



PRISMA ATM Automation System

**A modular ATM Automation Solution and
Transition into a SWIM environment**

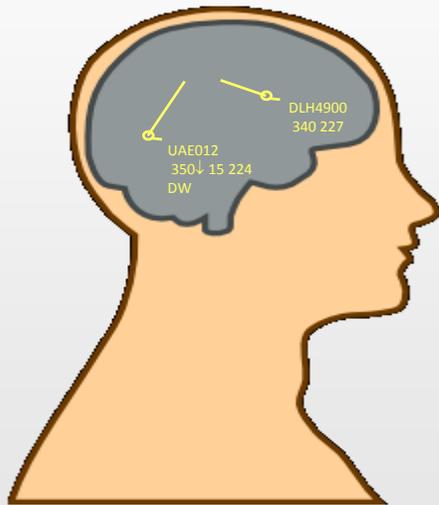
Werner Pitz

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

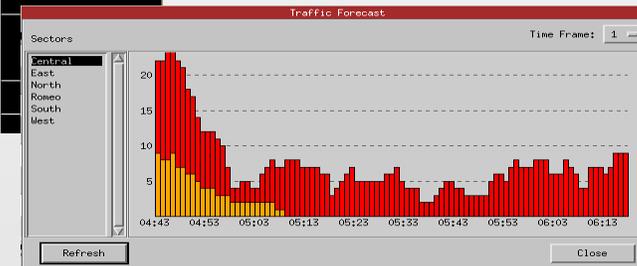
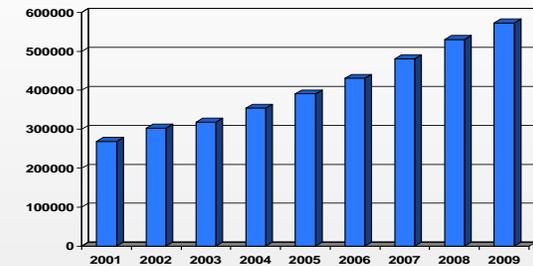
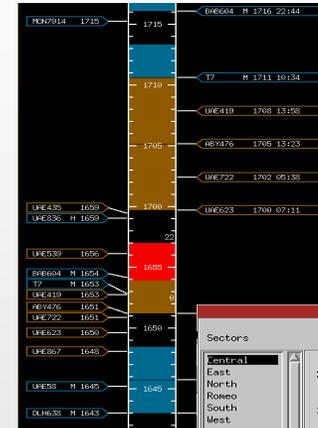
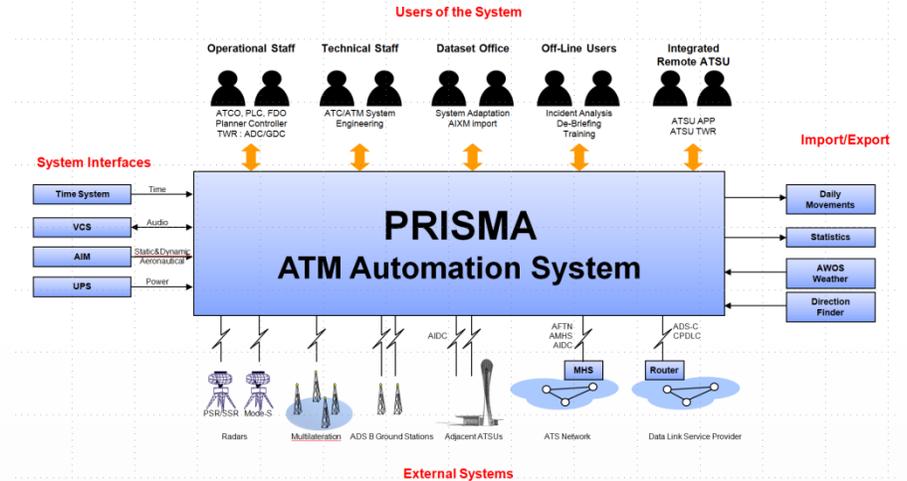
- Early online coordination and updates
- Updating flight profiles
- Integrated performance, complexity and safety monitoring

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

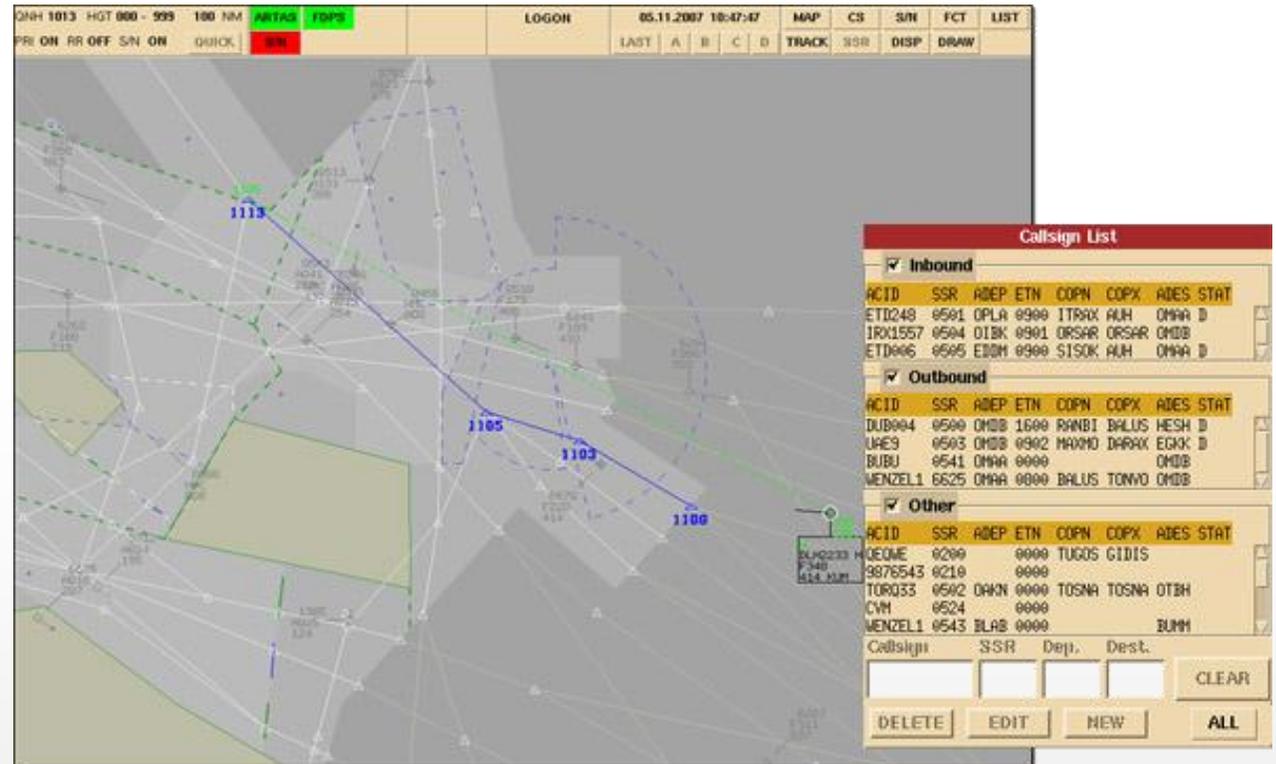
Air Situation Picture

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

Seamlessly supporting heterogeneous Environments

Flight Plan Processing

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

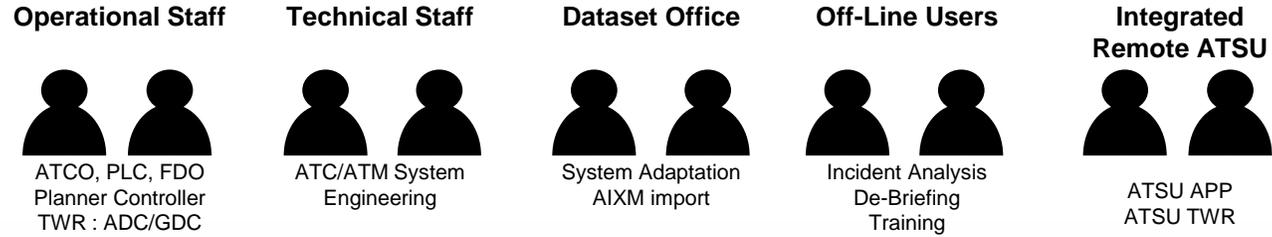


Enhanced Capabilities

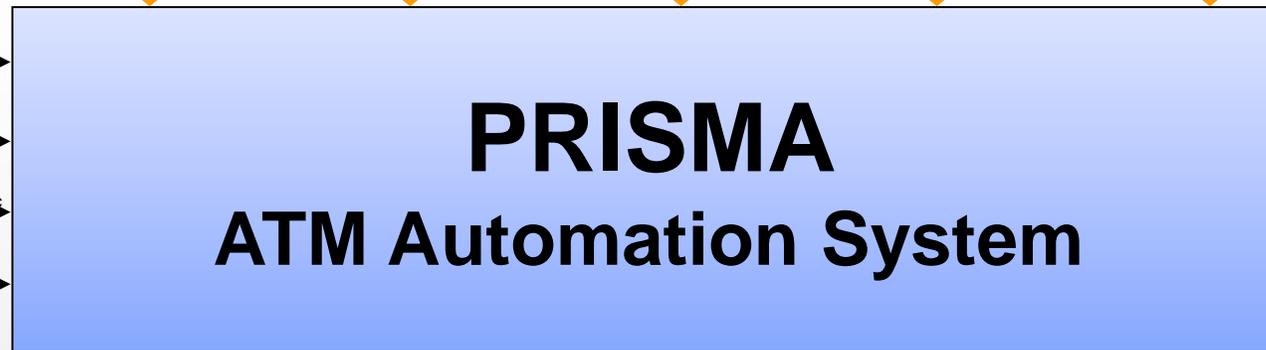
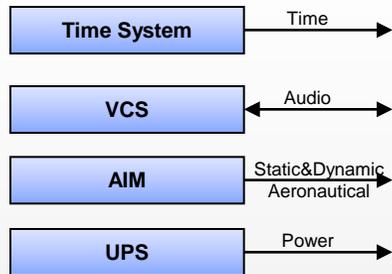
- Multi Site Processing
- Integrated D-FLOW Management
- Integrated Arrival Manager

PRISMA System Boundaries

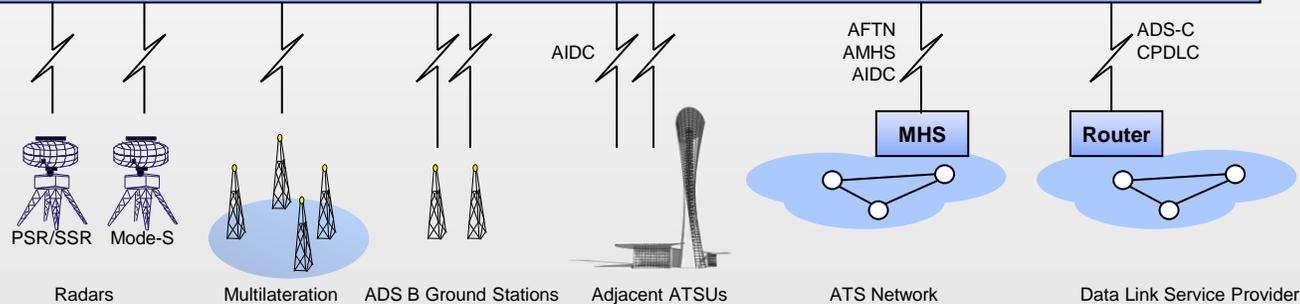
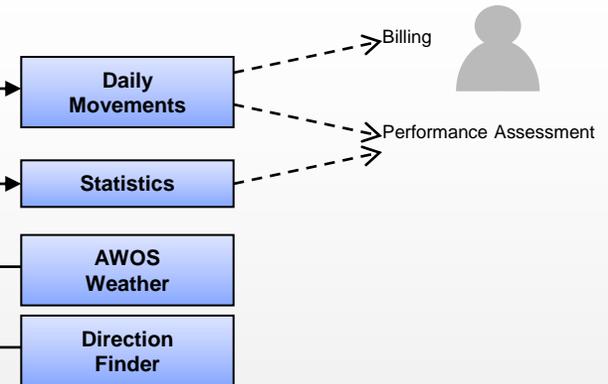
Users of the System



System Interfaces

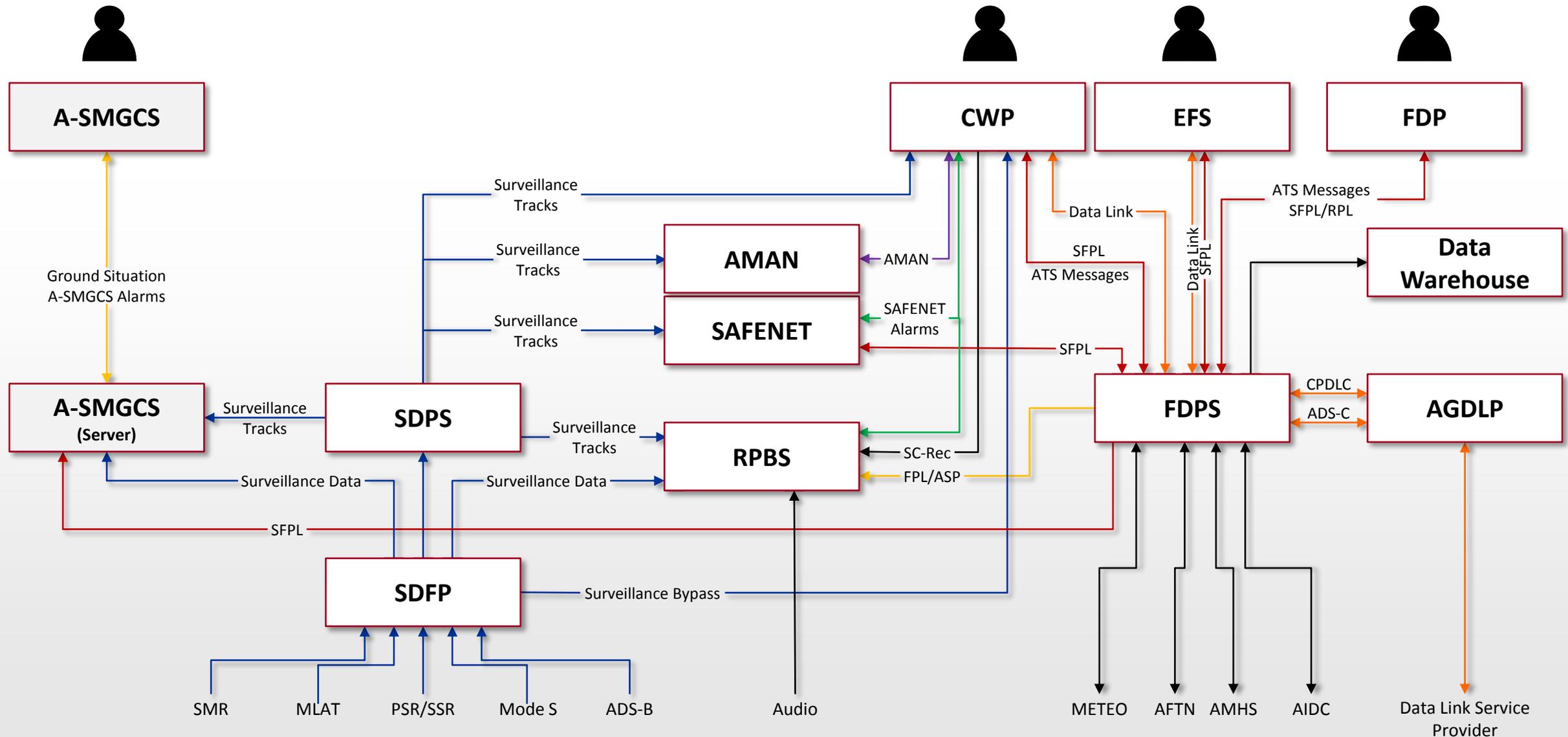


Import/Export



External Systems

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

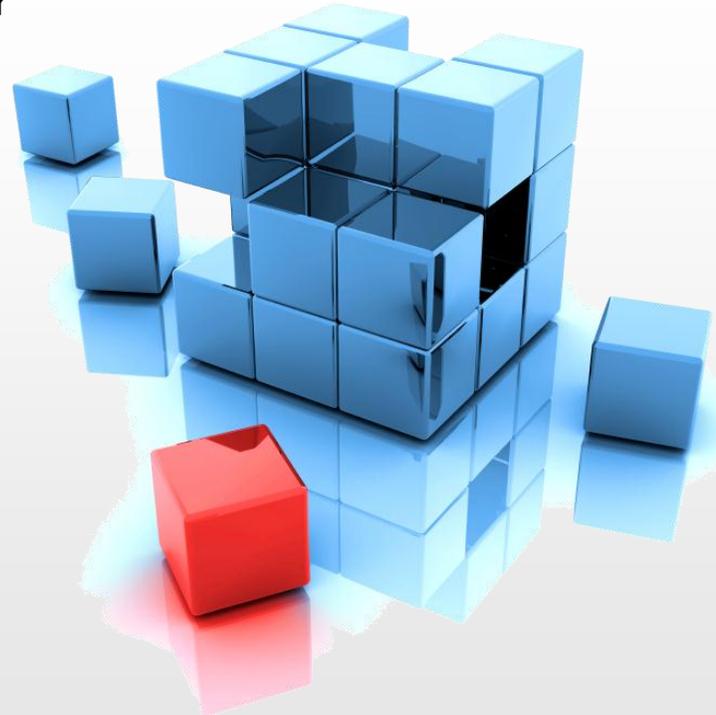
- CWP - Controller Working Position
- EFS – Electronic Flight Strips
- FDP – Flight Plan Data Position

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

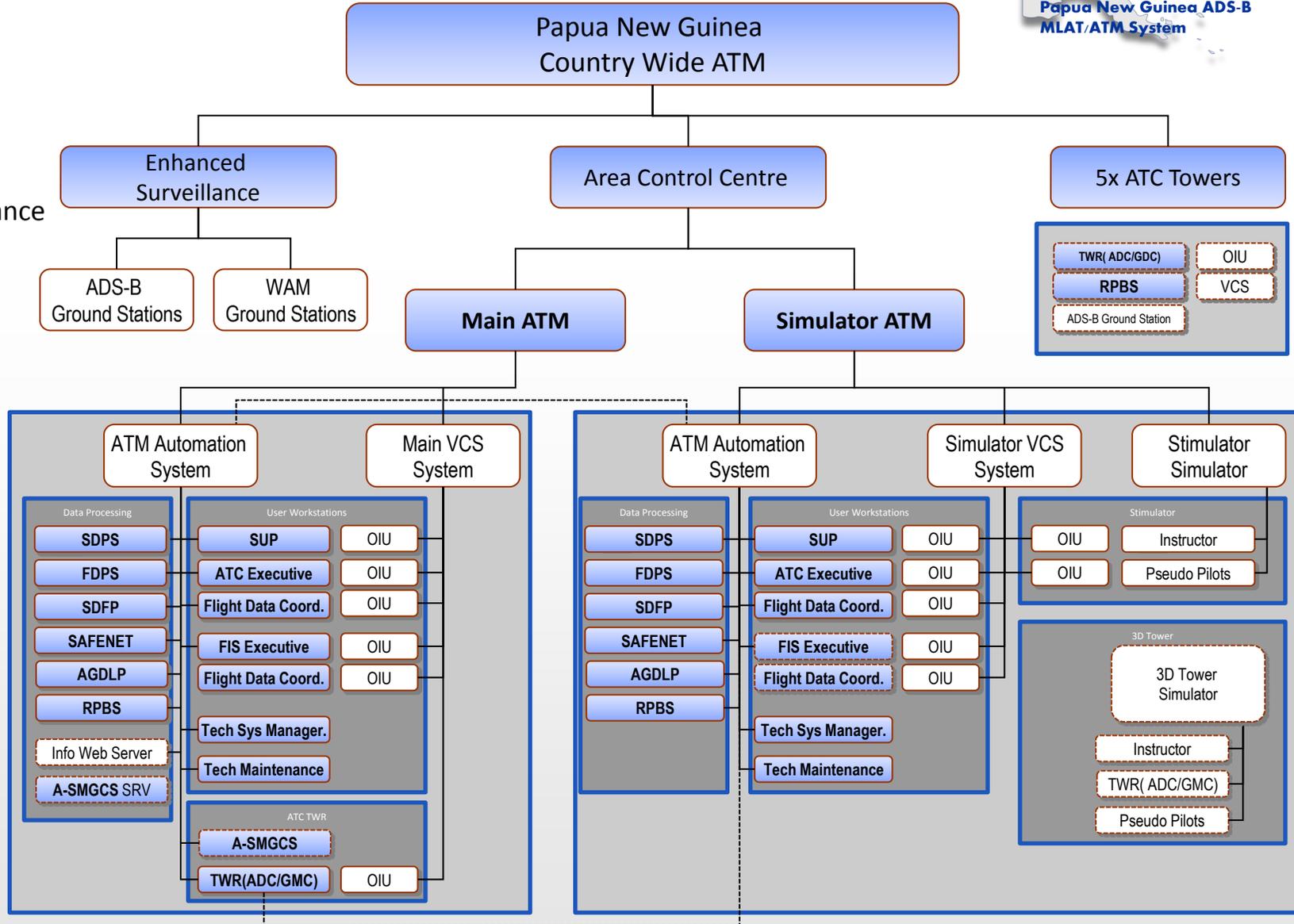
- En-Route Centre
- Integrated Approach Port Moresby
- ATC Tower Port Moresby
- Five ATC Towers connected to Data Processing

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

Bypass Mode

- Present Air Situation using individual surveillance sources
- Local Correlation
- Maintain a Mini Flight Plans Data base (shared between CWP's)

Callsign List

Inbound

ACID	SSR	ADEP	ETN	COPN	ETX	COPX	CTX	CFL	XFL	ADES	FC	ATYP	EQ	STAT
IAC883	6646	VILK	1555	PASOV	1601	BUBIN	350	100	OMSJ	A320	P	CO		
BAB325	6142	OBBI	1509	NADAM	1516	DESDI	1516	340	100	OMDB	A320	P	LT	
AXB191	4012	VIAR	1535	PASOV	1542	BUBIN	1542	100	100	OMDB	B738	P	CO	
JAE333	4051	RPLL	1540	PASOV	1544	BUBIN	1545	300	100	OMDB	B77W	D	CO	
JAE378	4135	OIIE	1549	ORSAR	1554	DESDI	1555	300	100	OMDB	A332	D	CO	
BLK228	0622	OKBK	1548	NADAM	1557	DESDI	1556	100	OMDB	A332	P	CO		

Outbound

ACID	SSR	ADEP	ETN	COPN	ETX	COPX	CTX	CFL	XFL	ADES	FC	ATYP	EQ	STAT
BFA565	0512	OMDB	1530	RANBI	1600	BALUS	1549	130	260	OBBI	A321	P	CO	
ABY505	0546	OMSJ	1530	TARDI	1543	TARDI	1538	300	250	VCBI	A320	P	CO	

Other

ACID	SSR	ADEP	ETN	COPN	ETX	COPX	CTX	CFL	XFL	ADES	FC	ATYP	EQ	STAT
QTR351	1156	VNKT	1602	LALDO	1630	TOSNA		300	300	OTBD	A320	P	CO	
QTR817	4063	VHHH	1520	SODEX	1550	BUNDU	1543	300	300	OTBD	A346	D	CO	
SIA365	6143	LIRF	1540	NADAM	1559	TONVO	1601	300	300	WSSS	B772	D	CO	
JAI594	6673	VOCI	1530	SODEX	1554	BALUS	1554	300	300	OBBI	B738	P	LC	

ACID SSR ADEP ADES

Clear

Edit Delete Save Ctrl Anou Othr All

Exit Aid Window (LH2013)

14:05 TONVO 100

XFL

LH2013

LH2014

DUB0815

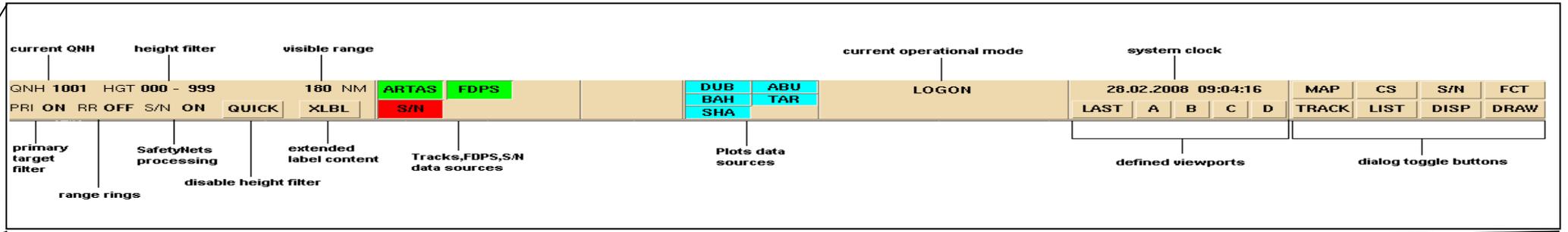
Central

Pointer Location

Hold BUBIN

ACID	AFL	CFL	ADES	HNT	EAT
JAE765	F316	300	JS	0836	0837
AXB312	F172	300	CL	0845	0848
STH7007	F360	130	BI	0901	0904

Display Control Area



The screenshot shows the main radar display with the following elements:

- Control Panel (Top):** QNH 1001, HGT 000 - 999, 180 NM, ARTAS, FDPS, DUB, ABU, BAH, TAR, LOGON, 28.02.2008 09:04:16, MAP, CS, S/N, FCT, TRACK, LIST, DISP, DRAW.
- Sector Toolbar:** North, West, East, South, Central.
- Map Area:** Radar display showing flight tracks, terrain, and various data points (e.g., 0544, 5562, 6741, 6273, 6240, 6617, 4008, 4046, 6604, 0460, 0467, 0456, 0466, 0465, 0464, 0463, 0462, 0461, 0460, 0459, 0458, 0457, 0456, 0455, 0454, 0453, 0452, 0451, 0450, 0449, 0448, 0447, 0446, 0445, 0444, 0443, 0442, 0441, 0440, 0439, 0438, 0437, 0436, 0435, 0434, 0433, 0432, 0431, 0430, 0429, 0428, 0427, 0426, 0425, 0424, 0423, 0422, 0421, 0420, 0419, 0418, 0417, 0416, 0415, 0414, 0413, 0412, 0411, 0410, 0409, 0408, 0407, 0406, 0405, 0404, 0403, 0402, 0401, 0400, 0399, 0398, 0397, 0396, 0395, 0394, 0393, 0392, 0391, 0390, 0389, 0388, 0387, 0386, 0385, 0384, 0383, 0382, 0381, 0380, 0379, 0378, 0377, 0376, 0375, 0374, 0373, 0372, 0371, 0370, 0369, 0368, 0367, 0366, 0365, 0364, 0363, 0362, 0361, 0360, 0359, 0358, 0357, 0356, 0355, 0354, 0353, 0352, 0351, 0350, 0349, 0348, 0347, 0346, 0345, 0344, 0343, 0342, 0341, 0340, 0339, 0338, 0337, 0336, 0335, 0334, 0333, 0332, 0331, 0330, 0329, 0328, 0327, 0326, 0325, 0324, 0323, 0322, 0321, 0320, 0319, 0318, 0317, 0316, 0315, 0314, 0313, 0312, 0311, 0310, 0309, 0308, 0307, 0306, 0305, 0304, 0303, 0302, 0301, 0300, 0299, 0298, 0297, 0296, 0295, 0294, 0293, 0292, 0291, 0290, 0289, 0288, 0287, 0286, 0285, 0284, 0283, 0282, 0281, 0280, 0279, 0278, 0277, 0276, 0275, 0274, 0273, 0272, 0271, 0270, 0269, 0268, 0267, 0266, 0265, 0264, 0263, 0262, 0261, 0260, 0259, 0258, 0257, 0256, 0255, 0254, 0253, 0252, 0251, 0250, 0249, 0248, 0247, 0246, 0245, 0244, 0243, 0242, 0241, 0240, 0239, 0238, 0237, 0236, 0235, 0234, 0233, 0232, 0231, 0230, 0229, 0228, 0227, 0226, 0225, 0224, 0223, 0222, 0221, 0220, 0219, 0218, 0217, 0216, 0215, 0214, 0213, 0212, 0211, 0210, 0209, 0208, 0207, 0206, 0205, 0204, 0203, 0202, 0201, 0200).
- Pointer Location:** 26:38:40 N 056:12:37 E

The inset window displays a vertical scale for CFL IL (Climax Filter Level) with the following values:

- 260
- 250
- 240
- 230
- 220
- 210
- 200

Additional text in the inset includes: UAE9991 H, F200, 258 DAR 25, and KINO.

CWP in A-SMGCS Mode

HGT 000 - 995 0.82 NM FUSION DM SYS FUS CAT10
QUICK XLBL CTRL RED CAT20 CAT21 LOGOFF Standard 12.06.2013 TRACK LIST MBL FCT
QNH 1013 14:07:28 LAST A B C D MAP TCTX ALRT

Alert List	
Time	Alert Type

PRISMA SMGCS-DS

- Fusion Tracking
- ADS-B / WAM / SMR
- Air Situation integrated
- A-SMGCS Level 2

Pointer Location

0123
00007B
A000
004

0555
00007B
A000
12F

0555
A000
008

Electronic Flight Strips

System SFPL ATS Messages User Ground Control FDP5 ON LOGOFF Login control 25.07.2013 07:31:21 EFS-DEMO COMSOFT

Push Back / Parking

Sorted by **Manually**

GIA7119	350	1045	WIII	TAXI
B743 + 497	HSUTS			

Taxi

Sorted by **Manually**

PIA2052	470	OPKC	PRK
B772 ^ 470	AP		

UAE2734	410	0940	OMDB	16R
B773 ^ 475	VFR	A6EBV		

SVA4253	350	0745	VOMM	16C
B743 + 460	HSVAN			

Runway 16L/34R

Sorted by **Manually**

ETD2345	410	0930	OMAA	LUAW
A332 + 463	A6-EYE			

TJK3122	410	0830	UTDL	CROSS
L101 + 480	N194AT			

Start Up / Shut Down

Sorted by **ETD**

ABY146	390	1130	OMSJ	PUSH
A320 446	A6ABZ			

AIC890	330	1130	VIDP	PUSH
A332 + 466	VTIWA			

Runway 16C/34C

Sorted by **Manually**

GIA1217	350	0825	WAAA	CROSS
B763 + 467	GDAJC			

Cleared

Sorted by **ETD**

SMY3010	B733	OMSJ	1225	known AIRI	UP
OMSJ					

SMY3010	330	1135	OMSJ	UP
B733 443	HZCJB			

Startup delayed due to technical problems

Runway 16R/34L

Sorted by **Manually**

PIA3604	491	OPKC	TAXI
B743 ^ 491	APBFW		

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

The screenshot displays a 'Taxi' interface with a 'Sorted by Manually' dropdown. It shows three flight strips, each with a left and right arrow button. The first strip (PIA2052) has a green header and footer. The second (UAE2734) and third (SVA4253) have blue headers and footers. Each strip contains flight details such as flight number, aircraft type, altitude, and gate information.

Flight Number	Aircraft	Altitude	Operator	Gate
PIA2052	B772 ^	470	AP	PRK
UAE2734	B773 ^	475	A6EBV	16R
SVA4253	B743 +	460	HSVAN	16C

Surveillance Data Processing



Multi-Sensor Fusion Tracker

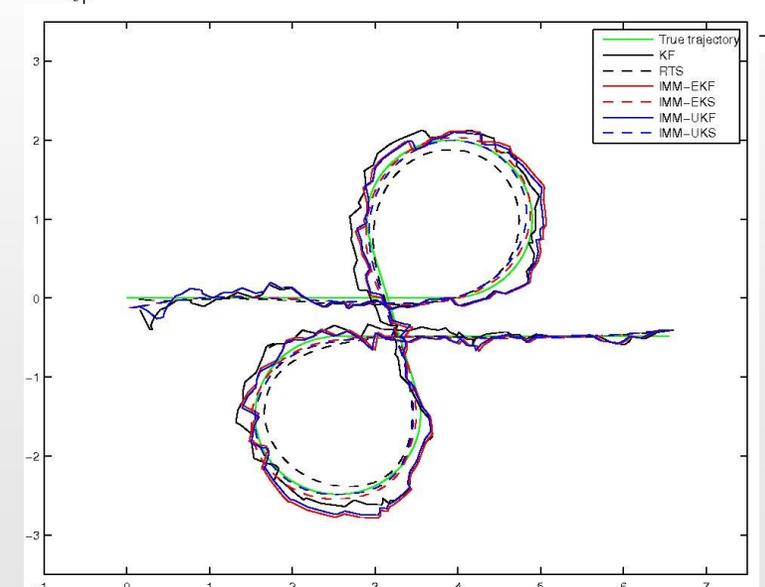
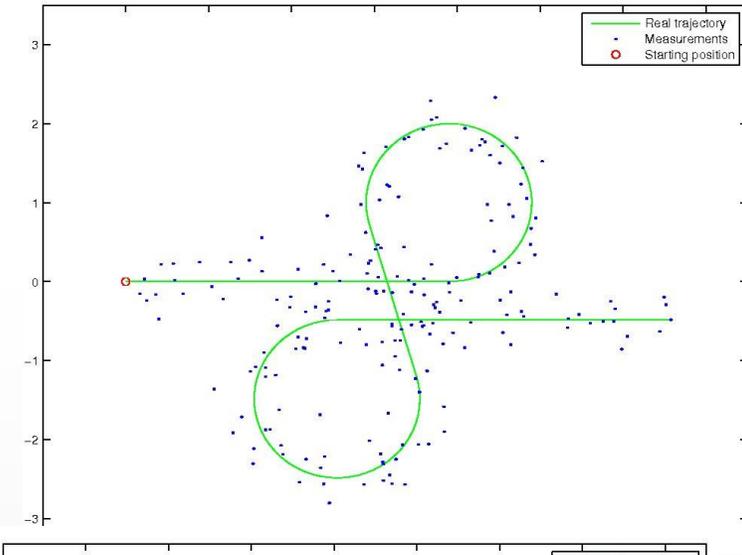
- Domain of Interest (DOI) of max 2048 x 2048 NM 4000 system tracks
- 120 surveillance data sources

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

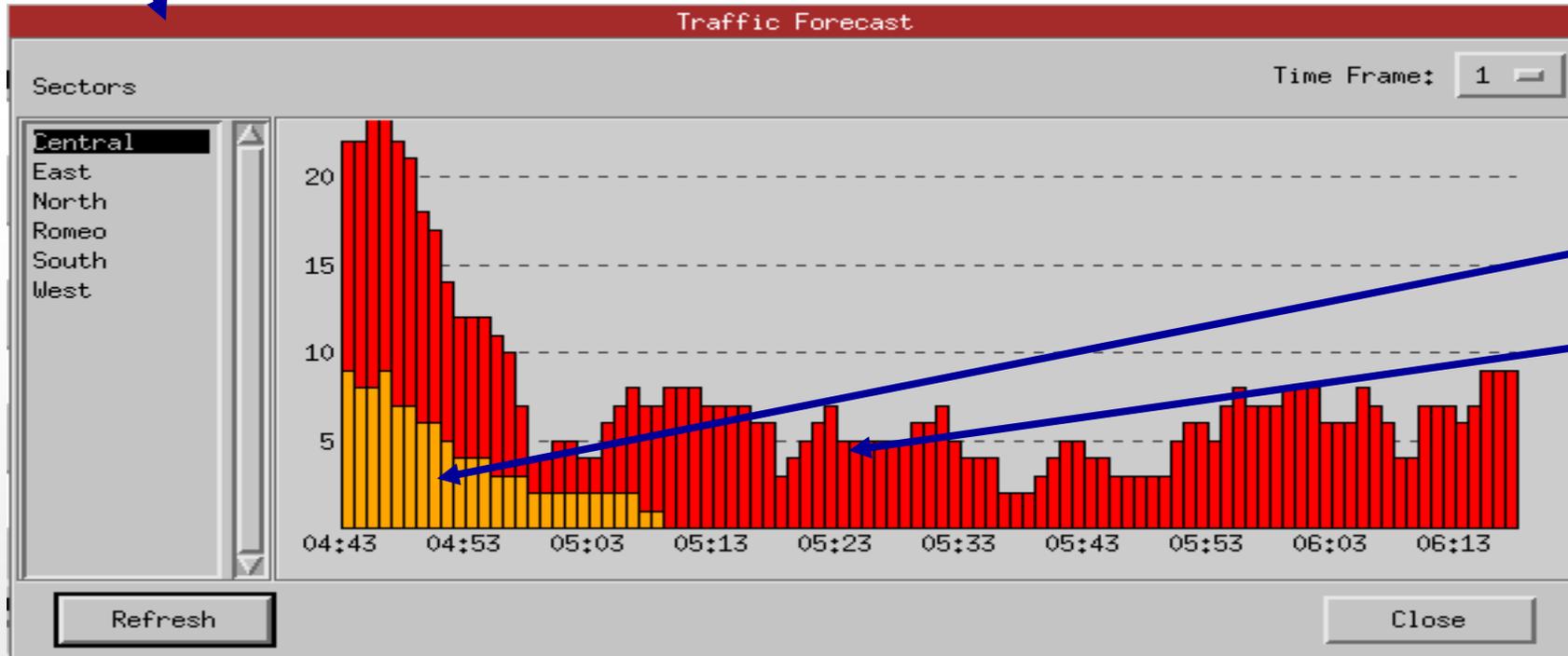
- Dependent Surveillance with high quality
- Omitting Garbling
- High Frequency / low latency position updates
- Dense Areas / Holding Patterns

ADS-C

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

Traffic Forecast

Sectors / Waypoints / Aerodromes



Forecast Traffic in Sector

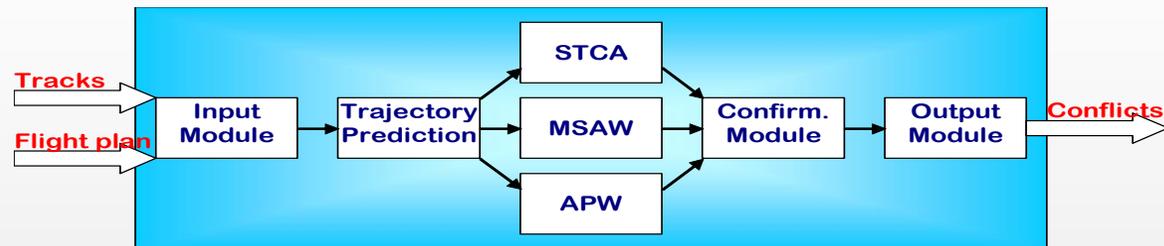
Coordinated

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

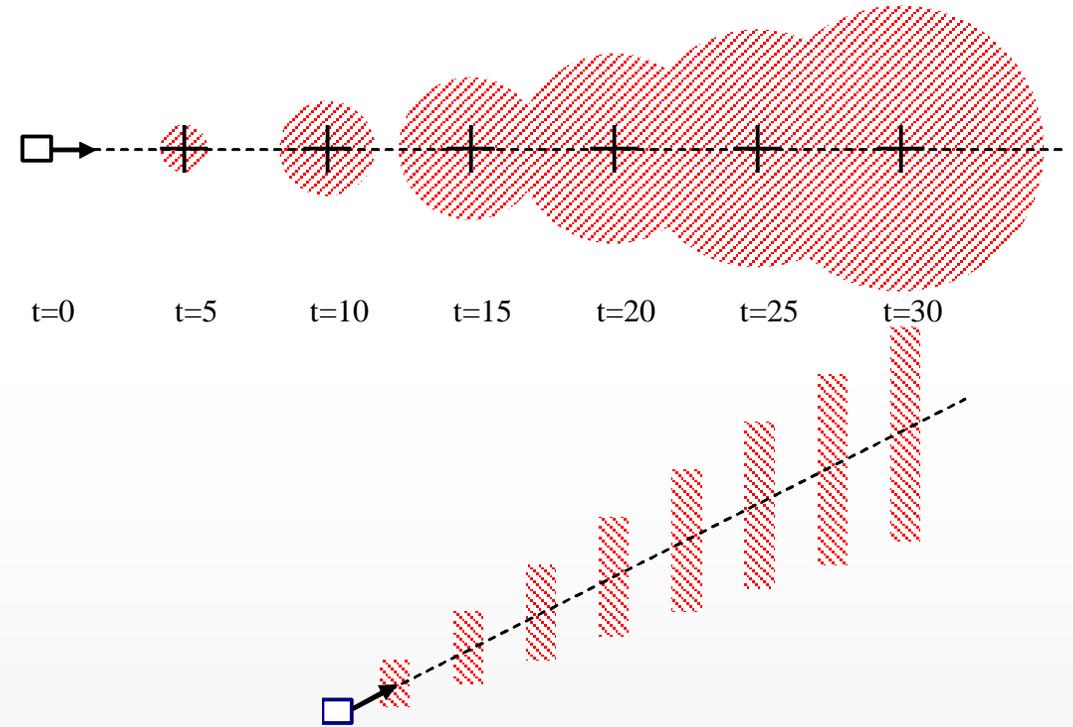
- Compare current situation with planned situation and flag (significant) divergence
- Cleared Level Adherence Monitor (CLAM)
- Route Adherence Monitor (RAM)
- Lost Track Warning (LTW)
- RVSM / PBN Adherence

Enhanced Processing

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

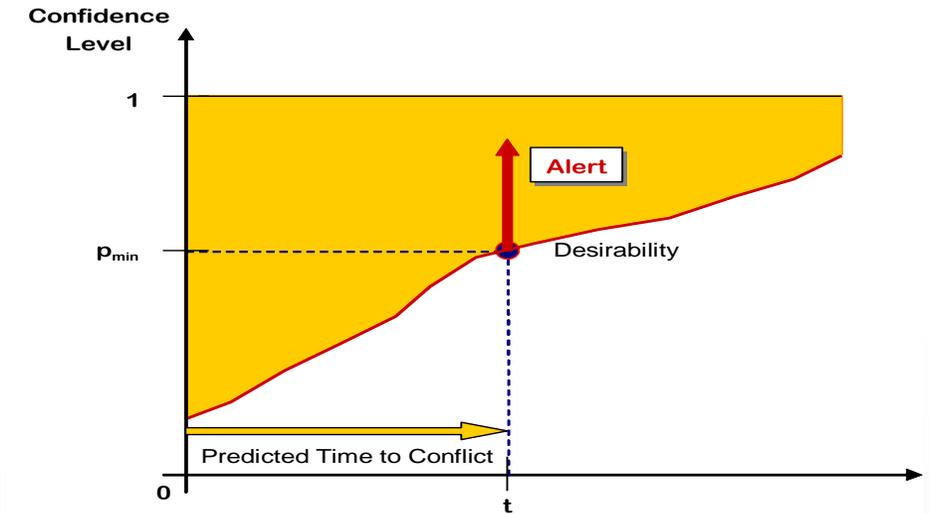
Predictive Safety Nets

- Based on trajectories predicted from surveillance data
- **Uncertainty** of trajectory prediction
 - Short term prediction time frame
 - Typically **2 minutes** : good trade-off
- warning time \leftrightarrow 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
 - Desirability 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

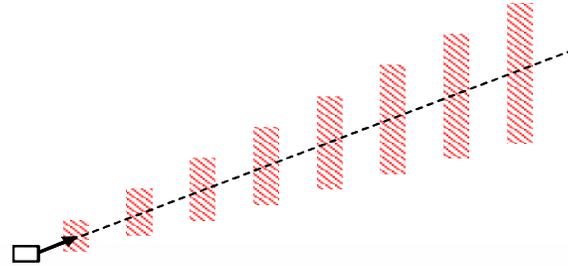


STCA

Use of Cleared Flight Level and Downlinked Parameters

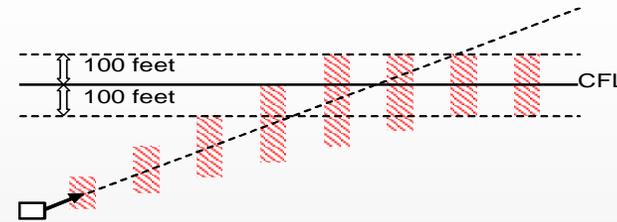
Without clipping

- Linear extrapolation until max time is reached (2 min)



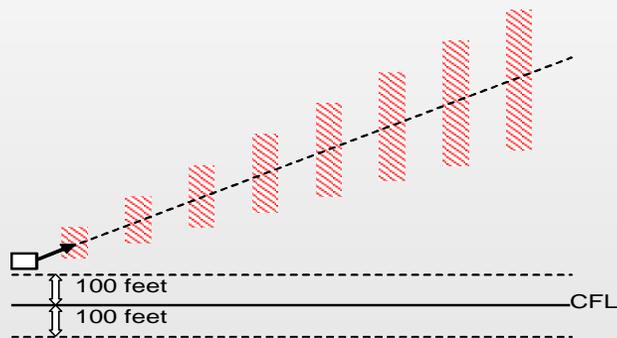
With clipping

- Linear extrapolation until CFL
- Levelled clipping after CFL
 - Lower bound: $CFL - 100$ feet
 - Upper bound: $CFL + 100$ feet



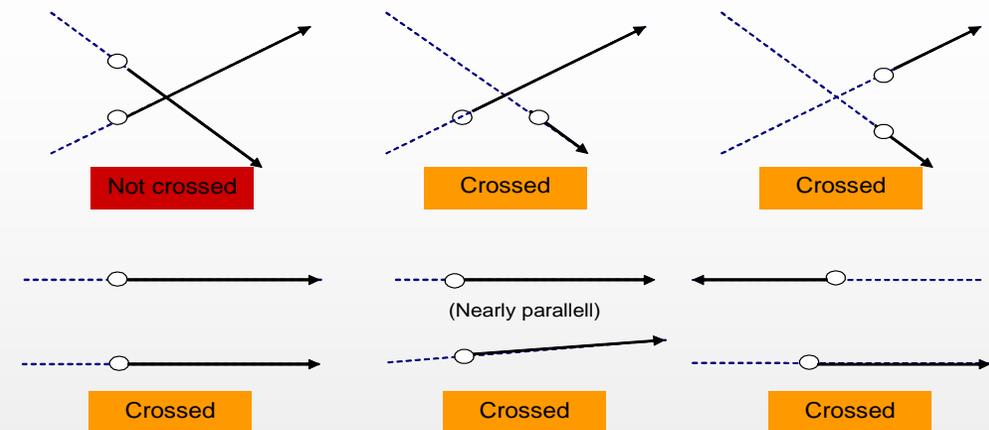
Case of level bust

- 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:

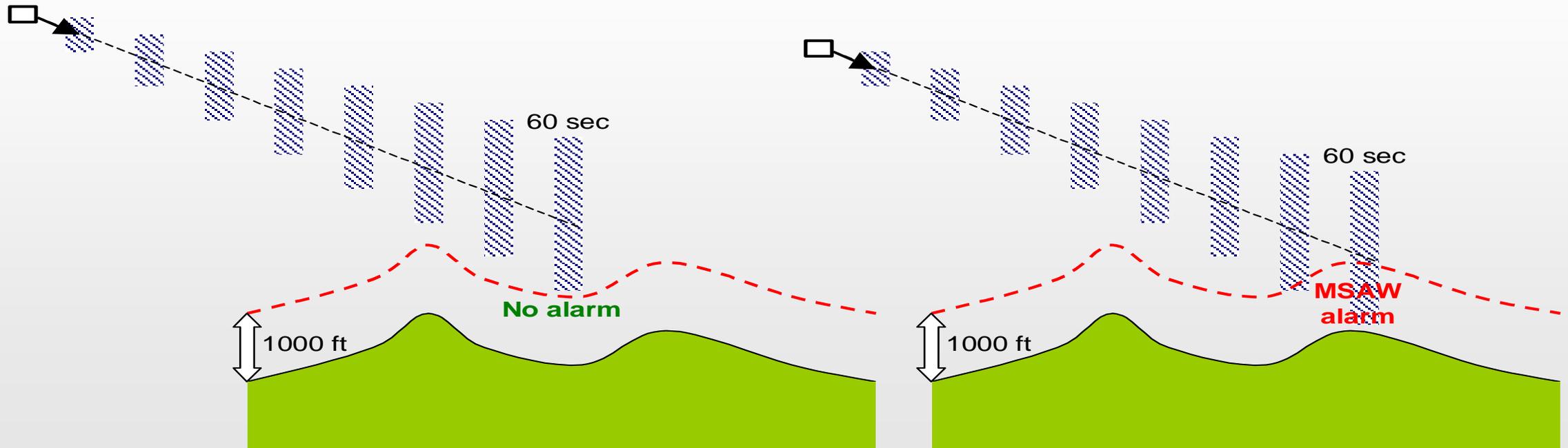
Use QNH-corrected mode C

Minimum safe altitude = terrain + 1000 feet

Configurable warning time

Depends on MSAW region

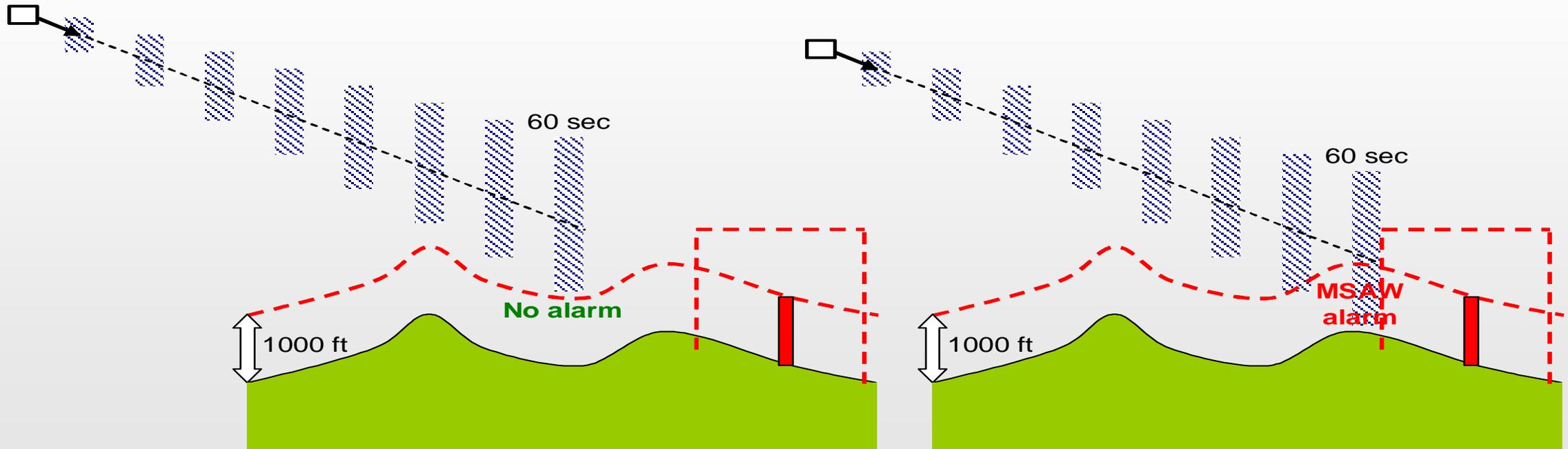
Typically 40 sec to 1 min



Operational Concepts: MSAW

Obstacles

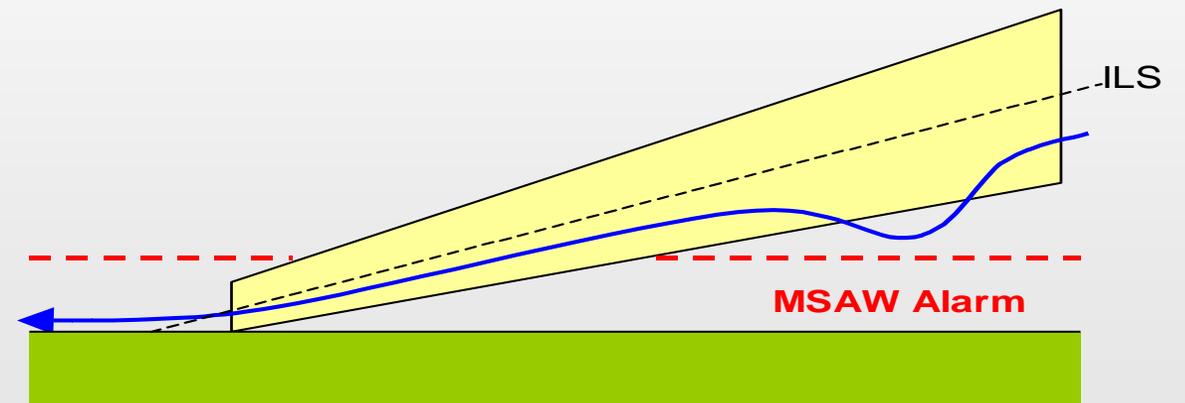
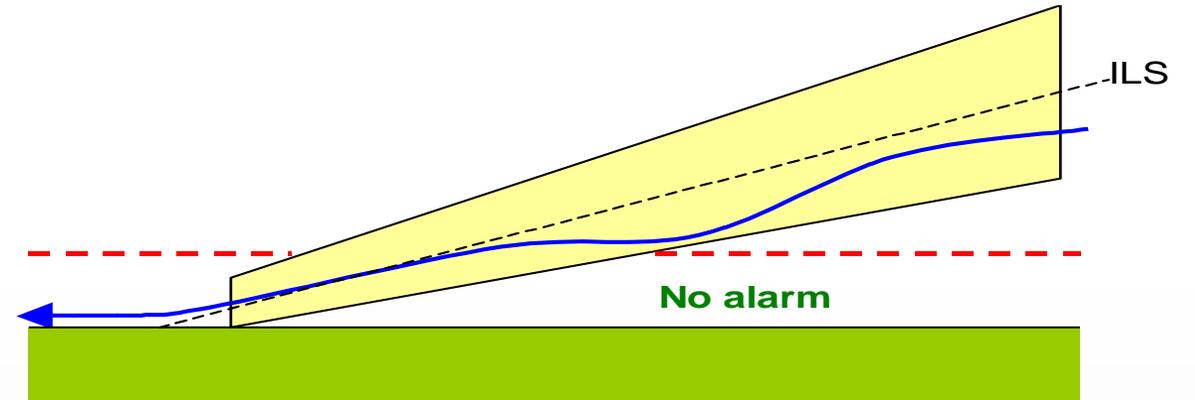
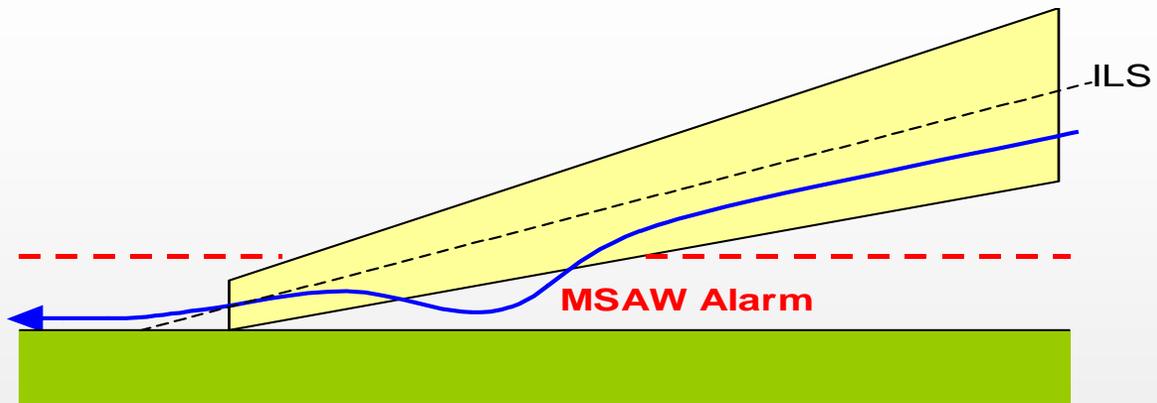
- Man build structures which raise significantly the minimum safe altitude
- Local definitions by WGS-84



MSAW with Approach Path Monitor

MSAW glide slope protection

- Integrated Function of MSAW
- Responsibility of Controller



Situational Safety Nets

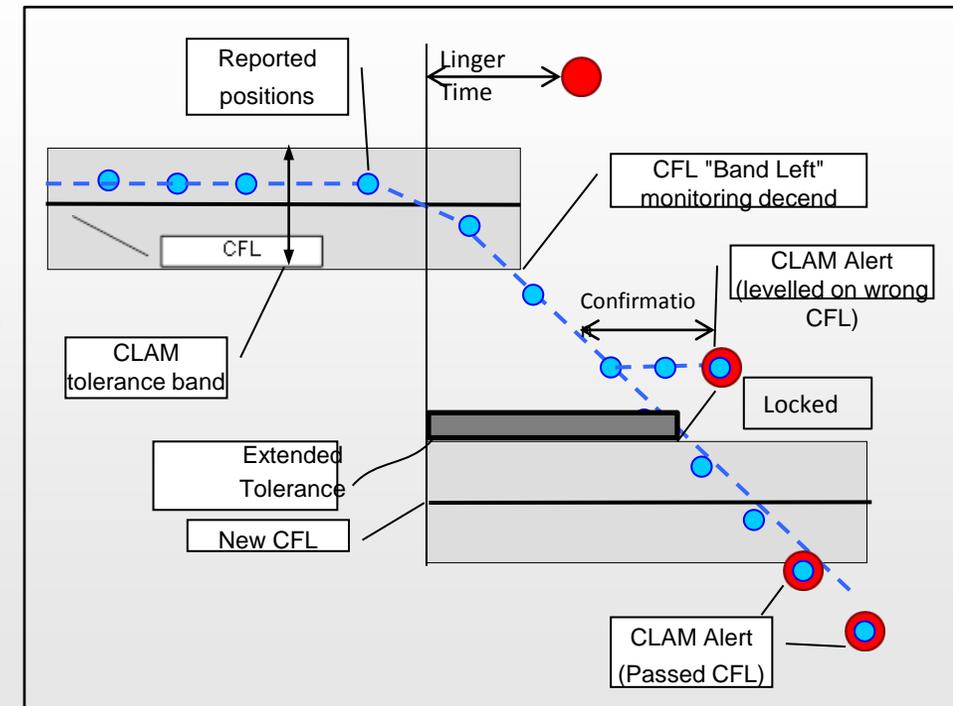
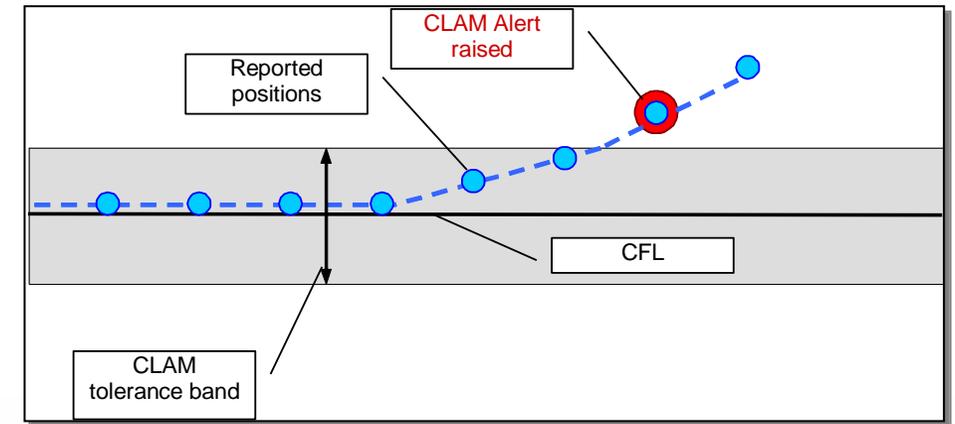
Shared Characteristics

- 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

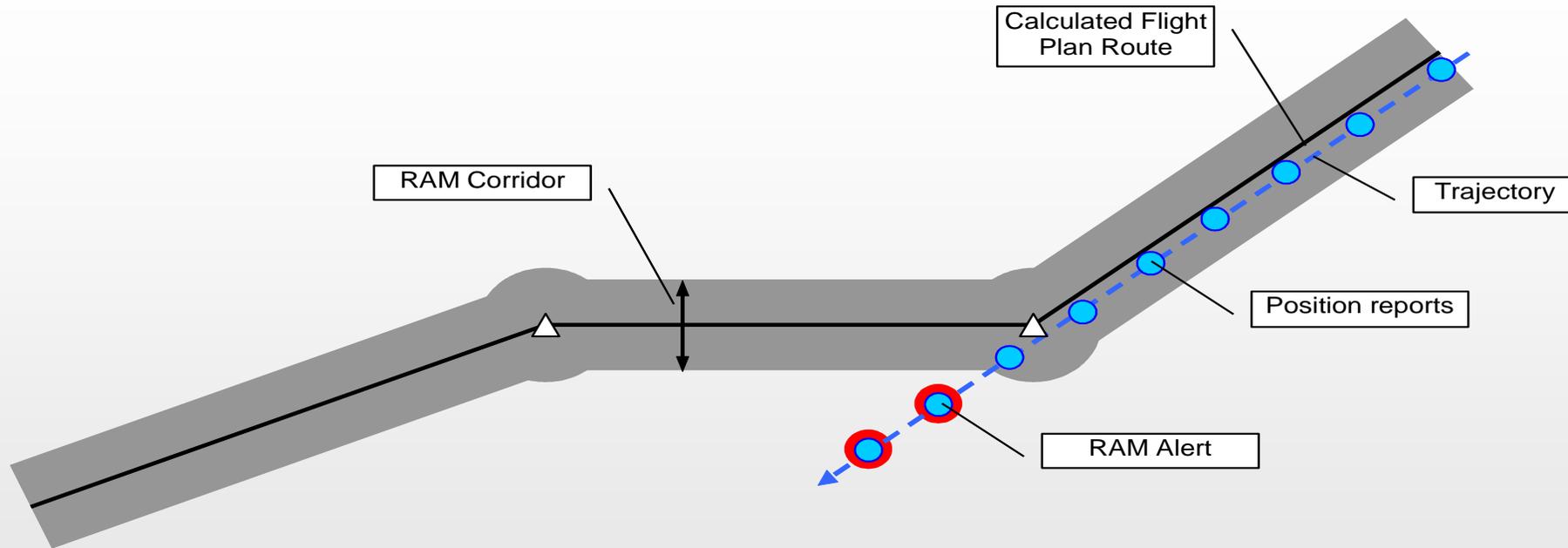
Use of Downlinked Parameters to Monitor Selected Altitude DAP



Situational Safety Nets

Route Adherence Monitoring (RAM)

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

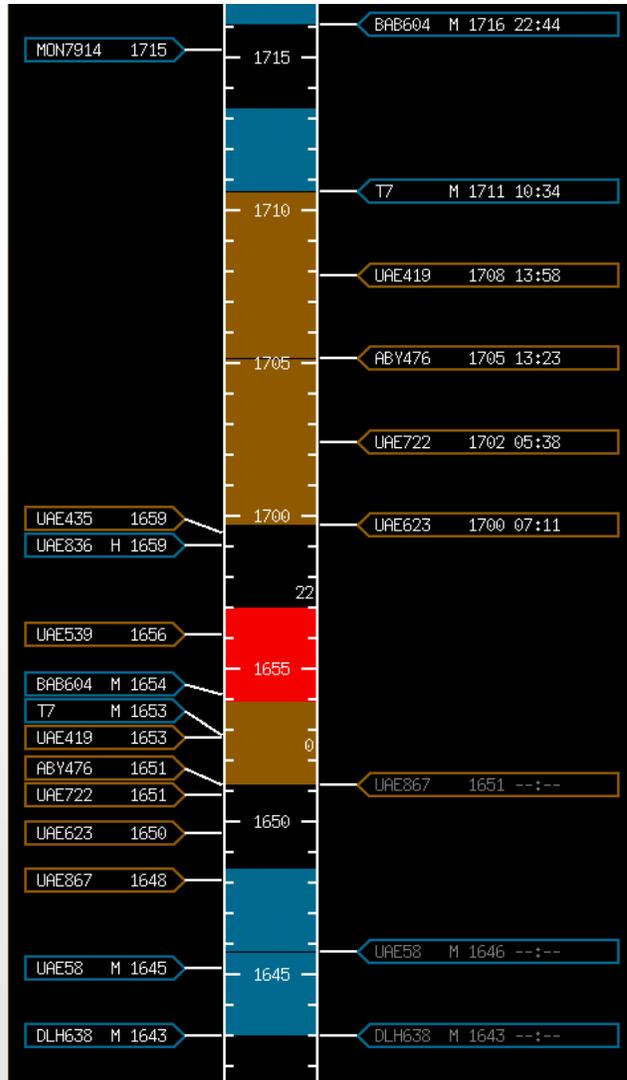


Option - Enhanced Functions

Integrated Arrival Management

- Manages inbound air traffic
- Multi Aerodrome Management
- Controlled by Runway Capacity
- Indicates dynamically determined Time to Loose
- Fully integrated with target label presentation

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

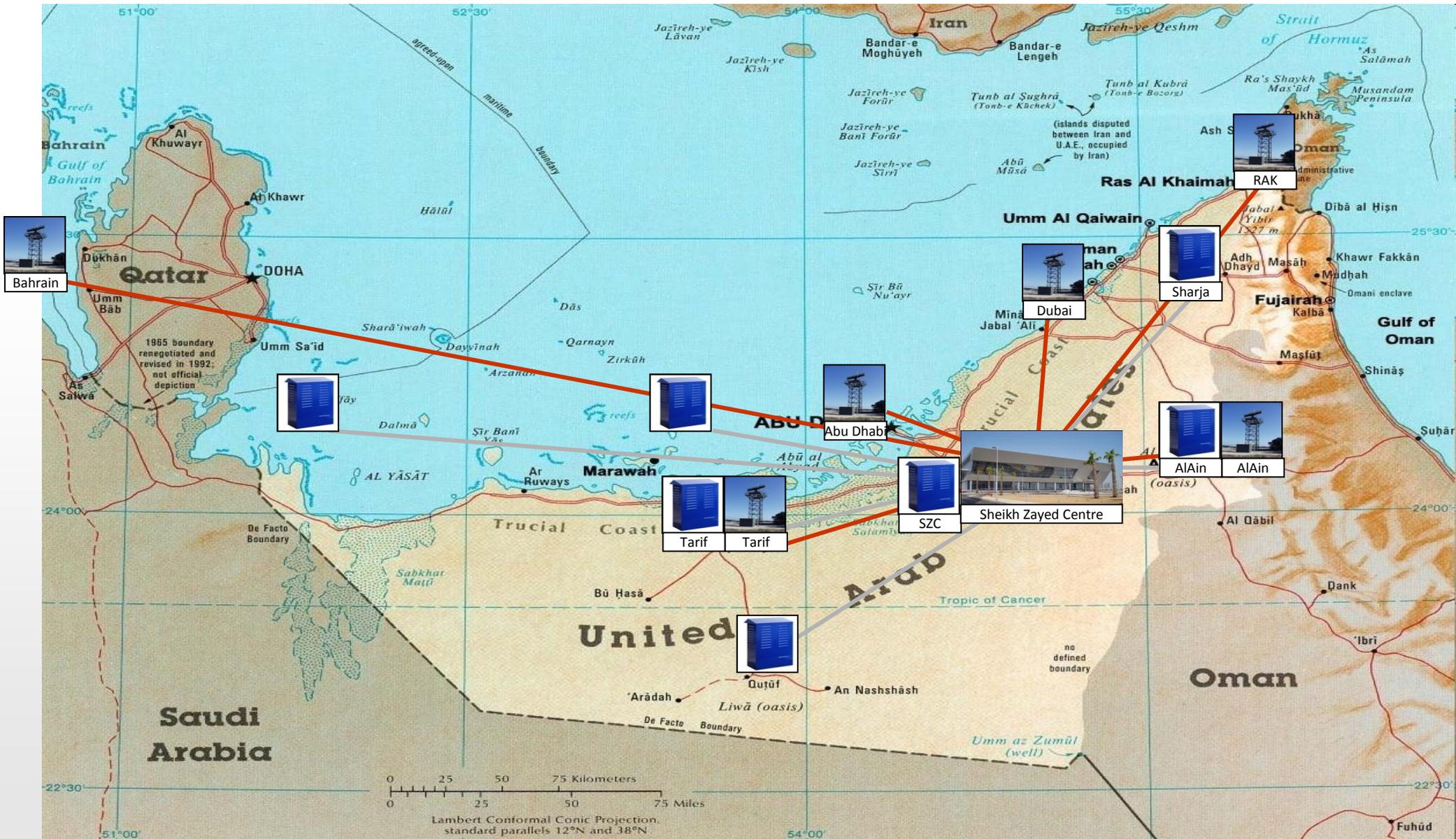
- Autonomous Data Processing
- Controller Working Positions
 - 28 operational positions
 - 2 COM Terminals
 - 1 Supervisor
 - 2 Military Coordination
 - 2 Replay
- Diversity Display System (Independent Surveillance path)



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

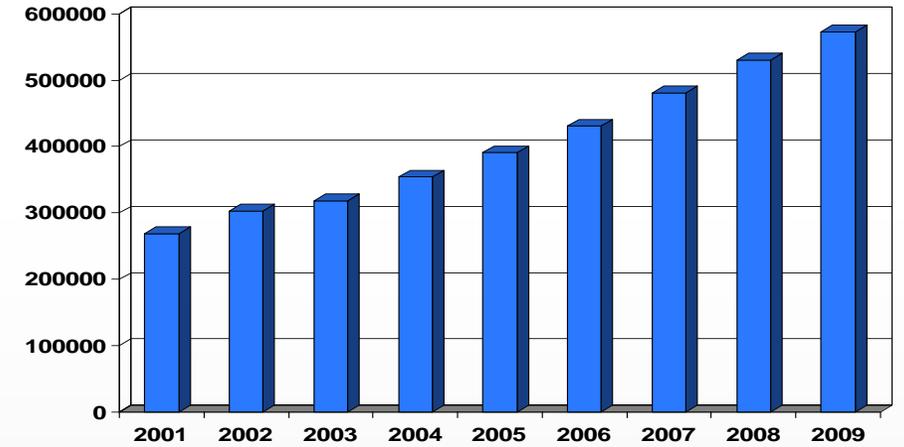
- Stripless operation
- Jurisdiction and Silent Hand-over
- OLDI / AIDC Connections
- Safety net functions
- Autonomous Diversity System
- Integrated Arrival Manager
- Integrated Flow Control System (extending beyond FIR boundary)
- Military Coordination Cell
- ADS-B Validation Suite

- Military / Civil Approach

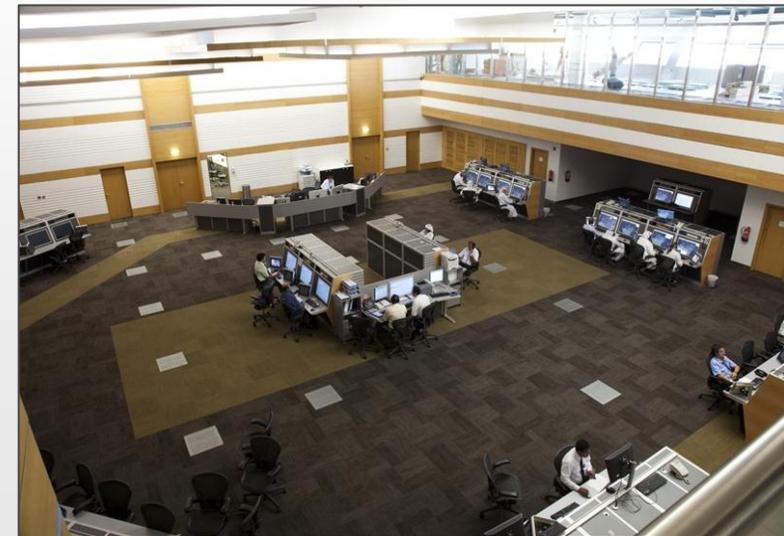
- ATC Towers at Remote Sites
- OLDI Integration with several domestic airports



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

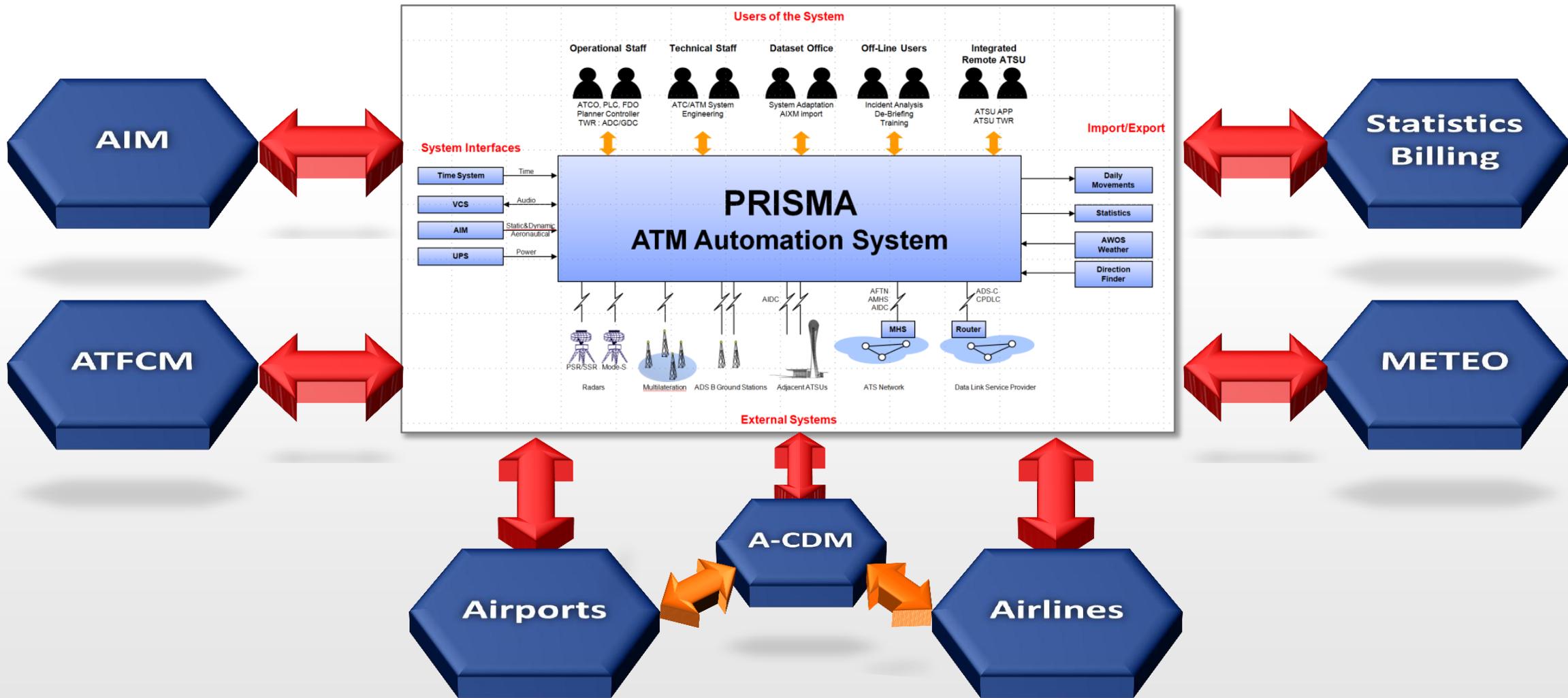
System Wide Information Management



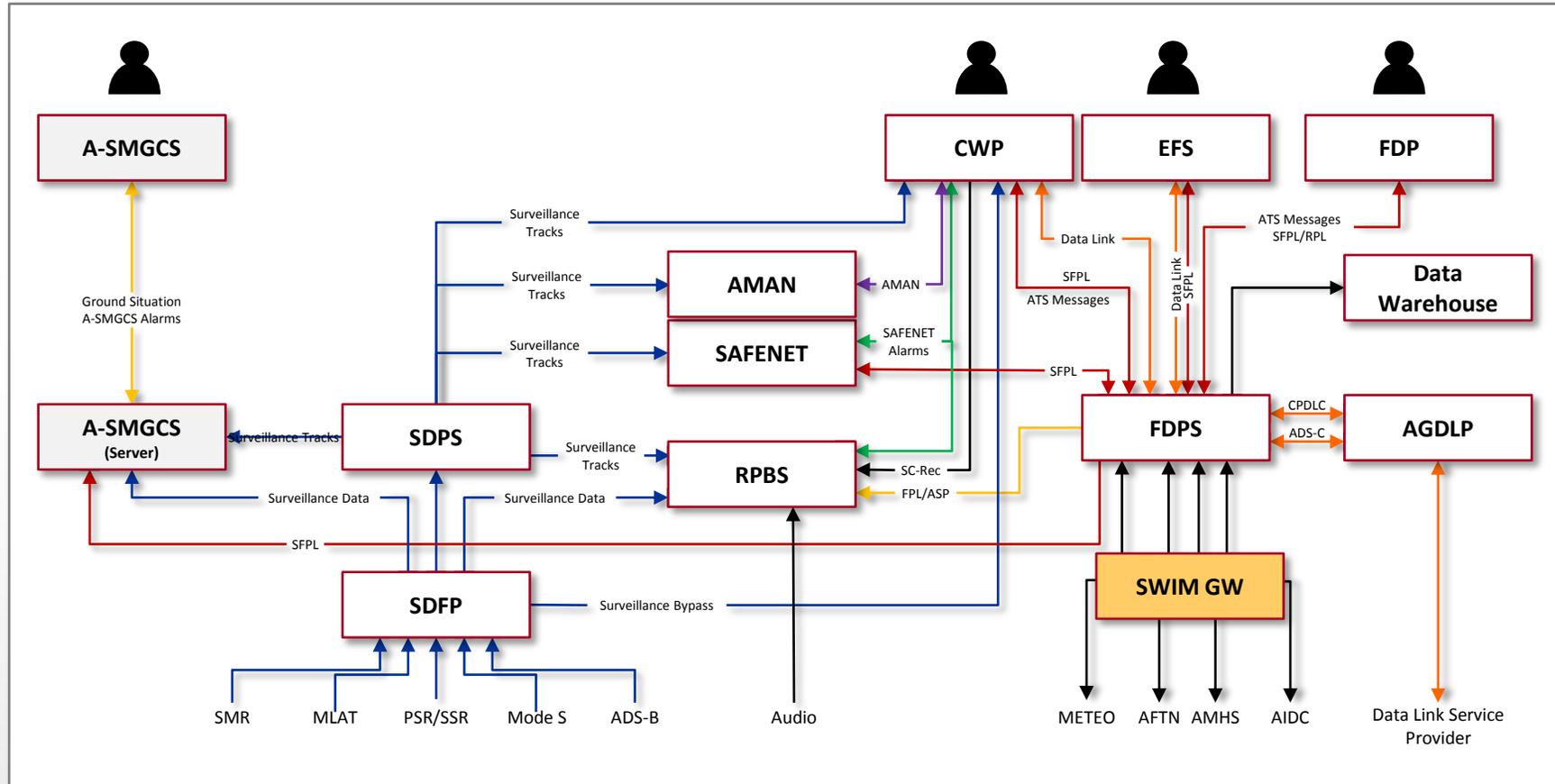
Information to share

- **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
 - Subscribe Service
- „Translate“ and Encapsulate
- Segregation of Information Environment
- Secure Access to Data (External Authorisation)
- Protect System (Firewall)
- Imports Data by
 - Requesting Data
 - Subscribe 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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