Safety Net System
- RPBS - Recording and Playback System
- AGDLP – Air Ground Data Link Processor

Operational User Interfaces
- CWP - Controller Working Position
- EFS – Electronic Flight Strips
- FDP – Flight Plan Data Position

Extensions
- A-SMGCS
- AMAN – Arrival Manager
- DFLOW – Flow Management

Others
- CMS – Control and Monitoring System
- DBM – Data Base Management



Benefits
- Individual moduls form perfectly suited solutions
- Co-hosting and scalability
- Set up of multiple levels of redundancy
- Industrial Communication Standards
- Supporting multi-site distributed architectures

Interfaces
- Front End Processing allows peripheral adaptation
- Flexible interfaces for ATS and Data Link
- Air Ground Data Link Processor
- others …

AFTN, AMHS, AIDC
- Complementary AFTN/AMHS Message Handling System Available

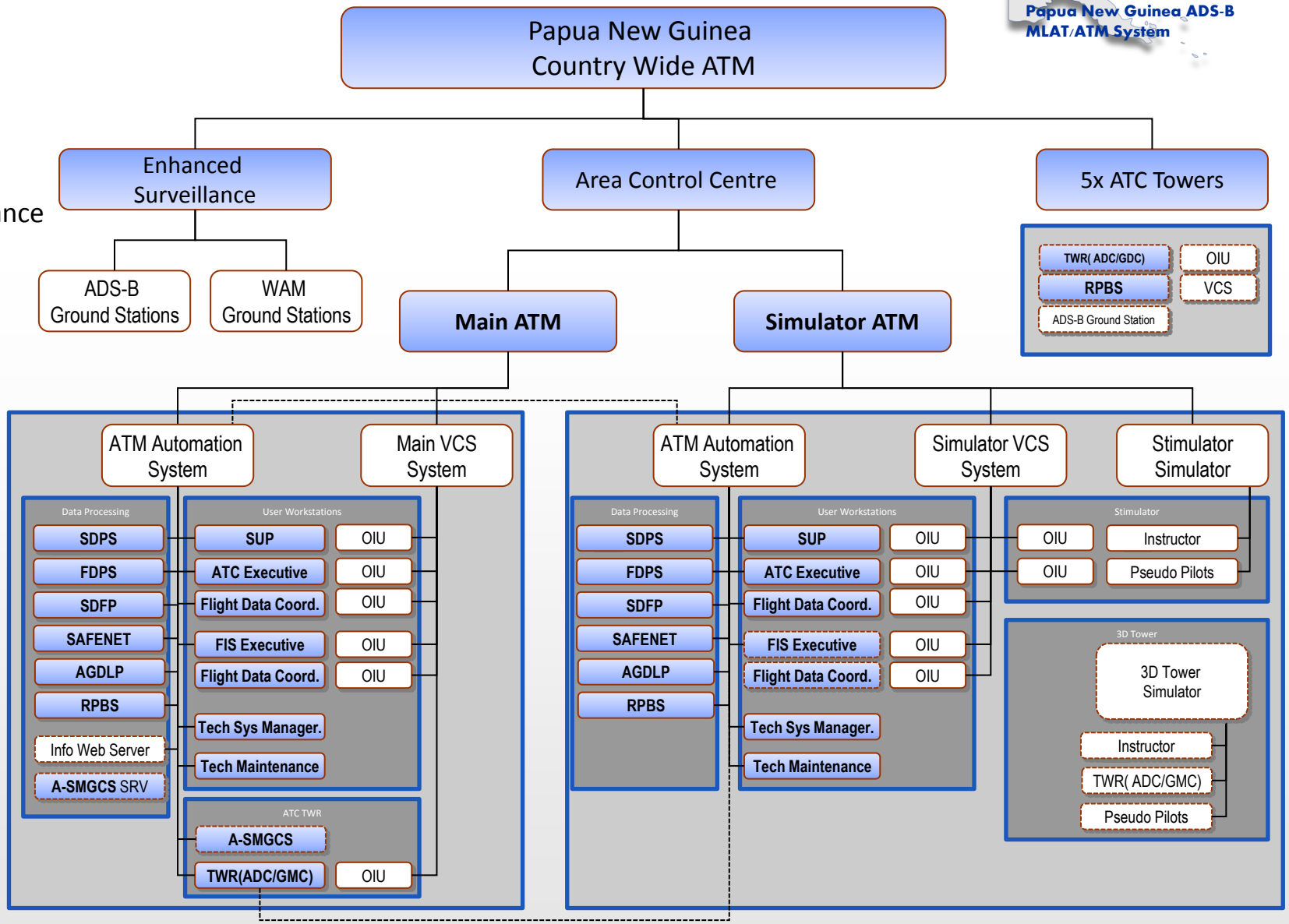
Example Configuration: Papua New Guinea

Country Wide ATM Solution
- FIR Papua New Guinea
- APP and Tower Port Moresby
- Five ATC Towers (Remote Sites)
- Integration of PSR/SSR / ADS-B and WAM surveillance
- Support ADS-C in non-surveillance areas
- Integrated CPDLC Communication
- AIDC with adjacent FIRs

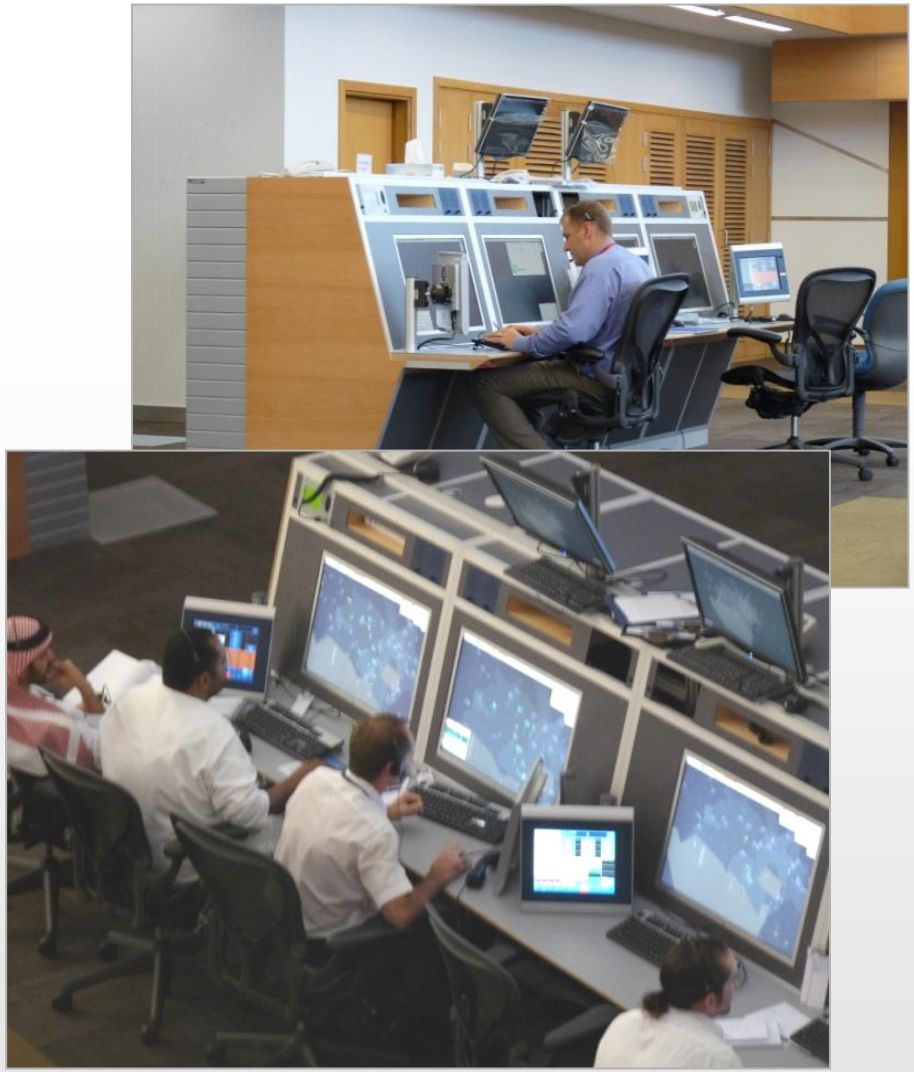
PRISMA ATM Solution
- En-Route Centre
- Integrated Approach Port Moresby
- ATC Tower Port Moresby
- Five ATC Towers connected to Data Processing

MAIN ATM System
- 20 Operational Positions
- 4 Technical Positions

Simulator ATM System
- 6 Operational Positions
- 2 Technical Positions
- 6 Pilot Positions



Controller Working Position



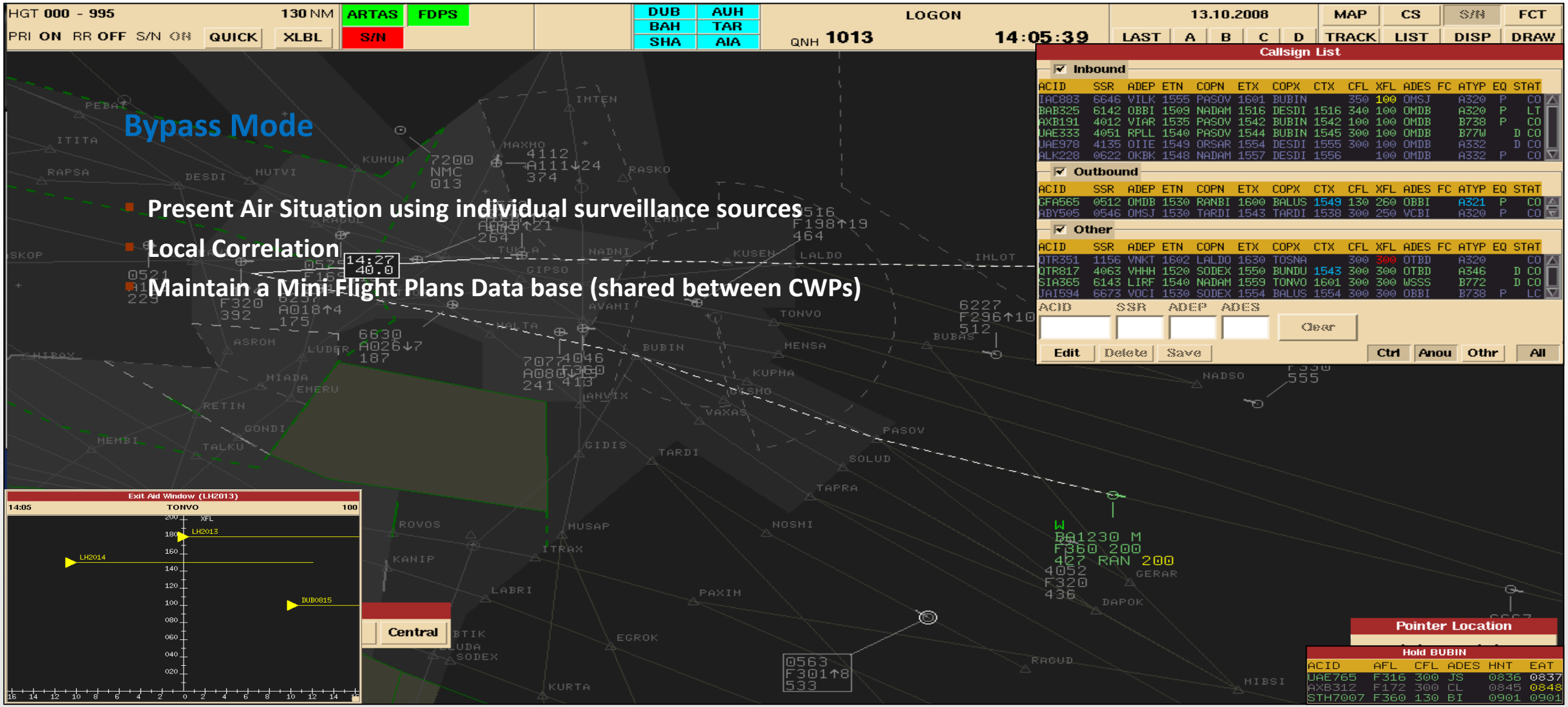
Platforms

- Workstations using Linux Operating System
- Displays from 20” (1600x1200) up to 30” (2048x2048)
- Multi-Screen Displays supported
- High-Brightness Displays for Towers
- 3 button Wheel-Mouse

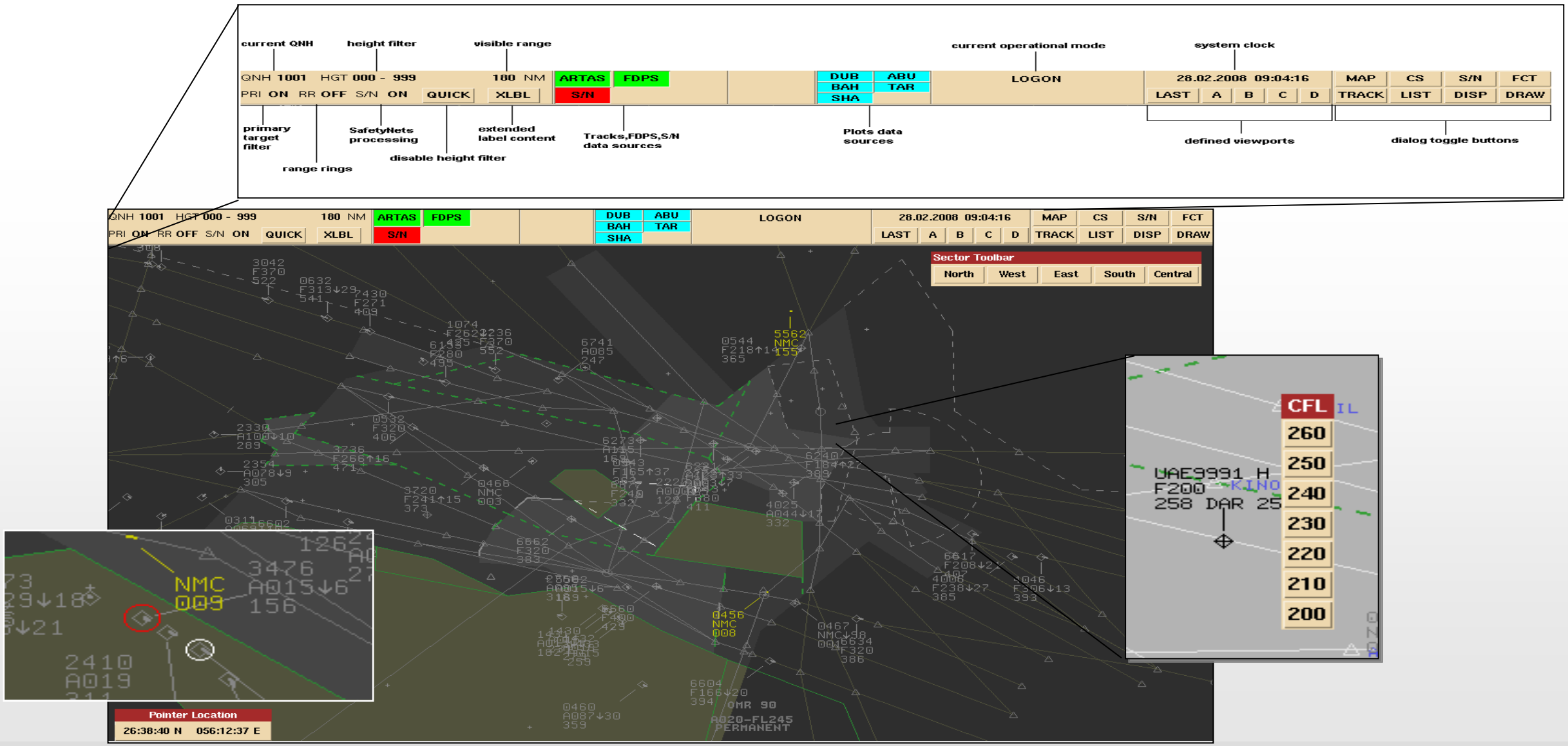
Functions

- Presentation of air situation
- Alarm presentation
- Coordination and Jurisdiction
- Local callsign assignments
- Integrated Screen recording and replay
- Data Link

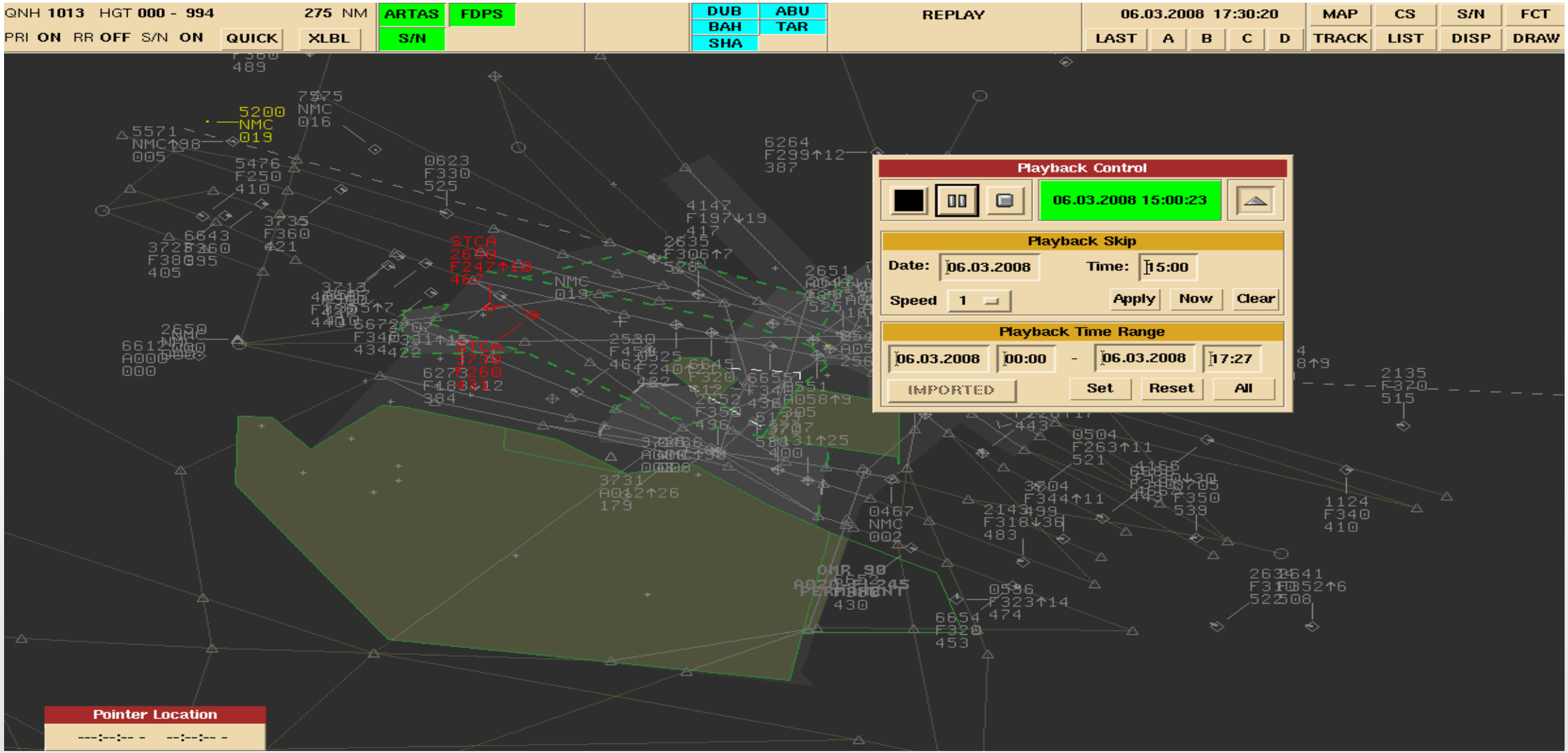
Bypass Function



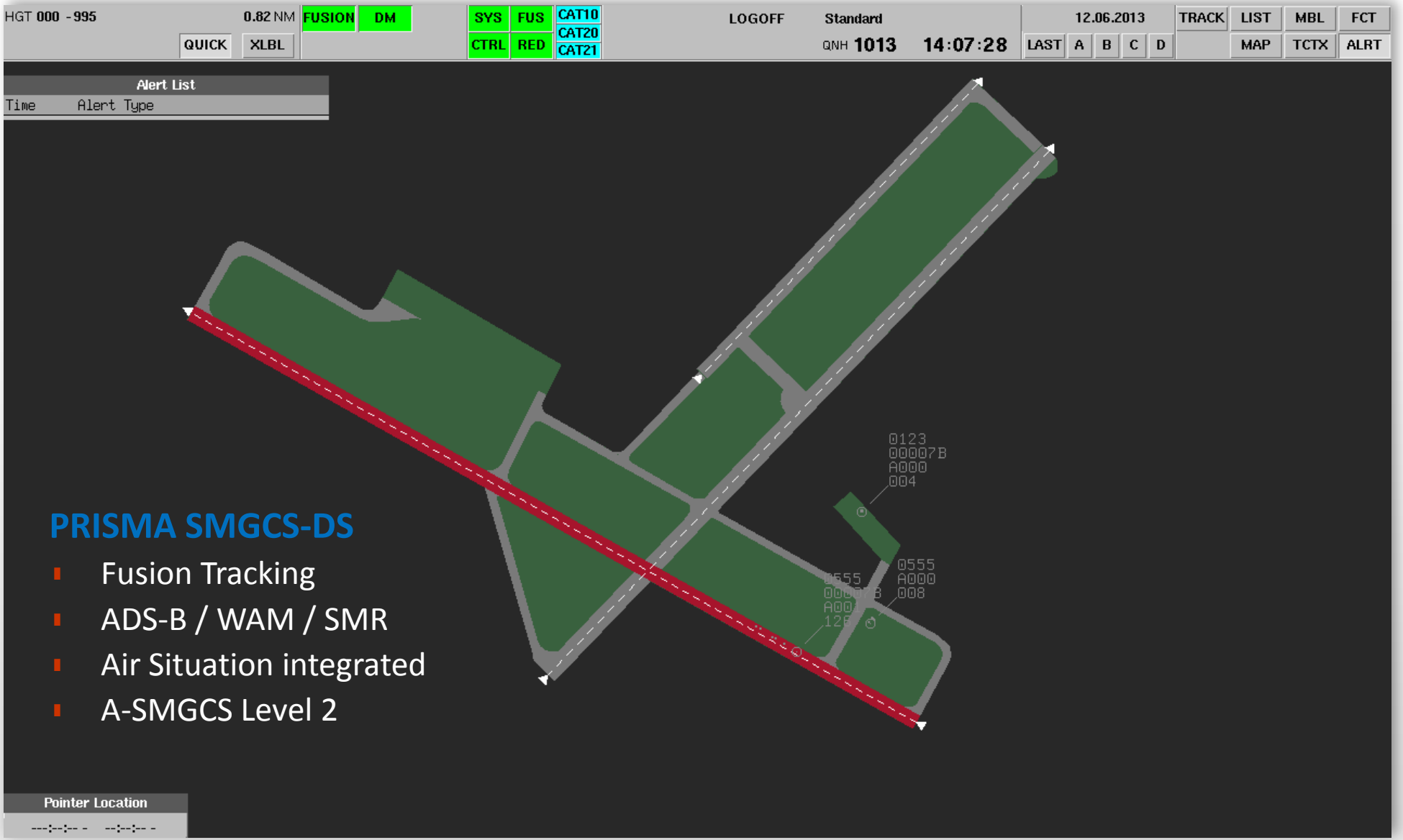
Display Control Area



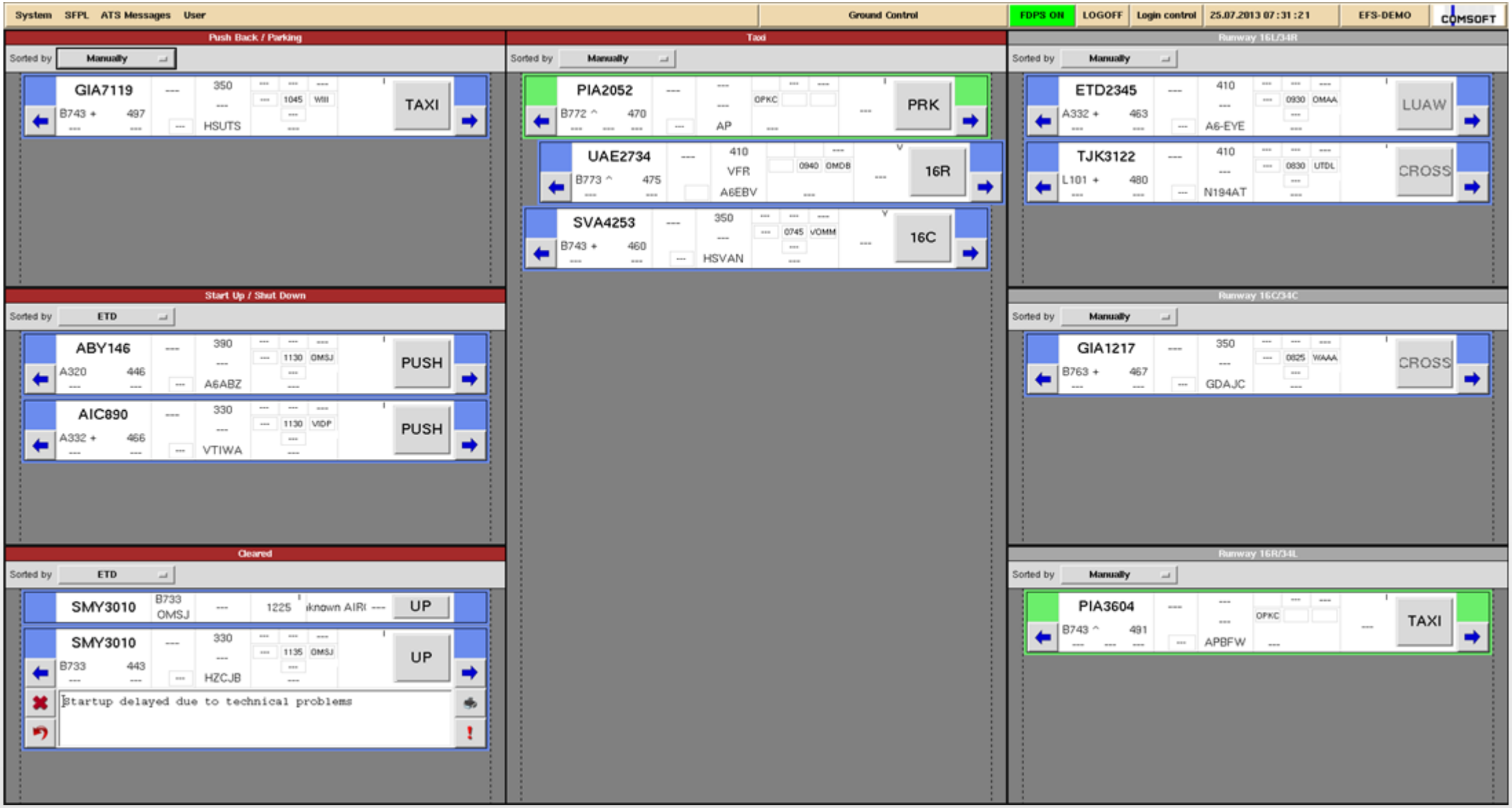
Integrated Recording and Replay



CWP in A-SMGCS Mode



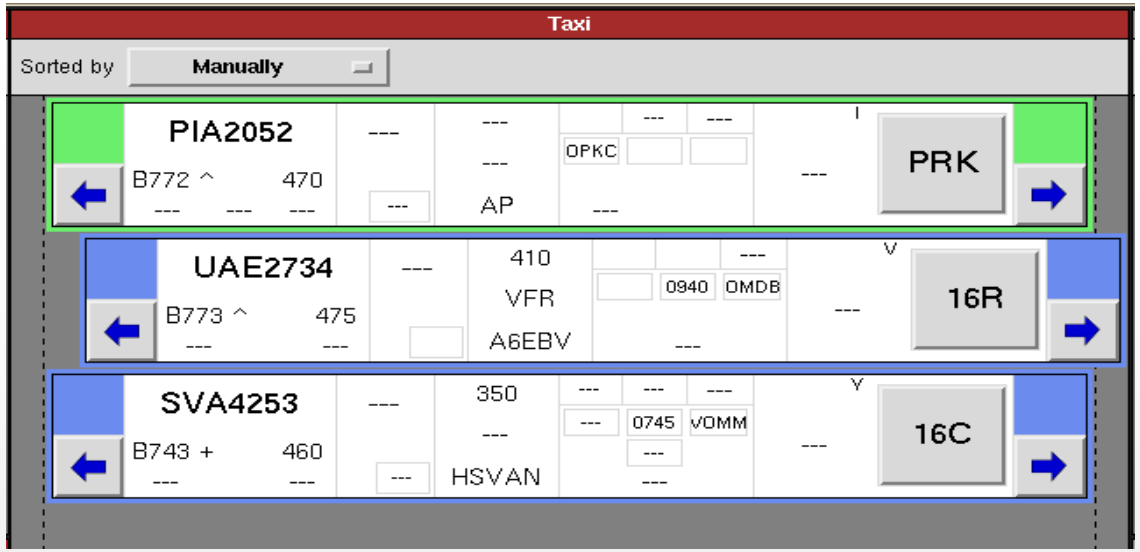
Electronic Flight Strips



Electronic Flight Strip Sub-System

Core Functions

- Multi-Format Flight Strip Display
- Configurable Layouts of Bays and Flight Strips
- Fully integrated with FDPS



Flight Strip Display

- Different Layouts
- Role dependent presentation
- Shared View and Cooperation

Data Integration

- Full Integration and data sharing with FDPS DB
- Instant coordination TWR and ACC/APP

Surveillance Data Processing

Multi-Sensor Fusion Tracker

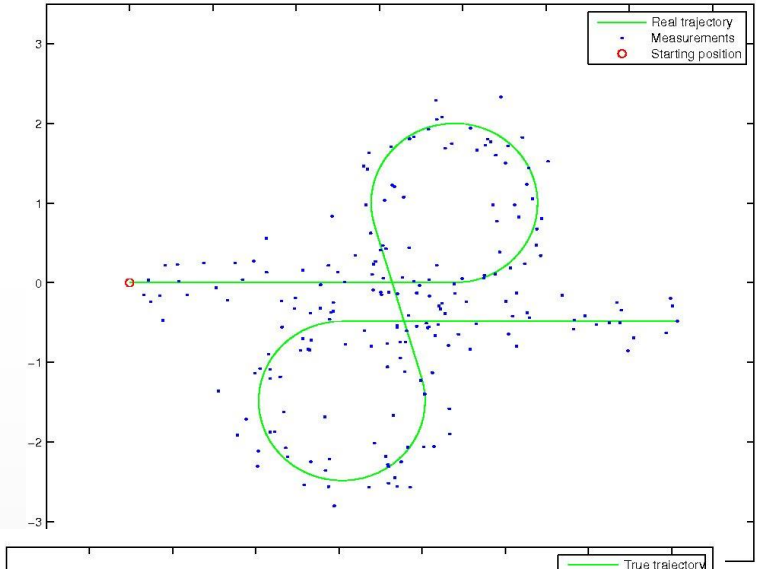
- Domain of Interest (DOI) of max 2048 x 2048 NM 4000 system tracks
- 120 surveillance data sources

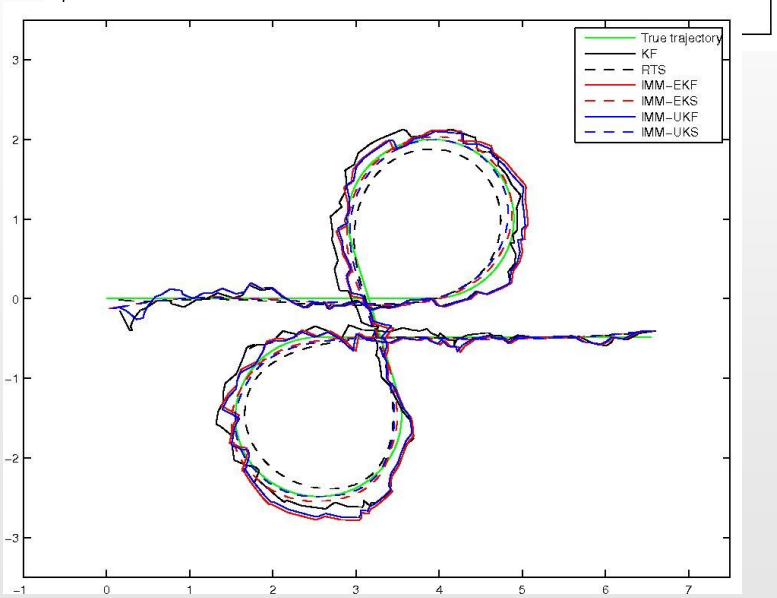
Tracking Functions

- Use of state of the art tracking technology (Extended Kalman Filtering, JPDA, IMM, MHT,...)
- Integration of all surveillance sources
- Sensor Type specific error models
- Multi Sensor Environment Assessment (MSEA)
- Single stage data fusion
- Flexible service definition
- Use of ASTERIX as universal exchange format (input, output)
- Dual hot redundant system

Non Radar Areas

- Rule based ADS-C with automatic acquiring
- Flight Plan Tracks





Surveillance Data Processing

Conventional PSR/SSR and Mode S Radar

- Reliable Surveillance function for cooperative targets (SSR and Mode S) as well as for non-cooperative aircrafts (PSR)
- Well defined surveillance performance with known systematic accuracy errors
- Periodic Position Updates

Multilateration

- Cooperative air and ground surveillance for cooperative targets, compatible to (SSR and Mode S)
- Operational performance requires specific design of ground network
- supporting commercially attractive complementary surveillance system with defined errors (per target)

ADS-B

- Dependent Surveillance with high quality
- Omitting Garbling
- High Frequency / low latency position updates
- Dense Areas / Holding Patterns

ADS-C

- Dependent Surveillance (low frequency, high latency
- Not suited for surveillance separation

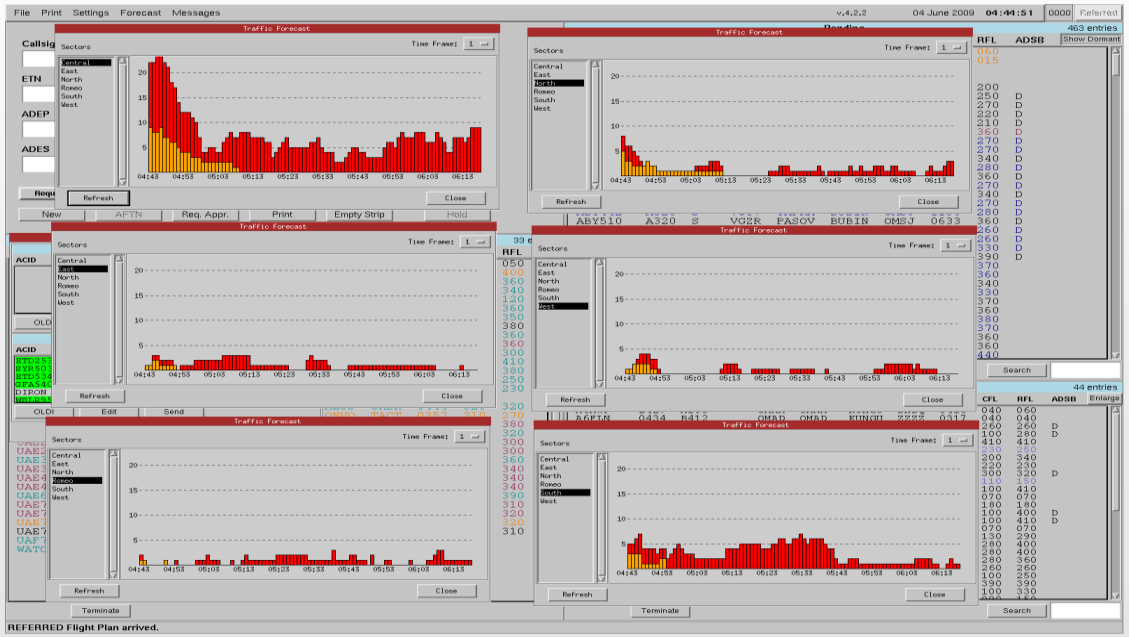
Flight Plan Data Processing

Core Flight Plan Functions

- ATS Message Interface
- Management of System Flight Plan Data Base
- FPL Message Processing
- RPL Processing
- Abbreviated Flight Plans
- Conventional Strip Printing
- Track Correlation
- Trajectory Prediction
- Data Collection

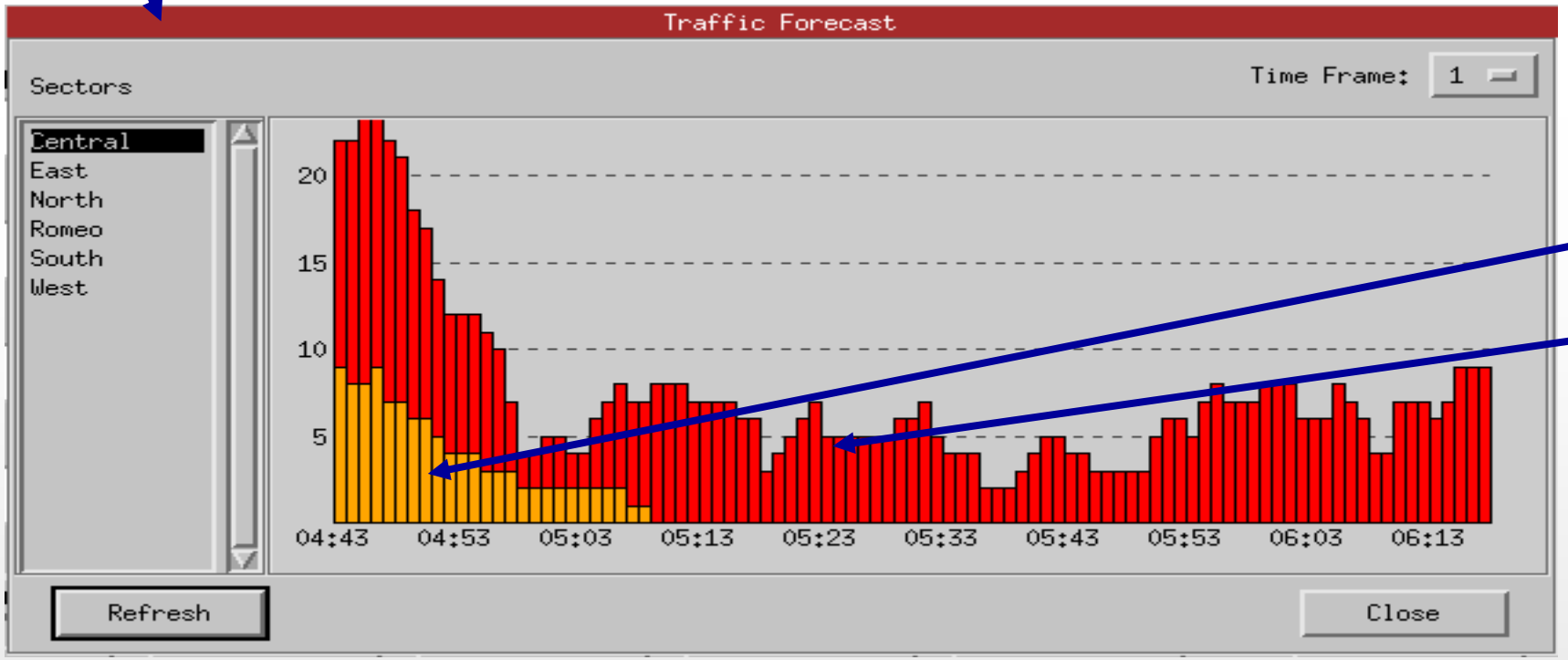
Enhanced Processing

- Electronic Flight Strip Interface
- Support for FPL based Safety Nets
- Traffic Forecast
- Flow Monitoring
- AIDC Coordination
- Airspace / Sector Management
- Trajectory Prediction & Maintenance
- Monitoring Flight Progress
- Supporting CPDLC
- Manage Jurisdiction
- ADS-C (Rule Based)
- Flight Plan Tracks



Traffic Forecast

Sectors / Waypoints / Aerodromes



Forecast Traffic in Sector

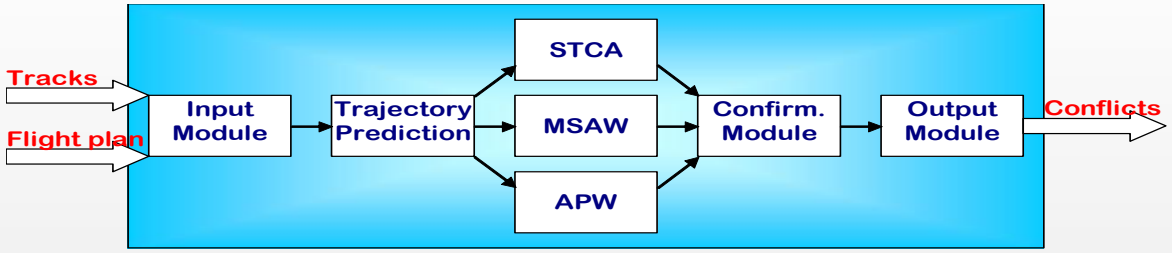
Coordinated

Scheduled

Safety Net Functionality

Predictive Surveillance Based Safety Nets

- Identify hazardous critical situation in the near future
- Short Term Conflict Alert (STCA)
- Minimum Safe Altitude Warning (MSAW)
- Area Proximity Warning Alert (APW)
- Approach Path Monitor (APM)



Predictive Plan based Safety Nets // Controller Tools

- Mean Time Conflict Alert (MTCD)
- Exit Level Monitor

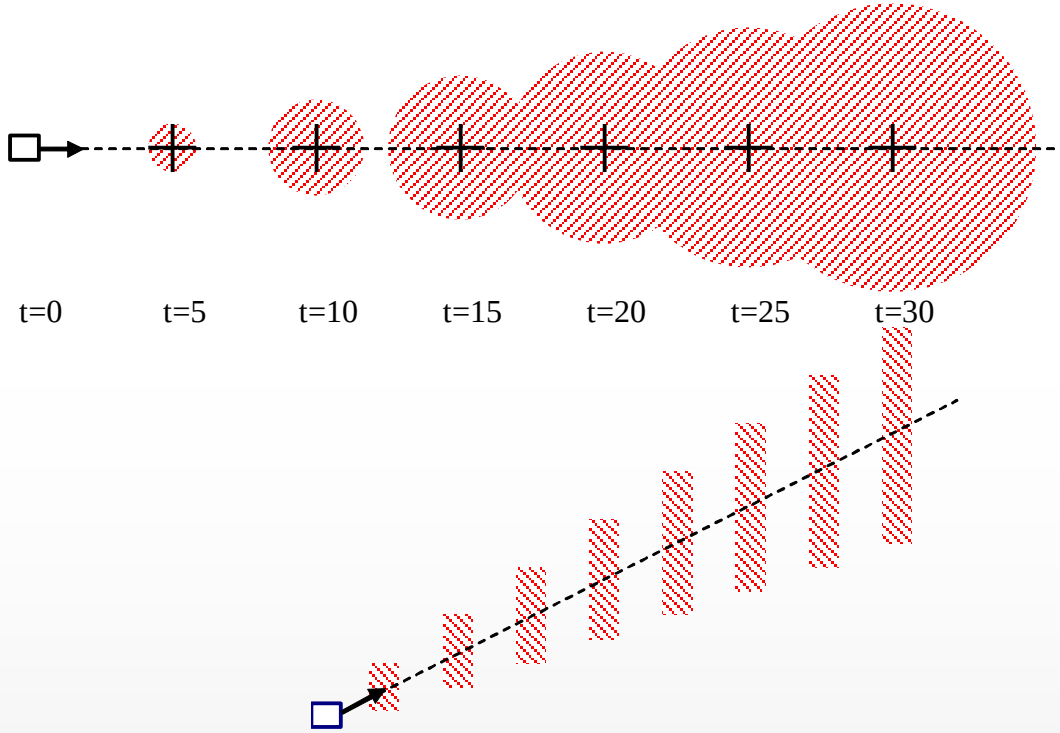
Situational Safety Nets

- Compare current situation with planned situation and flag (significant) divergence
- Cleared Level Adherence Monitor (CLAM)
- Route Adherence Monitor (RAM)
- Lost Track Warning (LTW)
- RVSM / PBN Adherence

Enhanced Processing

- Electronic Flight Strip Interface
- Rule based ADS-C
- Flow Monitoring
- Performance Monitoring

Predictive Safety Nets

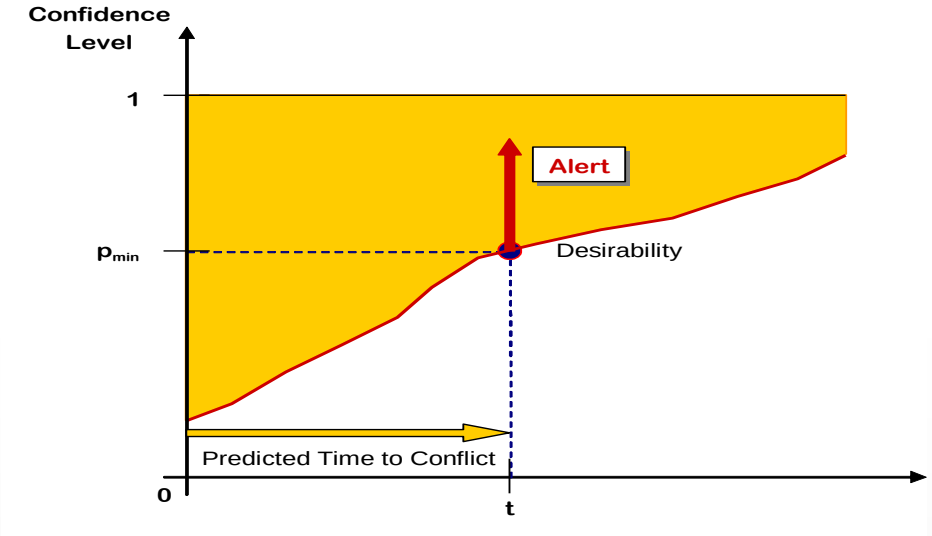


- Based on trajectories predicted from surveillance data
- **Uncertainty** of trajectory prediction
  - Short term prediction time frame
  - Typically **2 minutes** : good trade-off
- warning time ↔ trajectory prediction errors
- Normally, **transparent** to the controller
- If hazardous situation is detected, warn the controller to enable corrective manoeuver

Desirability of an Alert

- **Confidence vs. Desirability** of trajectory prediction
  - Desirabilty is a function of the time to conflict

- Analysis proves **excellent trade-off** between **in-time conflict prediction** and **nuisance alert**

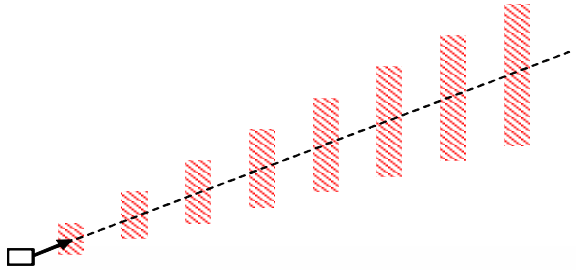


- Selected by **EUROCONTROL UAC Maastricht**
  - enhance the safety in one of the most complex and busiest airspaces in the world
  - **Real target load** up to **1500 tracks** measured
  - Significant Reduction of actual separation infringements while reducing the total number of alarms

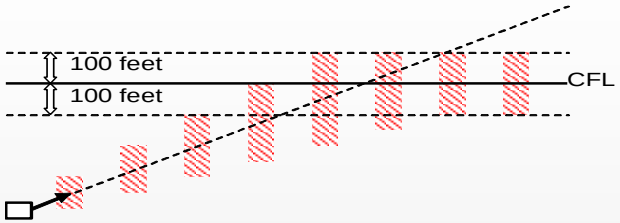
STCA

- **Use of Cleared Flight Level and Downlinked Parameters**

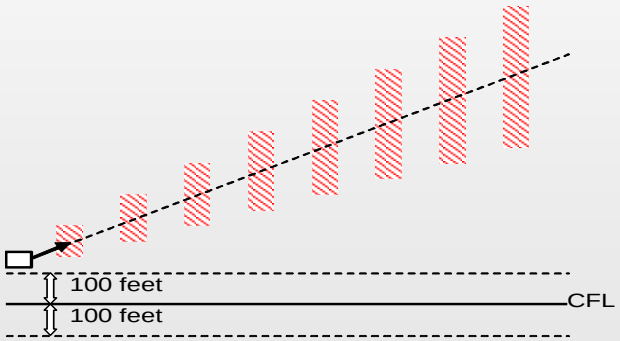
- **Without clipping**
- Linear extrapolation until max time is reached (2 min)



- **With clipping**
- Linear extrapolation until CFL
- Levelled clipping after CFL
  - Lower bound: CFL – 100 feet
  - Upper bound: CFL + 100 feet

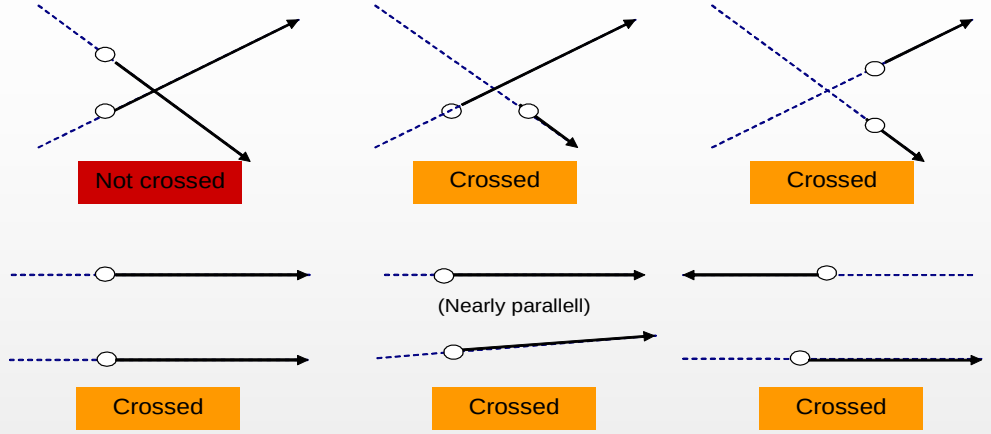


- **Case of level bust**
- If track has passed CFL no clipping takes place



Use of Geometry

Conflict Geometry determines if an alarm is desirable.



Operational Concepts: MSAW

MSAW terrain alarm

- Terrain altitude derived from DTED level 1
  - Horizontal resolution ~ 90 m
- Terrain resolution: 0,5 NM x 0,5 NM

MSAW conflict detection:

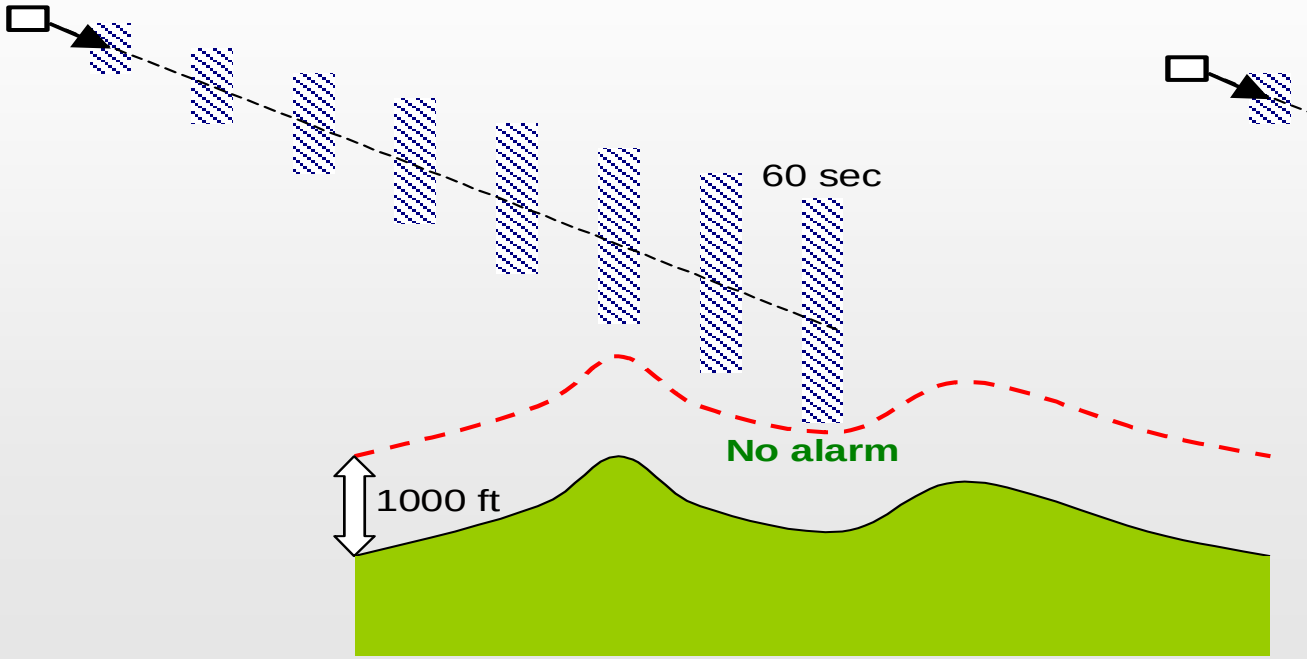
Use QNH-corrected mode C

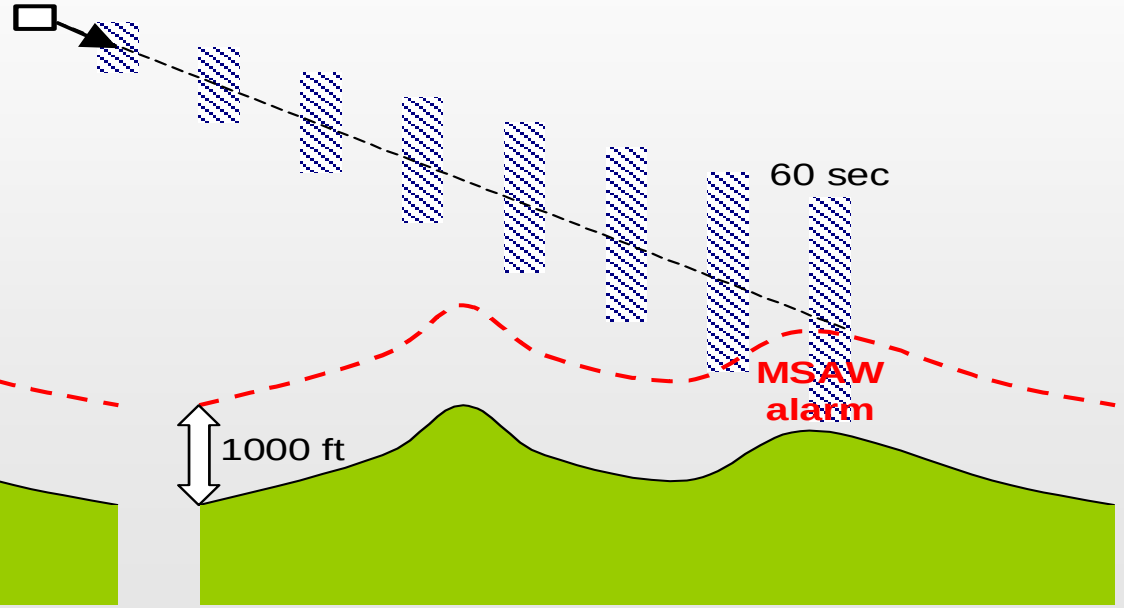
Minimum safe altitude = terrain + 1000 feet

Configurable warning time

Depends on MSAW region

Typically 40 sec to 1 min

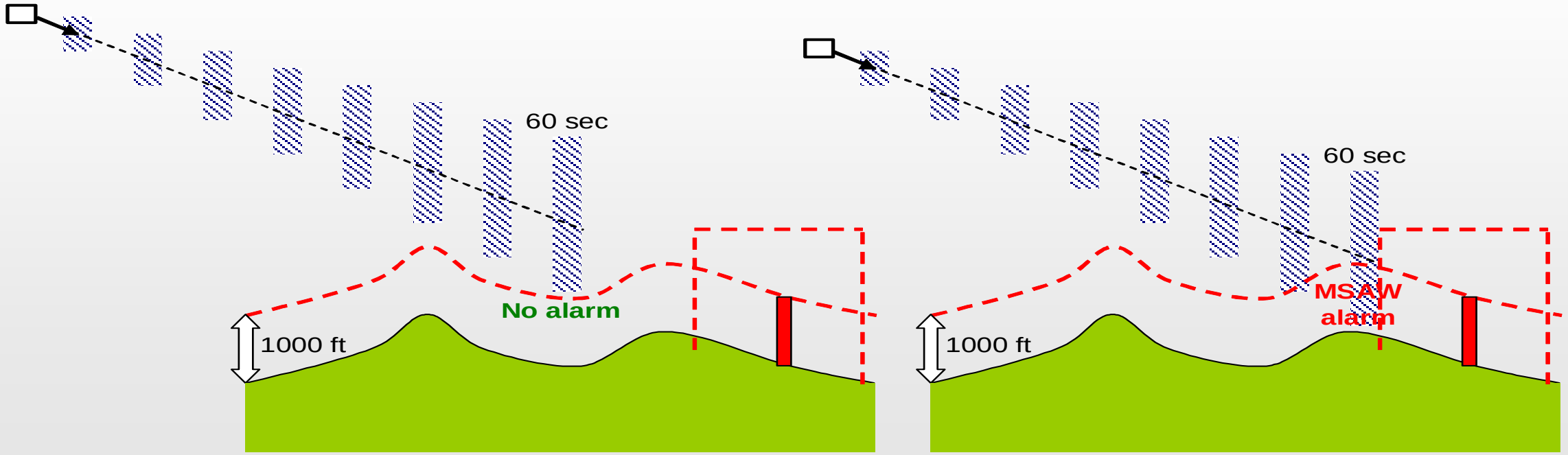




Operational Concepts: MSAW

Obstacles

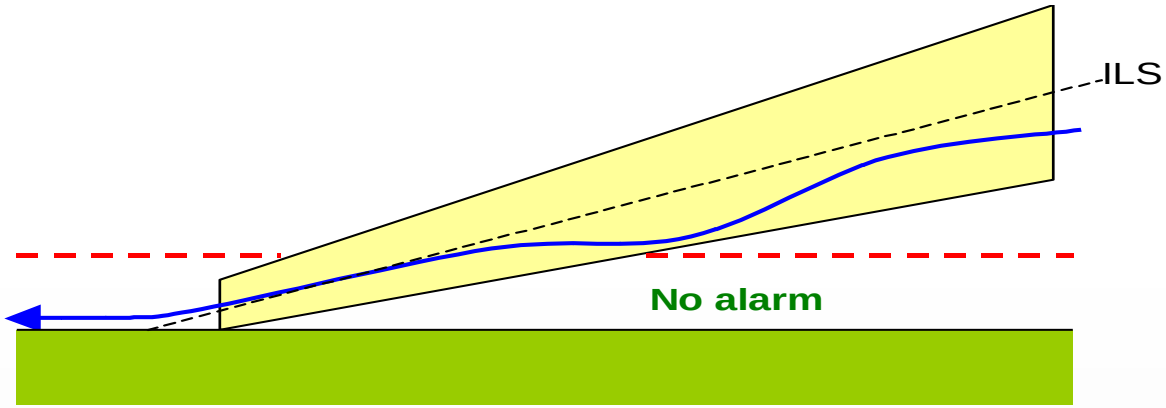
- Man build structures which raise significantly the minimum safe altitude
- Local definitions by WGS-84

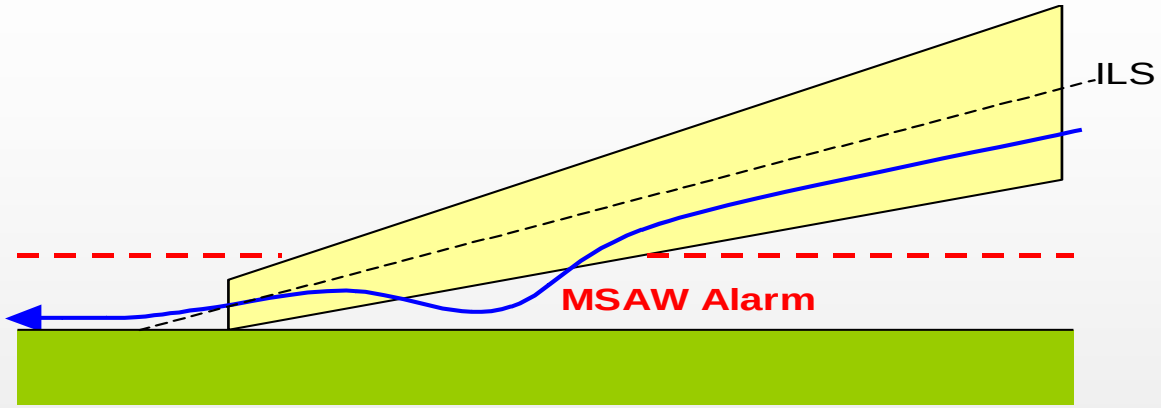


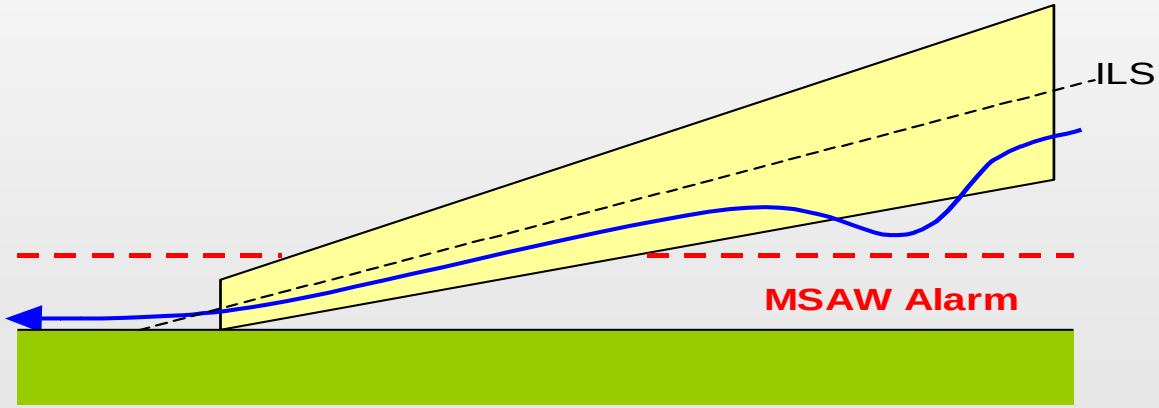
MSAW with Approach Path Monitor

MSAW glide slope protection

- Integrated Function of MSAW
- Responsibility of Controller



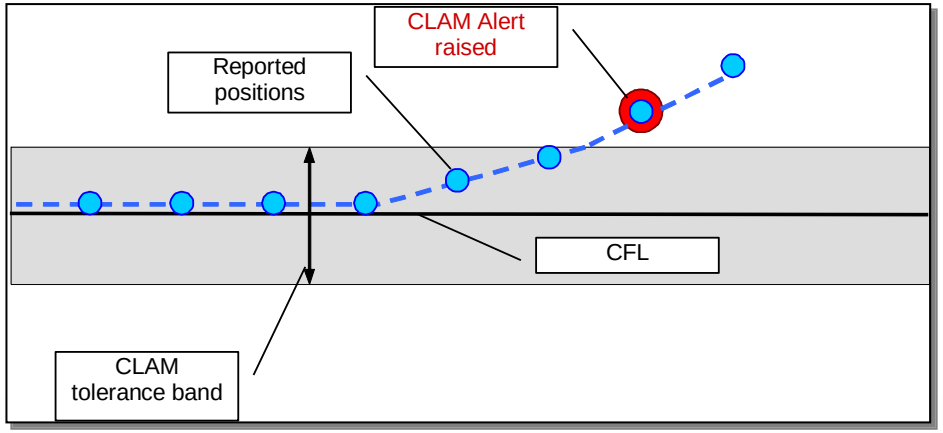




Situational Safety Nets

Shared Characteristics

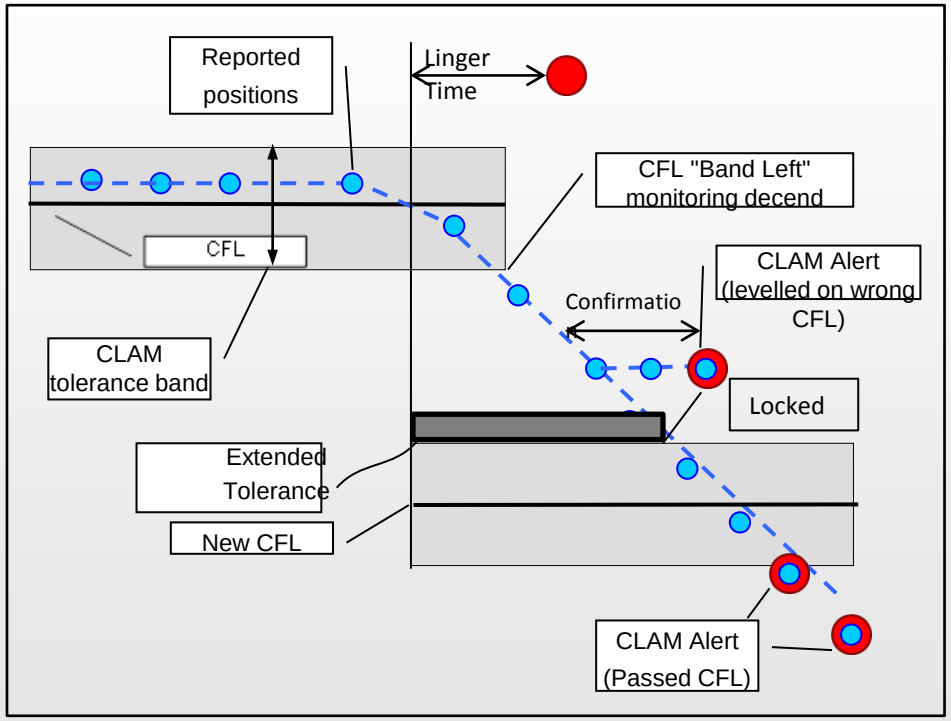
- Compare Surveillance Tracks with Flight Plan Clearances
- Report Divergences
- Apply Tolerances



Cleared Level Adherence Monitoring (CLAM)

- Compares Actual and Cleared Flight Level
- Considers and Monitors Level Transitions

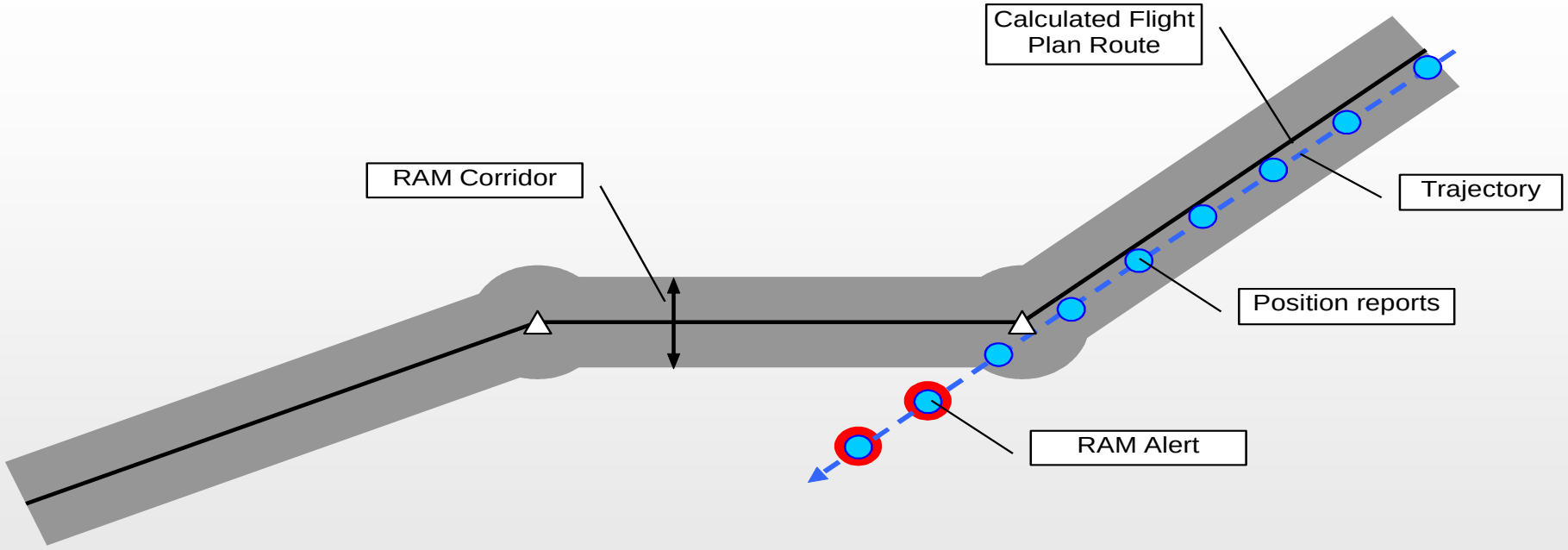
Use of Downlinked Parameters to Monitor Selected Altitude DAP



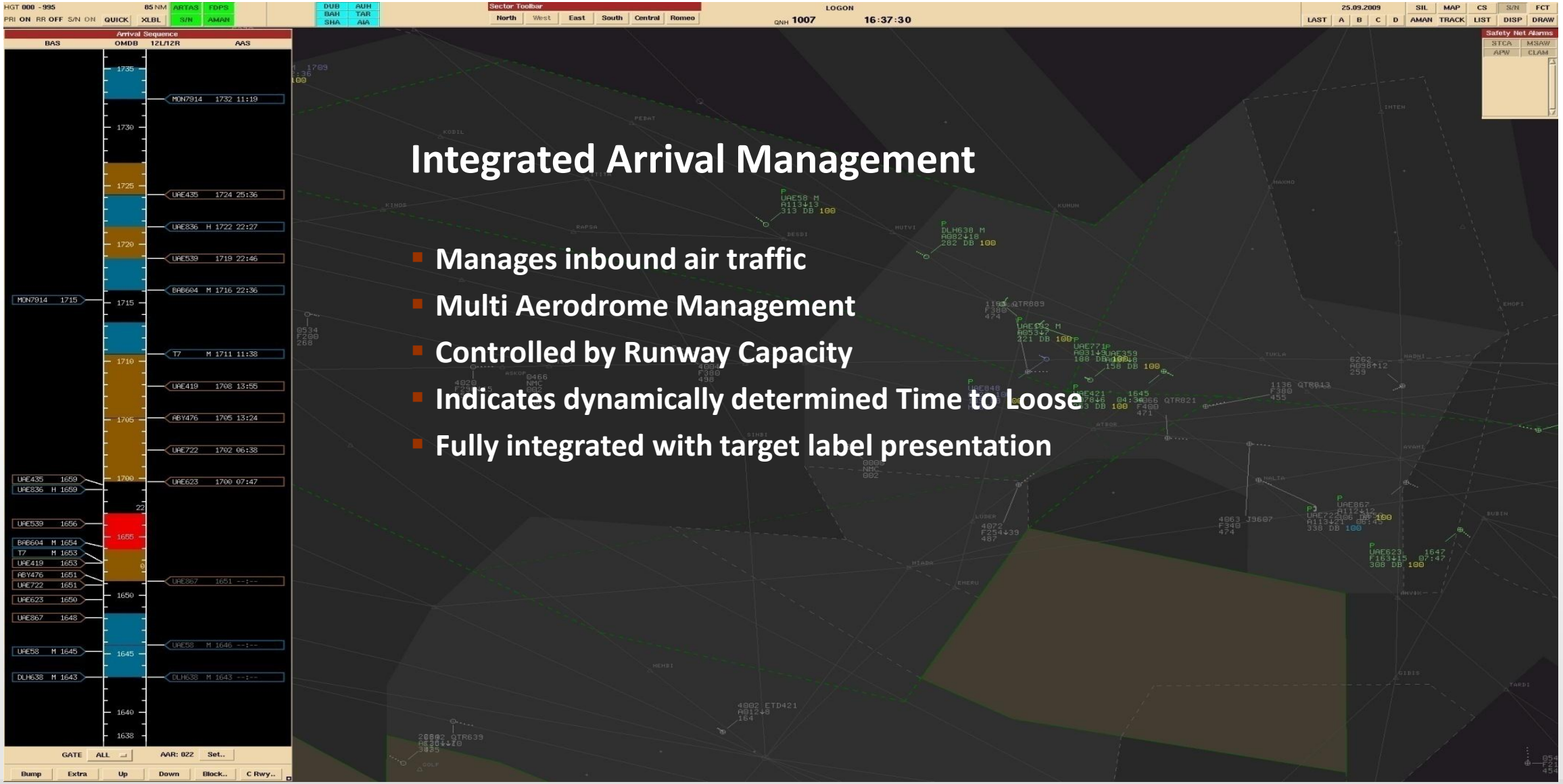
Situational Safety Nets

Route Adherence Monitoring (RAM)

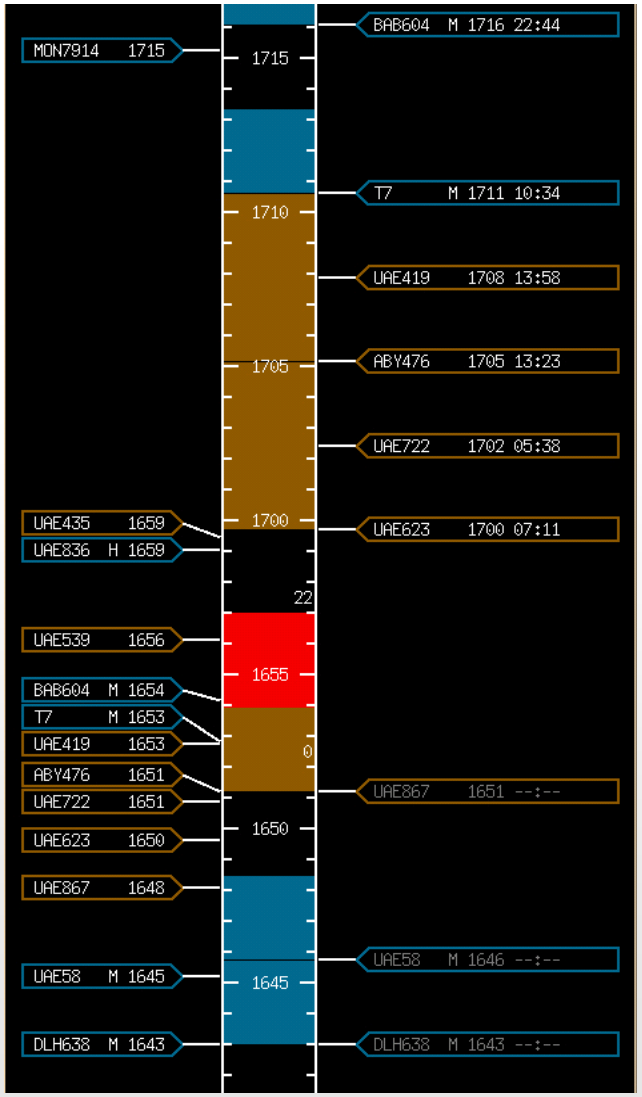
- Compares Actual Position and expected Route
- Also use ADS-C trajectory to monitor conformance



Option - Enhanced Functions



Option - Enhanced Functions



Time Ladder

- Indicates Initial Landing Time
- Allocated Landing Time
- Colour coded Approach Fix
- Time To Loose
- Show Runway block
- Show Scheduled Runway Acceptance Rate

Sheikh Zayed Air Traffic Control Centre

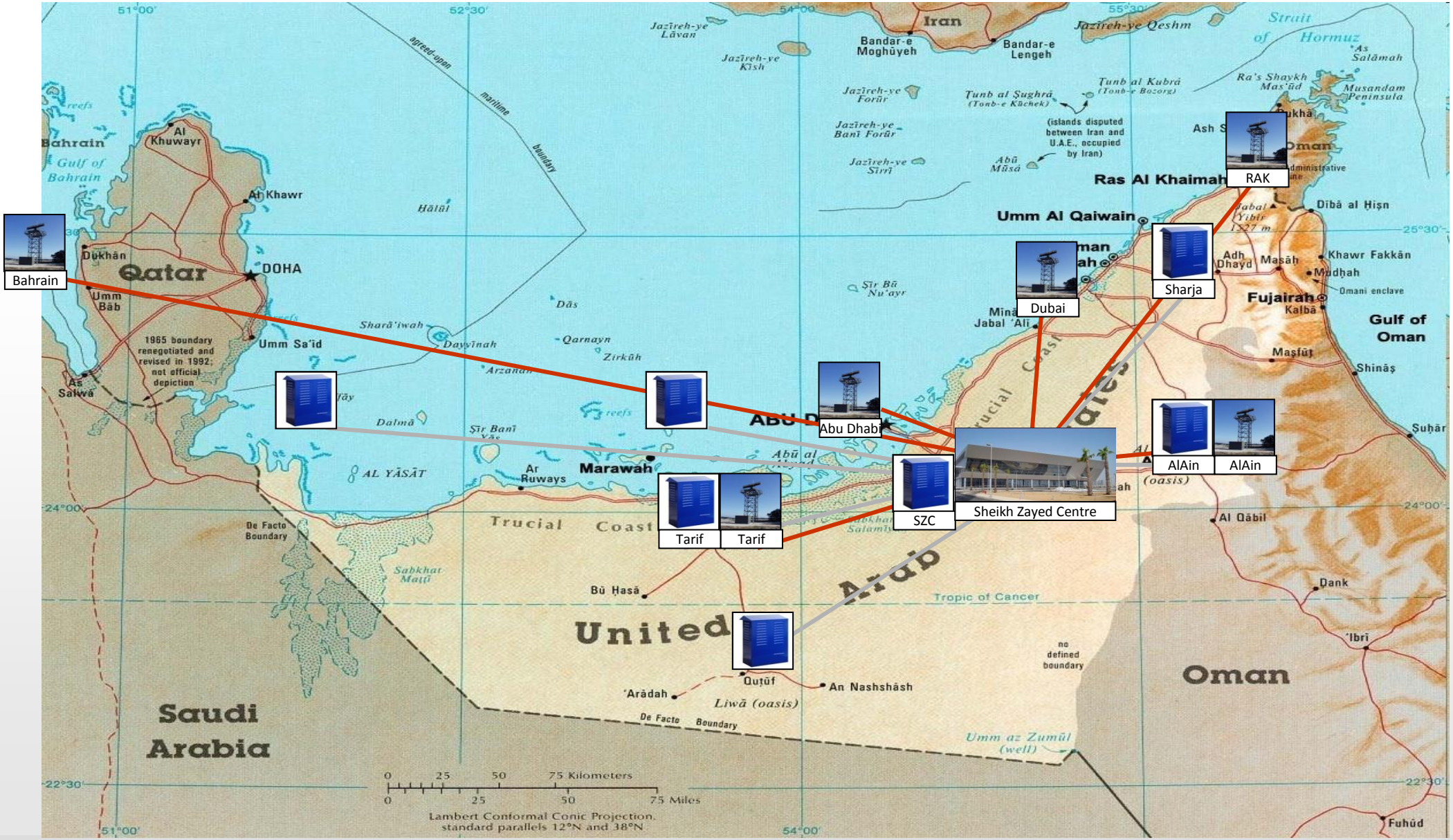
Air Traffic Control Centre

- Autonomous Data Processing
- Controller Working Positions
  - 28 operational positions
  - 2 COM Terminals
  - 1 Supervisor
  - 2 Military Coordination
  - 2 Replay
- Diversity Display System (Independent Surveillance path)

Emergency ACC Building

- Autonomous Data Processing
- Autonomous VCCS
- Training Facility
- 16 Controller Working Positions
  - 8 ops contingency
  - 8 Training Positions
  - 1 Supervisor
- 16 Pseudo Pilot Positions

Surveillance Infrastructure UAE



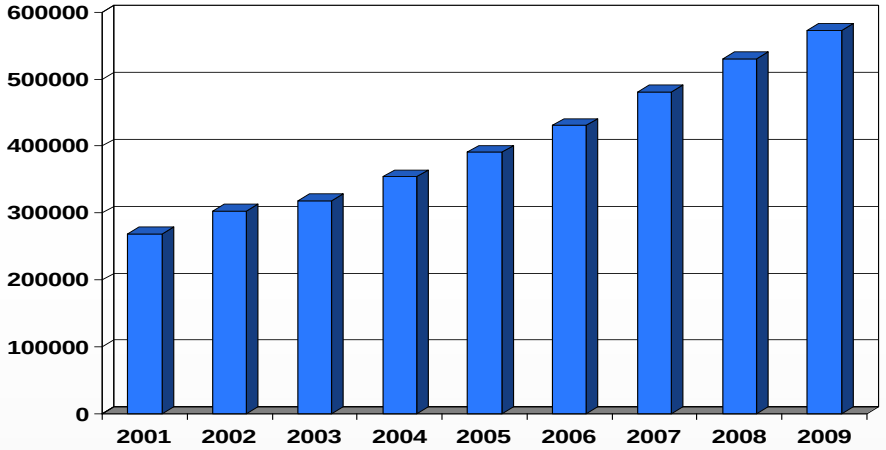
Sheikh Zayed Centre – Abu Dhabi

- Stripless operation
- Jurisdiction and Silent Hand-over
- OLDI / AIDC Connections
- Safety net functions
- Autonomous Diversity System
- Integrated Arrival Manager
- Integrated Flow Control System (extending beyond FIR boundary)
- Military Coordination Cell
- ADS-B Validation Suite

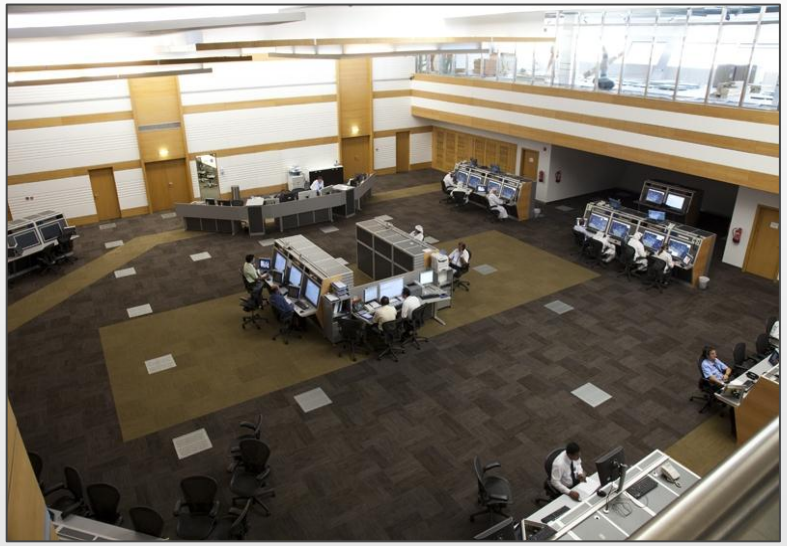
- Military / Civil Approach

- ATC Towers at Remote Sites
- OLDI Integration with several domestic airports

GCAA ATC Operations



- 9 “Radar Sectors”
- Stripless operation
- Integrated Military Approach/Civil Approach MICA
- 3 ATC Towers
- In 2008: more than 530.000 operated flights



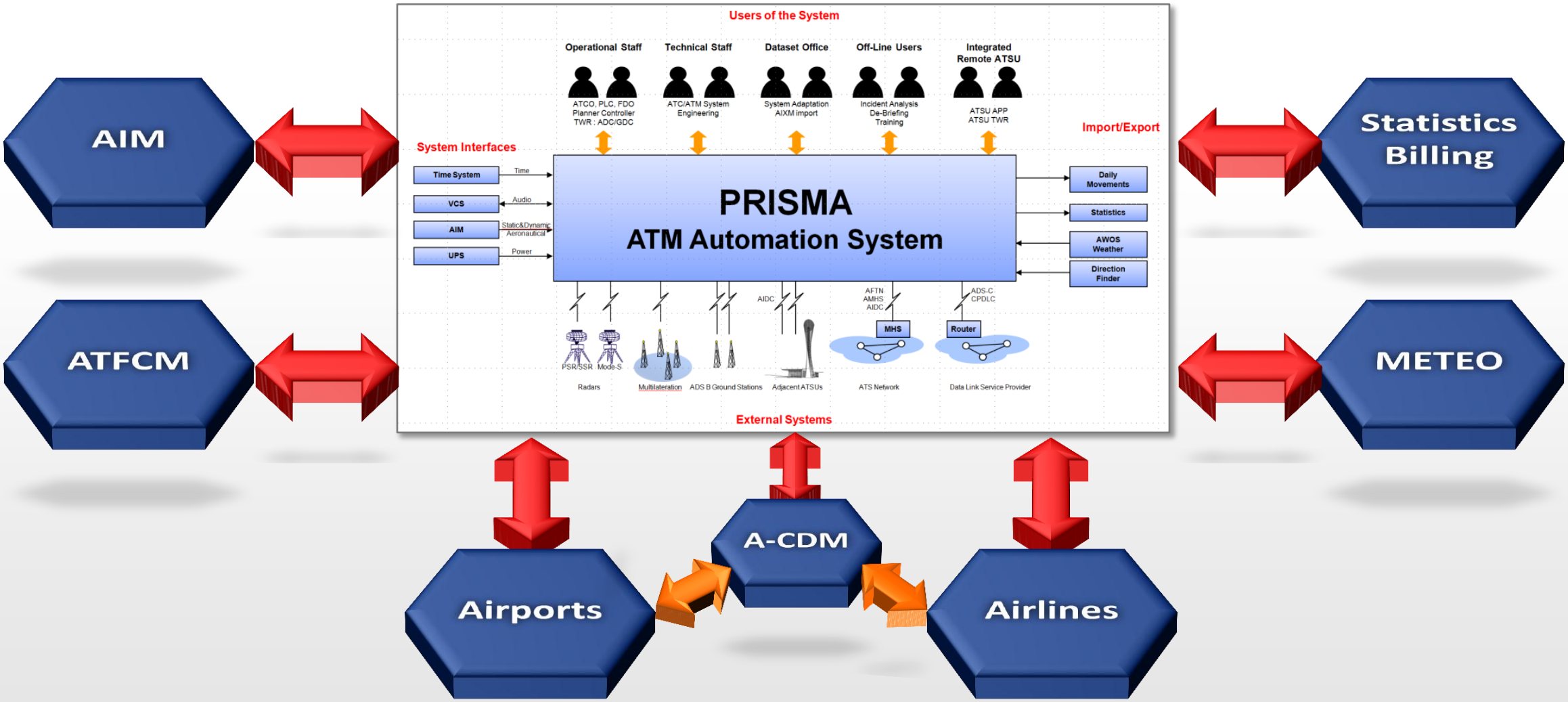
PRISMA Transition to SWIM

System Wide Information Management

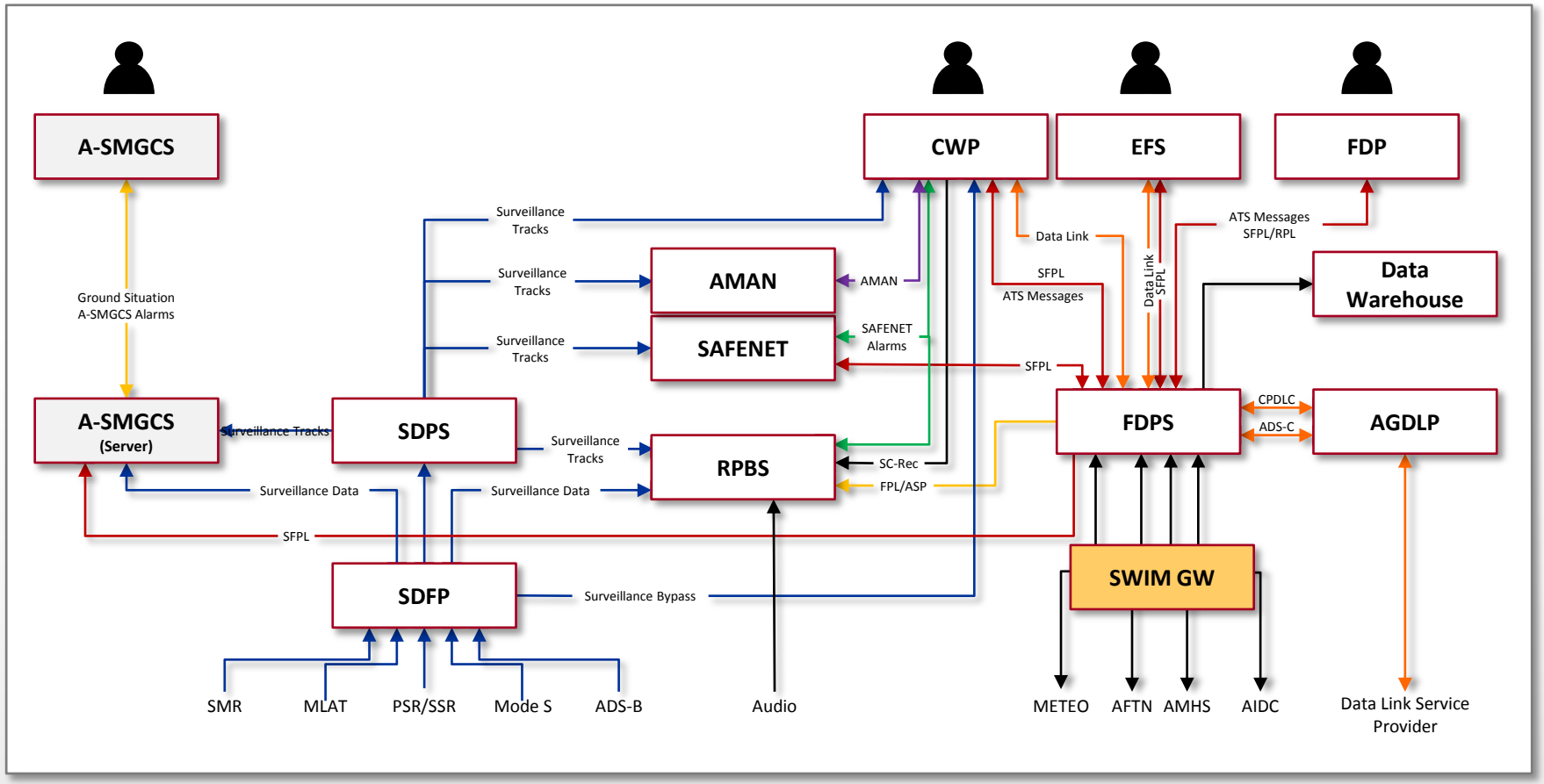
Information to share

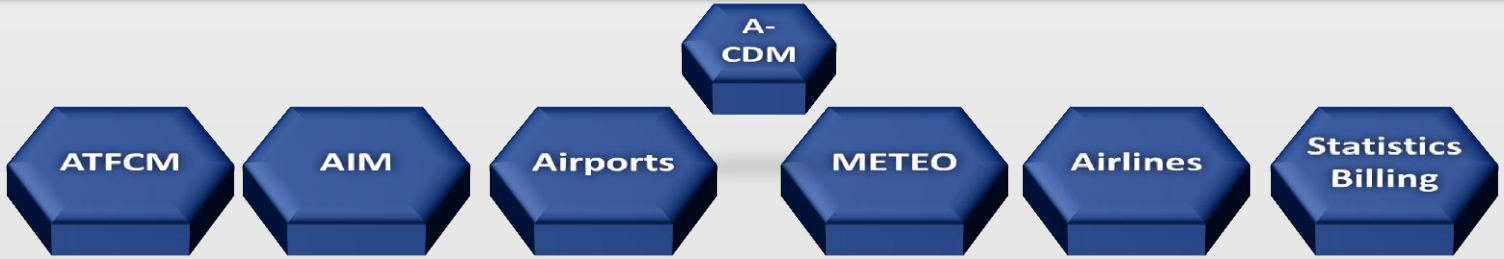
- **Aeronautical Information** - resulting from the assembly, analysis and formatting of aeronautical data
- **Flight trajectory** – the detailed route of the aircraft defined in four dimensions (4D), so that the position of the aircraft is also defined with respect to the time component.
- **Aerodrome operations** – the status of different aspects of the airport, including approaches, runways, taxiways, gate and aircraft turn-around information.
- **Meteorological** – information on the past, current and future state of earth's atmosphere relevant for air traffic'.
- **Air traffic flow** – the network management information necessary to understand the overall air traffic and air traffic services situation.
- **Surveillance – positioning** information from radar, satellite navigation systems, aircraft datalinks, etc.
- **Capacity and demand** – information on the airspace users needs of services, access to airspace and airports and the aircraft already using it.
- **Flight Statistics**– information required for post processing including performance assessments, billing and external services.

Transition into a SWIM Environment



PRISMA Processing Chains (Data Flow)





PRISMA SWIM Gateway

The SWIM Gateway offers a bi-directional interface for data within PRISMA

- Offers Service Oriented Access
  - Request / Response
  - Subsribe Service
- „Translate“ and Encapsulate
- Segregation of Information Environment
- Secure Access to Data (External Authorisation)
- Protect System (Firewall)
- Imports Data by
  - Requesting Data
  - Subsribe Services

Using SWIM over AMHS

- SWIM can be implemented without knowledge / disclosure of IP addressing schemes
- Use AMHS capabilities to encapsulate the HTTP
- Fast track for implementation SWIM without need to build new infrastructure
- Directory Services are available

Thank You

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