Multilateration at Italian Airports

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SELEX Sistemi Integrati

Major Programs

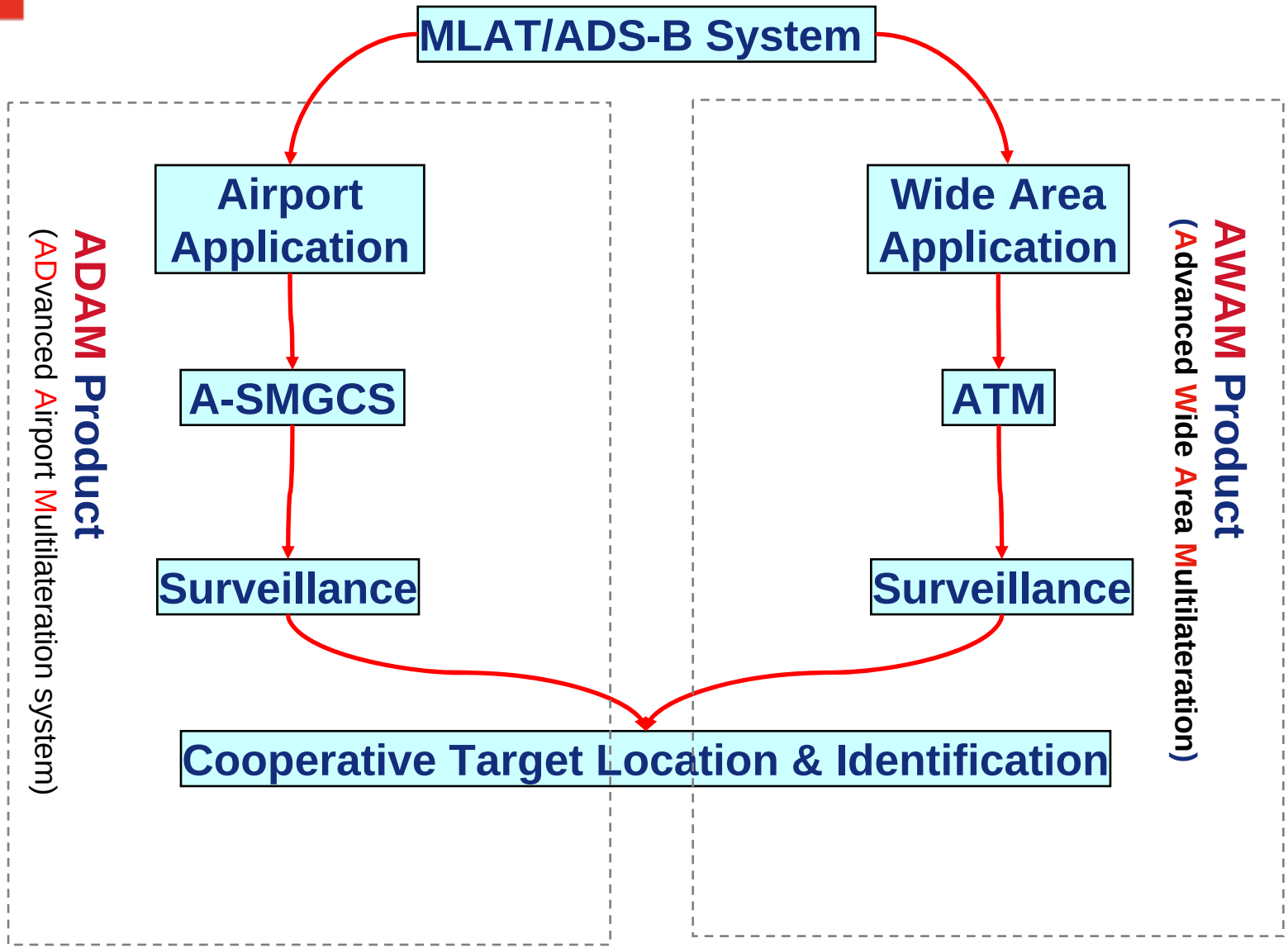
- Italy, Rome Fiumicino Airport – MLAT/ADS-B system
- Italy, Milan Malpensa Airport – MLAT/ADS-B system and VEGA
- Italy, Multiple airports – Wide Area MLAT (WAM)/ADS-B system
- Italy, Cristal Med Italy project (CASCADE/Eurocontrol) – ADS-B

- India, Hyderabad Intl. Airport – MLAT/ADS-B and VEGA
- India, Bangalore Intl. Airport – MLAT/ADS-B and VEGA
- Malta, Cristal Med Malta project (CASCADE/EUROCONTROL) – ADS-B
- Trinidad and Tobago – ADS-B

System compliant to:

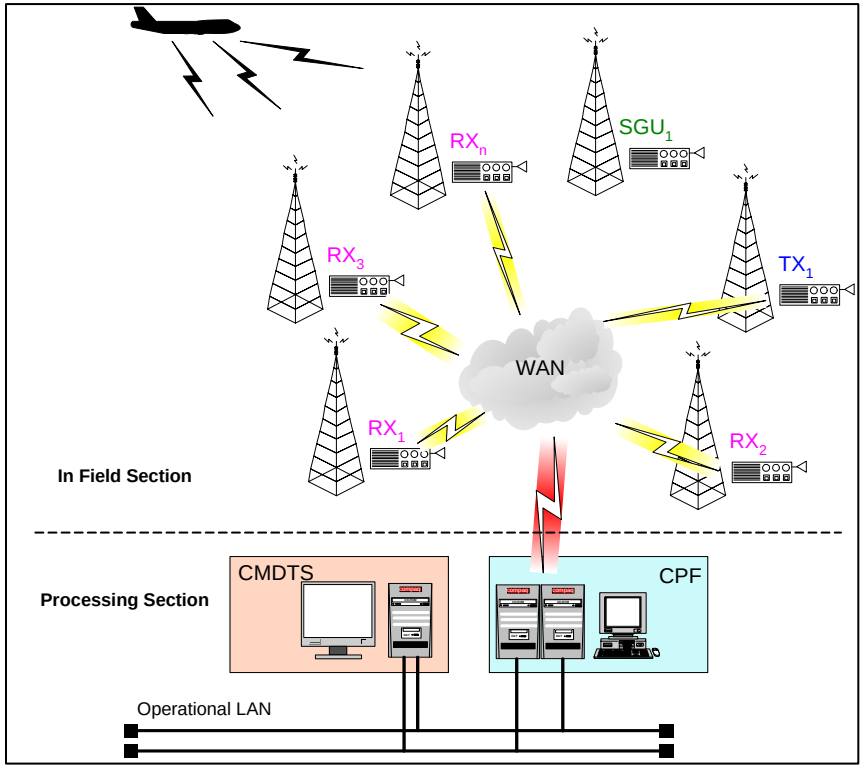
- *ICAO Annex 10 Vol.IV*
- *RTCA/EUROCAE standards*
  - *ED-117*
  - *DO 260-260A, DO 260A Change 1*
  - *WG51 ADS-B SG4 and WG70 WAM*

Cooperative Target Location & Identification



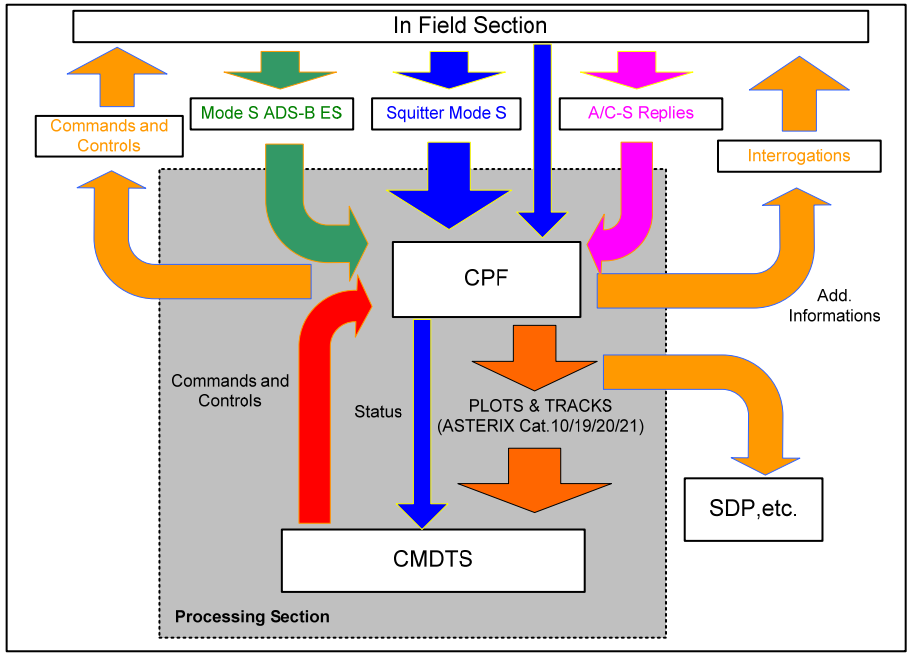
Multilateration: the Concept

- It uses the spontaneous Mode-S squitters as well as the responses to interrogations (Mode A/C/S) elicited by the MLAT system or other surveillance sources, to localize and identify aircraft and/or vehicles equipped with an operational ATC transponder or equivalent
- The system installation includes to place a certain number of receiving and transmitting stations in precisely surveyed locations nearby the Airport facilities and process the 2D/3D target location through the TDOA (Time Difference Of Arrival) principle, based on the "*arrivals*" of one signal received seen from different placed receivers
- It does not require any additional equipment to be installed on aircraft (portable and easy transponder installation on vehicles)
- It can provide sufficient information to unambiguously identify and track aircraft and/or vehicles with performances compatible with A-SMGCS or TMA/En-Route Surveillance requirements



MLAT/ADS-B Messages managed

- Mode-S Short Squitter (DF 11) and ADS-B Transponder-based Extended Squitter (DF 17)
- Elicited Mode-A/C/S replies (Mode A/C, Downlink Format 4, 5, 20 and 21):
  - due to mode A/C only All Call and selective interrogations (UF 4, 5, as option UF 20, 21)
- ADS-B Extended Squitter (DF 18):
  - sent by Mode S Non Transponder-based equipment
- Elicited 3A/C replies:
  - sent by conventional transponders, due to only All Call interrogations



Managed ADS-B messages and CAT21 Data Items

1090 MHz Mode S messages actually managed according to ICAO Annex 10 and RTCA DO-260/260A with Change 1

DF17/18:

- **Surface Position**
- **Airborne Position**
- **Airborne Velocity**
- **Aircraft identification & Type**
- **Operational Status**

DF5/21:

Mode 3A Code extraction (if an integrated 1030 MHz Transmitter is included in MXC configuration or overlapping coverage with Mode S radar)

UAP actually managed according to ASTERIX CAT21 rev. 0.23/0.26

Item	Type	Presence	Ver.0.26	Ver.0.23
I021/010	Data Source Identification	M	Y	Y
I021/020	Emitter Category	O	Y	Y
I021/030	Time of Day	M	Y	Y
I021/040	Target Report Descriptor	M	Y	Y
I021/070	Mode 3A Code in Octal Representation	O	Y	N
I021/080	Target Address	M	Y	Y
I021/090	Figure Of Merit	M	Y	Y
I021/095	Velocity Accuracy	O	Y	Y
I021/130	Position in WGS-84 co-ordinates	M	Y	Y
I021/131	Signal Amplitude	M	Y	N
I021/140	Geometric Altitude	O	Y	Y
I021/145	Flight Level	O	Y	Y
I021/150	Air Speed	O	Y	Y
I021/151	True Air Speed	O	Y	Y
I021/152	Magnetic Heading	O	Y	Y
I021/155	Barometric Vertical Rate	O	Y	Y
I021/157	Geometric Vertical Rate	O	Y	Y
I021/160	Ground Vector	O	Y	Y
I021/170	Target Identification	O	Y	Y
I021/200	Target Status	O	Y	Y
I021/210	Link Technology Indicator	M	Y	Y
SP	Special Purpose Field	O	Y	Y

N.B.: Special Purpose Item to include fields/messages not actually managed by CAT21 ver. 0.23/0.26, e.g. Version Number, NIC, SIL, etc.

(M) mandatory (configurable)

(O) On availability (if data are available)

Processing Section – Main Functionalities

•Target location/identification and plot extraction function

mixing of weighted (through real-time TOA accuracy) all-in-view sensor non-iterative/iterative position estimation algorithms

•Interrogation scheduling function (if enabled), to acquire additional Mode A/C/S information:

Mode C/S altitude, Mode A code, Callsign, Aircraft capability

•Target tracking function

Adaptive Kalman Filtering with an advanced manouvre detector to smooth targets with different kinematics characteristics (e.g. aircraft, vehicles, etc.), suppress false tracks and resolve target ID ambiguities

•ADS-B data extraction function: Mode-S ADS-B E.S. (DF17/DF18) subtypes managed:

- Surface Position messages (BDS0,6)
- Airborne Position messages (BDS0,5)
- Velocity messages (BDS0,9)
- A/C Identification & Type messages (BDS0,8)
- A/C Operational Status messages (BDS6,5)
- Emergency/Priority/Status messages (BDS6,1)

•ADS-B data integrity check function (if enabled)

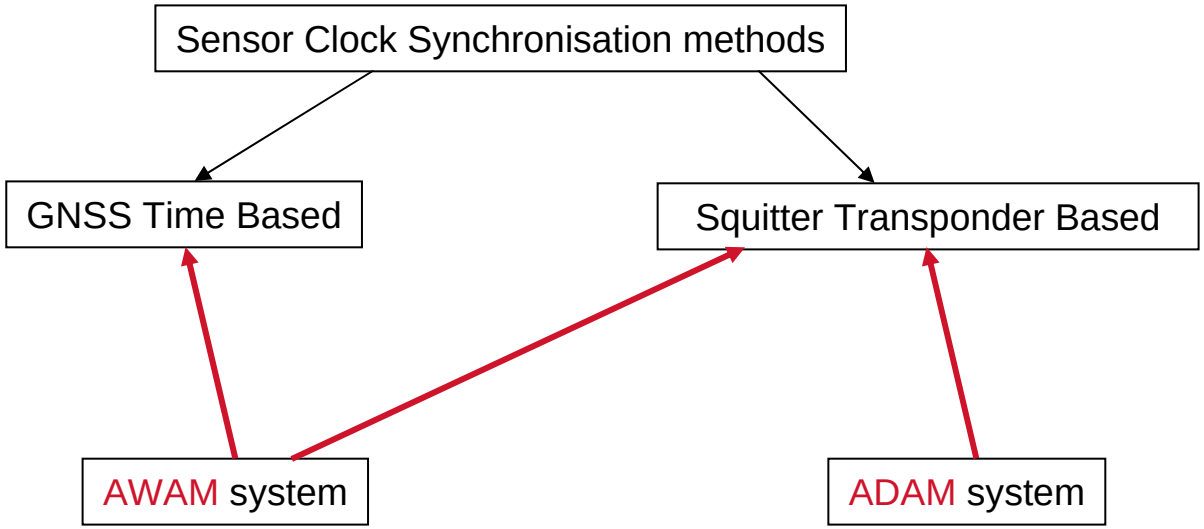
ADS-B data can be checked against the multilateration data or TDOA validation to verify the track keeping performance of the avionics

•Output Handling function: The plot/track output data format shall be configurable among the following:

•ASTERIX CAT10 rev.1.0: Mode A/C/S and ADS-B plot/track for airport application (up to 17.7 NM)
•ASTERIX CAT20 rev.1.0, and ASTERIX CAT19 rev.1.0: Mode A/C/S plot/track only
•ASTERIX CAT21 rev.0.23 or rev.0.26: ADS-B plot/track only
•SELEX-SI Legacy output format, to easily integrate the system within existing SELEX-SI Centres and Data Fusion with other SELEX-SI Surveillance sources

MLAT – Time synchronisation methods

•MLAT systems need to have a common time reference base for TOA estimation



Squitter Transponder Based method:

•Line of sight to each (or partitioned set) of the receivers (receving sensor baseline affected)
•TOA accuracy able to meet A-SMGCS requirements (1 nsec RMS)
•System auto-calibration
•GNSS independent for TOA estimation
•No specific datalink communication needed

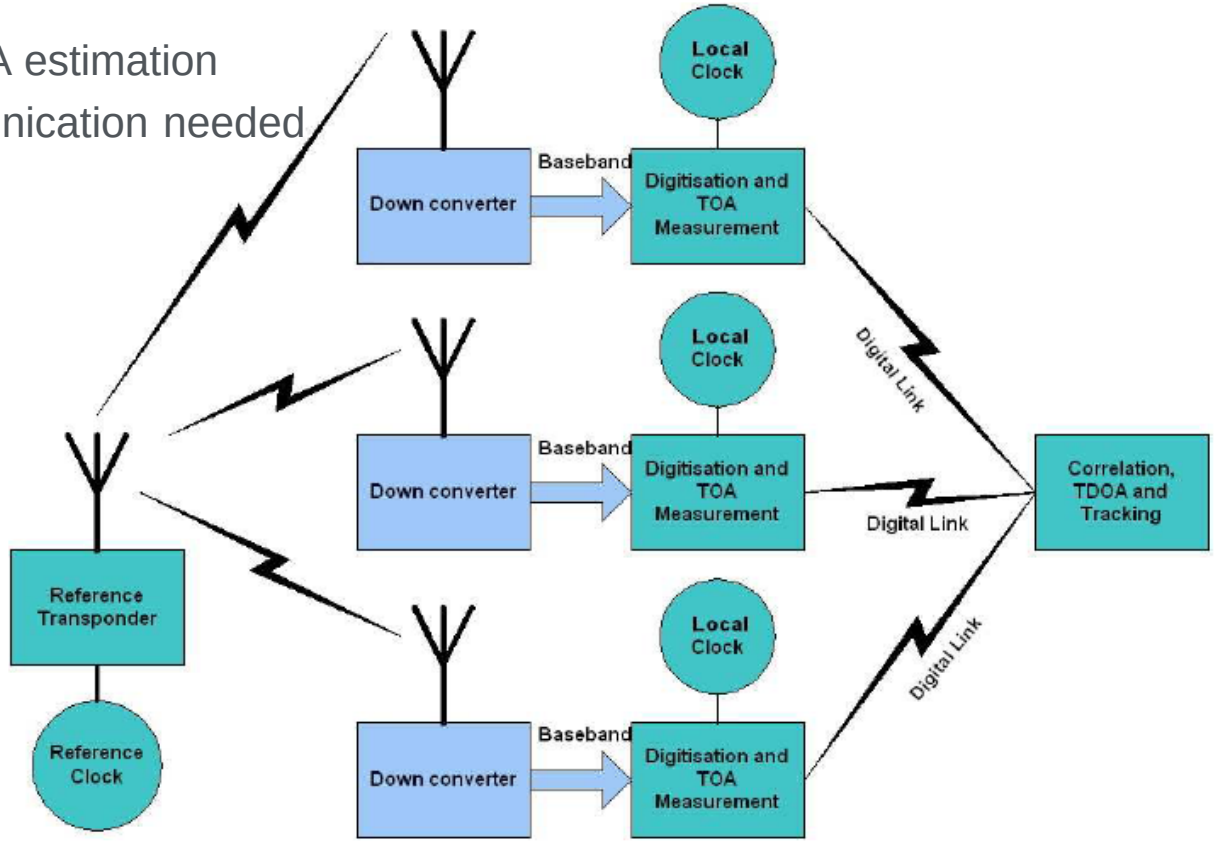
GNSS Time based method:

•TOA accuracy (15 nsec RMS)
•Large receiving sensor baseline
•GNSS dependent for TOA estimation
•No specific datalink communication needed

MLAT – Time synchronisation methods:
Squitter Transponder Based

Squitter Transponder Based main characteristics in SELEX-SI products:

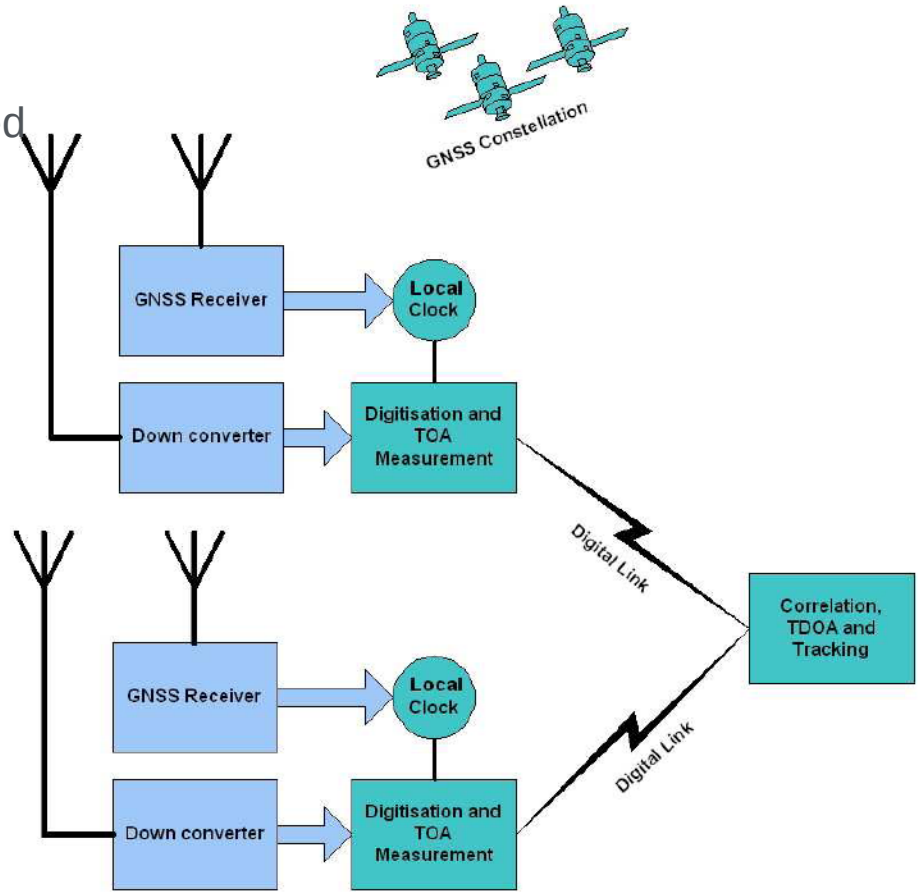
- Line of sight to each (or partitioned set) of the receivers (receving sensor baseline affected)
- TOA accuracy able to meet A-SMGCS requirements (1 nsec RMS)
- System auto-calibration
- GNSS independent for TOA estimation
- No specific datalink communication needed



MLAT – Time synchronisation methods:
GNSS Time base

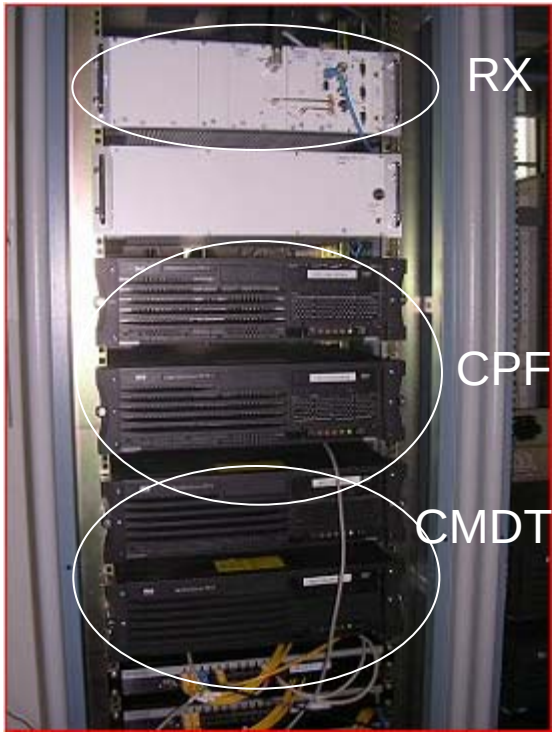
GNSS Time based method main characteristics in SELEX-SI products :

- Better TOA accuracy (15 nsec RMS) with respect to the standard techniques
- Large receiving sensor baseline
- GNSS dependent for TOA estimation
- No specific datalink communication needed



SELEX-SI MLAT Components (1/5)

- **Receivers (RX) placed in the area of interest**
- **Synchronization Transmitter (SGU) (if needed)**
- **Interrogator Transmitter (TX)**
- **Omni/Directional Antennas**
- **Central Processing Facility (CPF) (Redundant)**
- **Control/Monitoring Display Traffic (CMDT) (Redundant if needed)**



SELEX-SI MLAT Components (2/5)

- Rx Station
  - Channel: 1090 MHz
  - Bandwidth: ± 15 MHz
  - Sensitivity (MTL): configurable, min. better than –75 dBm
  - Reply type: Mode A/C, Mode-S (DF 4/ 5/ 11/ 17/ 18/ 20/ 21)
  - Data Sample rate: 60 MHz
  - TOA Accuracy: better than **1 ns** RMS (advanced decoder)
  - GPS Receiver (if needed) with UTC synchronisation accuracy within 15 nsec (useful for AWAM)
- Interfaces
  - Ethernet 10/100 BaseT (IEEE 802.3)
  - RS232 port for local monitoring/configuration
  - RS485 port for local monitoring/configuration

SELEX-SI MLAT Components (3/5)

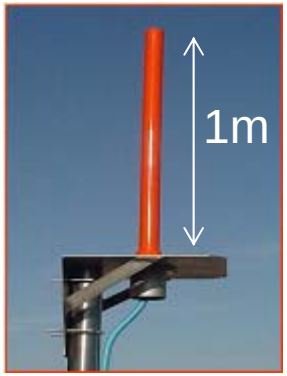
- **Tx Synchro**
  - Channel: 1090 MHz
  - Bandwidth: ICAO compliant
  - Squitter type: DF11 or DF18
  - Squitter rate: configurable, 2 Hz max
  - ICAO/Non-ICAO Address: configurable by local/remote
  - Output Power: configurable, 50 dBm max
- **Interfaces**
  - Ethernet 10/100 BaseT (IEEE 802.3)
  - RS232 port for local monitoring/configuration
  - RS485 port for local monitoring/configuration

SELEX-SI MLAT Components (4/5)

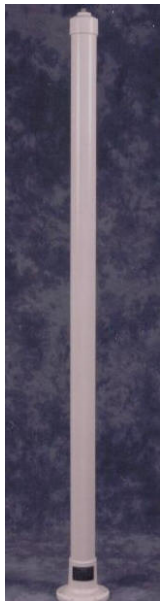
- **Tx Interrogator**
  - Channel: 1030 MHz
  - Bandwidth: ICAO compliant
  - Interrogator Type: A/C only All Call, UF4/5
  - Output Power: configurable, 50 dBm max
- **Interfaces**
  - Ethernet 10/100 BaseT (IEEE 802.3)
  - RS232 port for local monitoring/configuration
  - RS485 port for local monitoring/configuration

SELEX-SI MLAT Components (5/5)

- 1090/1030 MHz 3/6 dB gain for short range



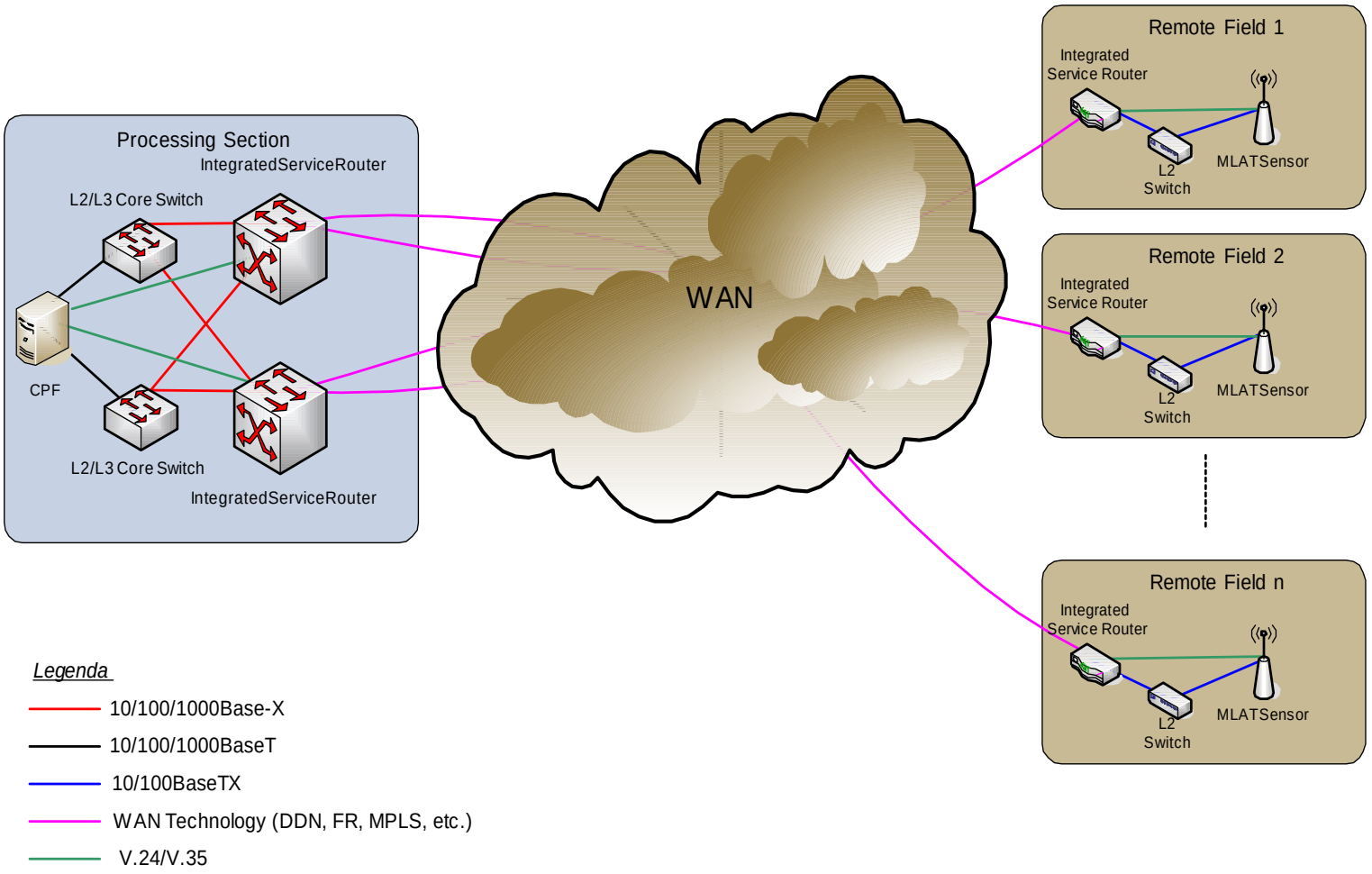
- DME dBs 610 (6 dBi) omnidirectional
- DME dBs 510A (8 dBi) omnidirectional
- DME dBs 5100A (9.5 dBi) high gain omnidirectional



- Kathrein Vpol 1087-1093 MHz (11.5 dBi) high gain omnidirectional

N.B.: Amplification Box (embarking ad-hoc LNA component) just after the antenna can be used to enlarge the range over 250 NM

General MLAT Communication Architecture



ADAM system installed in Milan Malpensa Airport

- **Configuration**
  - 6 RX
  - 2 RTX
  - 2 RTX Synch

ADAM system installed in Rome Fiumicino Airport

- **Configuration**
  - 10 RX
  - 4 RTX
  - 4 RTX Synch

ADAM – Malpensa ADS-B on the Ground Results (1/5)

Target	Aircraft ADS-B 4B161A
Movement	Stand-Rwy. Take Off
	MLAT Tracks
	ADS-B Tracks

ADAM – Malpensa ADS-B on the Ground Results (2/5)

Target	Aircraft ADS-B 400871
Movement	Rwy-Stand. Landing
	MLAT Tracks
	ADS-B Tracks

ADAM – Malpensa ADS-B on the Ground Results (3/5)

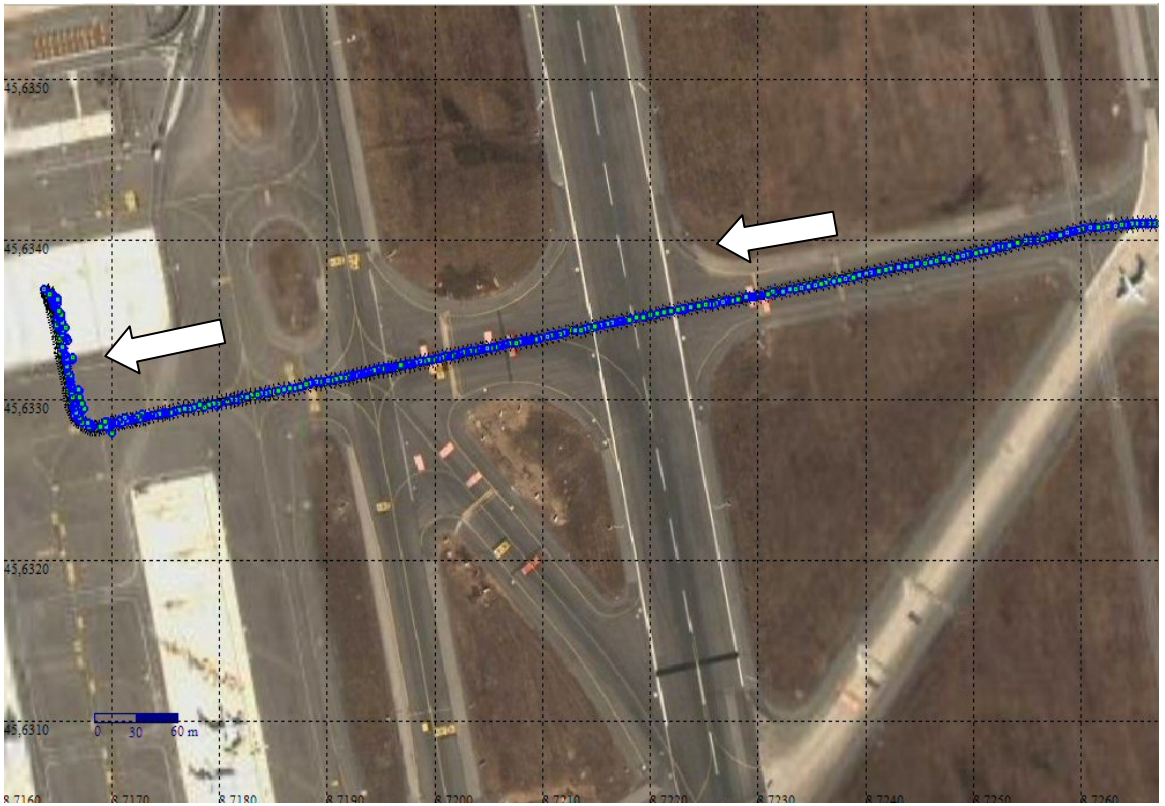
Target	Aircraft ADS-B 400871
Movement	Rwy-Stand. Landing
	MLAT Tracks
	ADS-B Tracks

Runway zoom

ADAM – Malpensa ADS-B on the Ground Results (4/5)

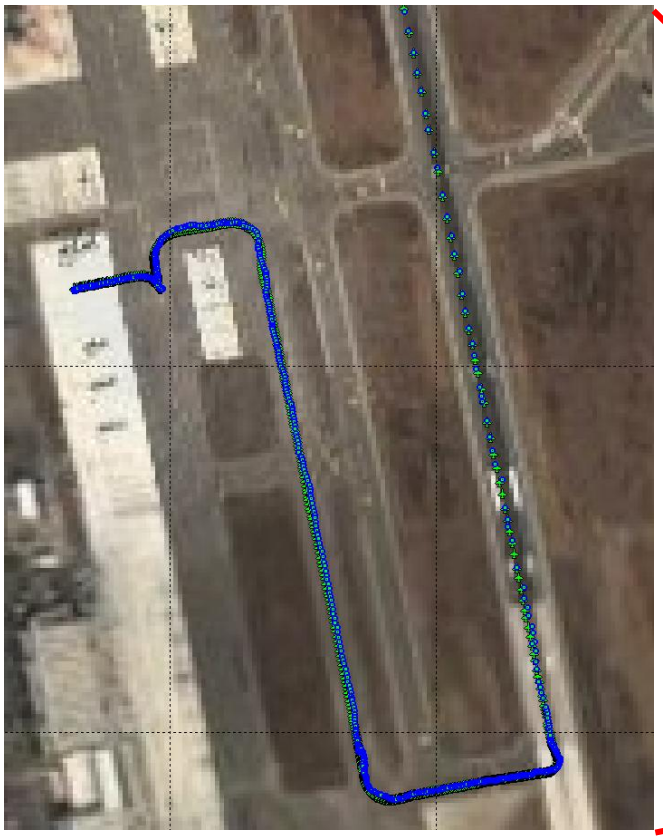
Target	Aircraft ADS-B 400871
Movement	Rwy-Stand. Landing
	MLAT Tracks
	ADS-B Tracks

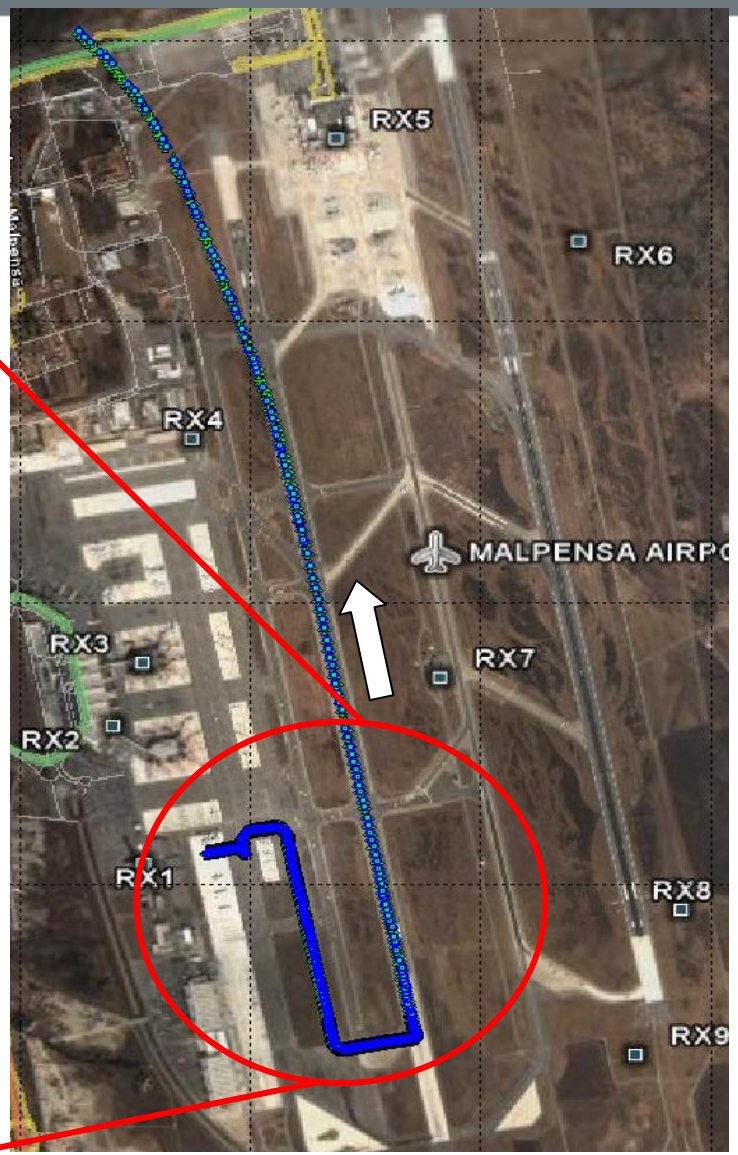
Runway zoom



ADAM – Malpensa ADS-B on the Ground Results (5/5)

Target	Aircraft ADS-B 30016E
Movement	Stand - Rwy. - Take Off
	MLAT Track
	ADS-B Track





ADS-B anomalies observed at Malpensa (1/2)

Target	Aircraft ADS-B 34138C
Call-Sign	IBE3637
Movement	Stand-Rwy. Take Off
	MLAT Tracks
	ADS-B Tracks

- **Transponder navigation source different from GPS Receiver (i.e. INS)**

ADS-B anomalies observed at Malpensa (2/2)

Target	Aircraft ADS-B 391551
Movement	Stand-Rwy. Take Off
	MLAT Tracks
	ADS-B Tracks

- **Transponder navigation source different from GPS Receiver (i.e. INS)**