

Software for statistical analysis of surveillance data (ADS-B).



Mexico City
April 2015



Automatic Dependent Surveillance (ADS)

(Transmission from aircraft (1090 MHz)



RDP

ICAO defines ADS-B as “a surveillance technique in which parameters are transmitted, such as the position, track and ground speed, by radio broadcast data link and in specific time intervals in such manner that can be used by any user on land or air as required”.

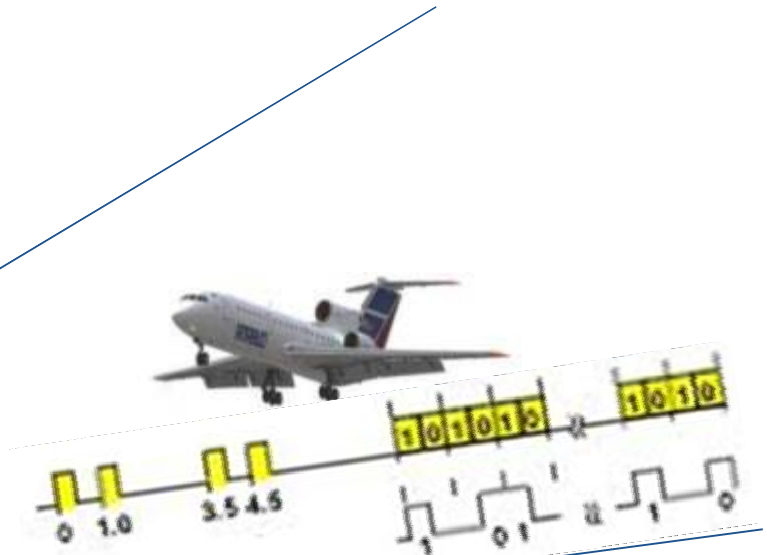




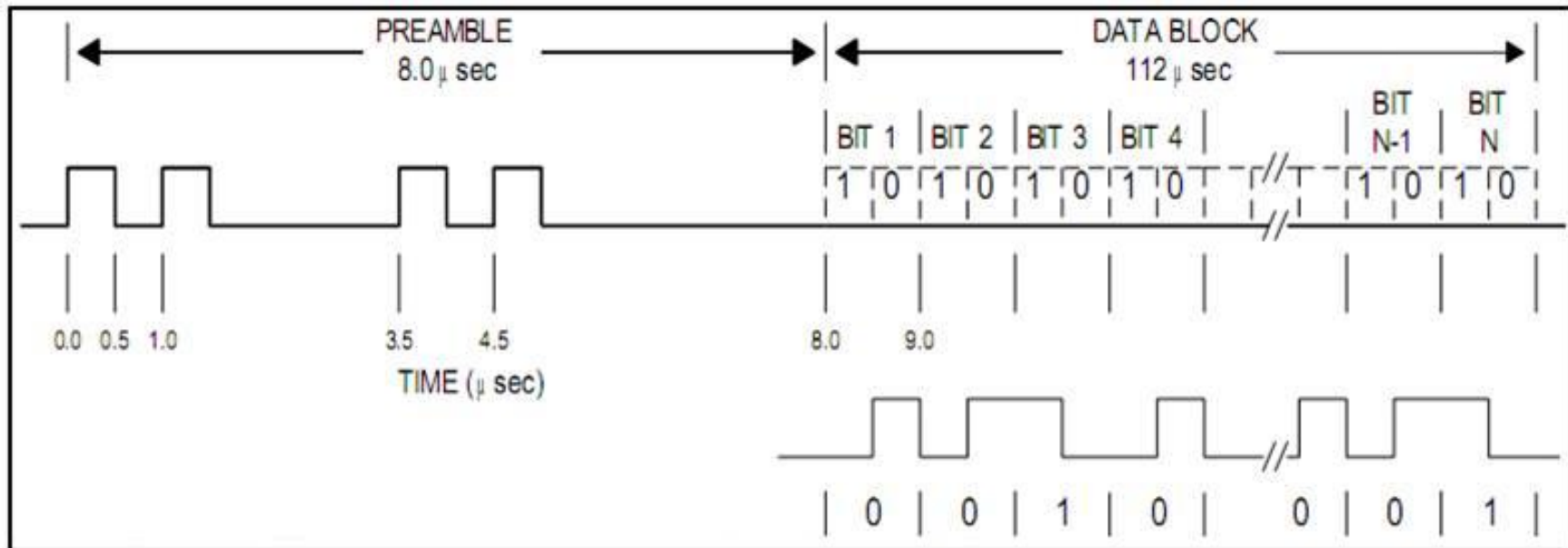
ADS-B General Structure



RDP



ADS-B Message Format



Total 120 μ s

Data rate: 1 Mbps

Modulation: PPM (Pulse Position Modulation)

Pulses transmitted in the 1st or 2nd half of the bit period (indicating either 1 or 0 respectively).



Examples of ADS-B data

Airborne Position		Tx: 2/1s
Cant.Bits	Content	
5	Format Type Code	
2	Surveillance Status	
1	NIC Supplement-B (§A.1.4.2.5)	
12	Altitude	
1	Time (T)	
1	CPR Format (F)	
17	CPR Encoded Latitude	
17	CPR Encoded Longitude	
Total: 56 bits		

Surface Position		Tx: 1/5 s 2/1s
Cant.Bits	Content	
5	Format Type Code	
7	Movement	
1	Status for Heading	
7	Heading	
1	Time (T)	
1	CPR Format (F)	
17	CPR Encoded Latitude	
17	CPR Encoded Longitude	
Total: 56 bits		

Identification and Category		Tx: 1/10s 1/5s
Cant.Bits	Content	
5	Format Type Code	
3	Aircraft Emitter Category	
6	Character 1	
6	Character 2	
6	Character 3	
6	Character 4	
6	Character 5	
6	Character 6	
6	Character 7	
6	Character 8	
Total: 56 bits		

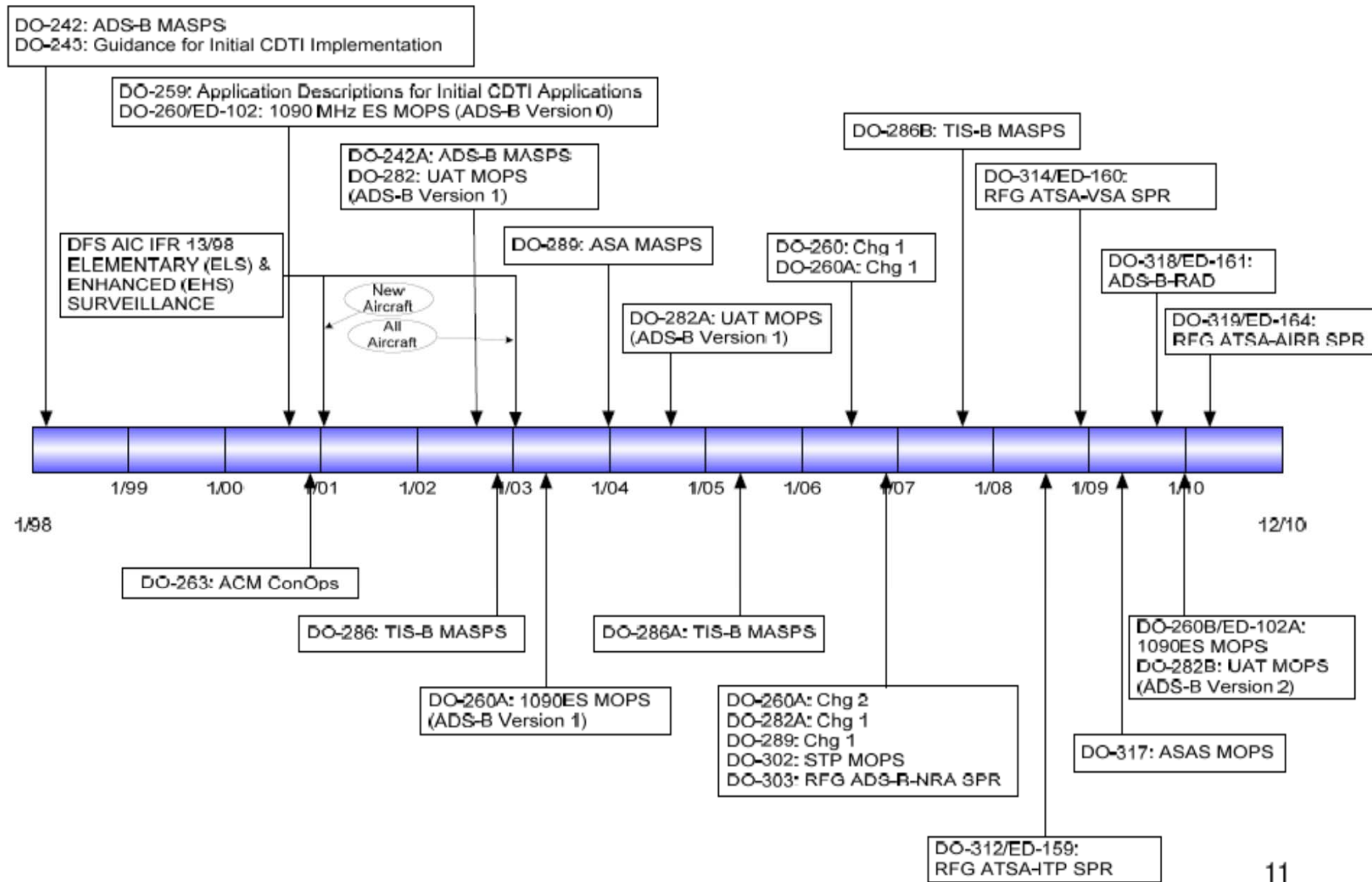


Evolution DO-260

Capability	DO-260	DO-260A	DO-260B	Comments
NUC (Navigation Uncertainty Code)	✓			Baseline
Mode A Code		✓	✓	Support legacy ATC infrastructure
NACp (Navigation Accuracy Code for Position)		✓	✓	Replaced NUC
SIL (Surveillance Integrity Level)		✓		Replaced NUC
NIC (Navigation Integrity Code)		✓	✓	Replaced NUC
Revise SIL to become Source Integrity Level & add: SDA (System Design Assurance)			✓	Clearly separates the reporting to reflect equipment certification levels and navigation source fault detection capability
Revise NIC/NAC/SIL and add GVA (Geometric Vertical Accuracy)			✓	To improve vertical accuracy, decouple vertical from NIC/NAC/SIL and add GVA
Add ADS-B IN bits			✓	Enhancement to show both UAT IN and 1090ES IN receiver equipage
Changes to the Target State Report			✓	To better align with available aircraft data
Offer non-diversity antenna options for small aircraft			✓	Lower cost of equipage for General Aviation
Revise latency requirement (limit extrapolation)			✓	Enhancement
New guidance on how to determine NACv			✓	Fix
New guidance on how to select the best position/state vector sources			✓	Fix
Changes to the Mode A Code transmission rates			✓	Improvements and squitter efficiencies
Redefine TCAS status bits			✓	Fix
Fixes and improvement to NIC reporting and modified surface movement field for airport surface			✓	Improvements for Surface applications



Evolution DO-260





Asterix

Cat 21: ADS-B Reports.

Cat 23: CNS/ATM Ground
Station Service Messages.



ASTERIX Cat 21 Differences

v0.26 y v1.80

Edition : 0.26

Edition Date : 27 June 2005

FRN	Data Item	Information	Length
1	I021/010	Data Source Identification	2
2	I021/040	Target Report Descriptor	1+
3	I021/030	Time of Day	3
4	I021/130	Position in WGS-84 co-ordinates	6
5	I021/080	Target Address	3
6	I021/140	Geometric Altitude	2
7	I021/090	Figure of Merit	2
FX	-	Field extension indicator	-
8	I021/210	Link technology	1
9	I021/230	Roll Angle	2
10	I021/145	Flight Level	2
11	I021/150	Air Speed	2
12	I021/151	True Air Speed	2
13	I021/152	Magnetic Heading	2
14	I021/155	Barometric Vertical Rate	2
FX	-	Field extension indicator	-
15	I021/157	Geometric Vertical Rate	2
16	I021/160	Ground Vector	4
17	I021/165	Rate of Turn	1+
18	I021/170	Target Identification	6
19	I021/095	Velocity Accuracy	1
20	I021/032	Time of day accuracy	1
21	I021/200	Target Status	1
FX	-	Field extension indicator	-
22	I021/020	Emitter Category	1
23	I021/220	Met report	1+
24	I021/146	Intermediate State Selected Altitude	2
25	I021/148	Final State Selected Altitude	2
26	I021/110	Trajectory Intent	1+N*15
27	I021/070	Mode 3/A Code	2
28	I021/132	Report Amplitude	1
FX	-	Field extension indicator	-
29	-	Spare bits set to zero	-
30	-	Spare bits set to zero	-
31	-	Spare bits set to zero	-
32	-	Spare bits set to zero	-
33	-	Spare bits set to zero	-
34	RE	Reserved Expansion Field	1+
35	SP	Special Purpose Field	1+
FX	-	Field extension indicator	-

Edition : 1.8

Edition Date : January 2011

FRN	Data Item	Information	Length
1	I021/010	Data Source Identification	2
2	I021/040	Target Report Descriptor	2+
3	I021/161	Track Number	2
4	I021/015	Service Identification	1
5	I021/071	Time of Applicability for Position	3
6	I021/130	Position in WGS-84 co-ordinates	6
7	I021/131	Position in WGS-84 co-ordinates, high res.	8
FX	-	Field extension indicator	-
8	I021/072	Time of Applicability for Velocity	3
9	I021/150	Air Speed	2
10	I021/151	True Air Speed	2
11	I021/080	Target Address	3
12	I021/073	Time of Message Reception of Position	3
13	I021/074	Time of Message Reception of Position-High Precision	4
14	I021/075	Time of Message Reception of Velocity	3
FX	-	Field extension indicator	-
15	I021/076	Time of Message Reception of Velocity-High Precision	4
16	I021/140	Geometric Height	2
17	I021/090	Quality Indicators	1+
18	I021/210	MOPS Version	1
19	I021/070	Mode 3/A Code	2
20	I021/230	Roll Angle	2
21	I021/145	Flight Level	2
FX	-	Field extension indicator	-
22	I021/152	Magnetic Heading	2
23	I021/200	Target Status	1
24	I021/155	Barometric Vertical Rate	2
25	I021/157	Geometric Vertical Rate	2
26	I021/160	Ground Vector	4
27	I021/165	Track Angle Rate	2
28	I021/077	Time of Report Transmission	3
FX	-	Field extension indicator	-
29	I021/170	Target Identification	6
30	I021/020	Emitter Category	1
31	I021/220	Met Information	1+
32	I021/146	Intermediate State Selected Altitude	2
33	I021/148	Final State Selected Altitude	2
34	I021/110	Trajectory Intent	1+
35	I021/016	Service Management	1
FX	-	Field extension indicator	-
36	I021/008	Aircraft Operational Status	1
37	I021/271	Surface Capabilities and Characteristics	1+
38	I021/132	Message Amplitude	1
39	I021/250	Mode S MB Data	1+N*8
40	I021/260	ACAS Resolution Advisory Report	7
41	I021/400	Receiver ID	1
42	I021/295	Data Ages	1+
FX	-	Field extension indicator	-
43	-	Not Used	-
44	-	Not Used	-
45	-	Not Used	-
46	-	Not Used	-
47	-	Not Used	-
48	RE	Reserved Expansion Field	1+

Cuba



Software for statistical analysis of surveillance reports.

Cuba



Main Screen

Chequeo de Estacion de VIGILANCIA. v1.0.2



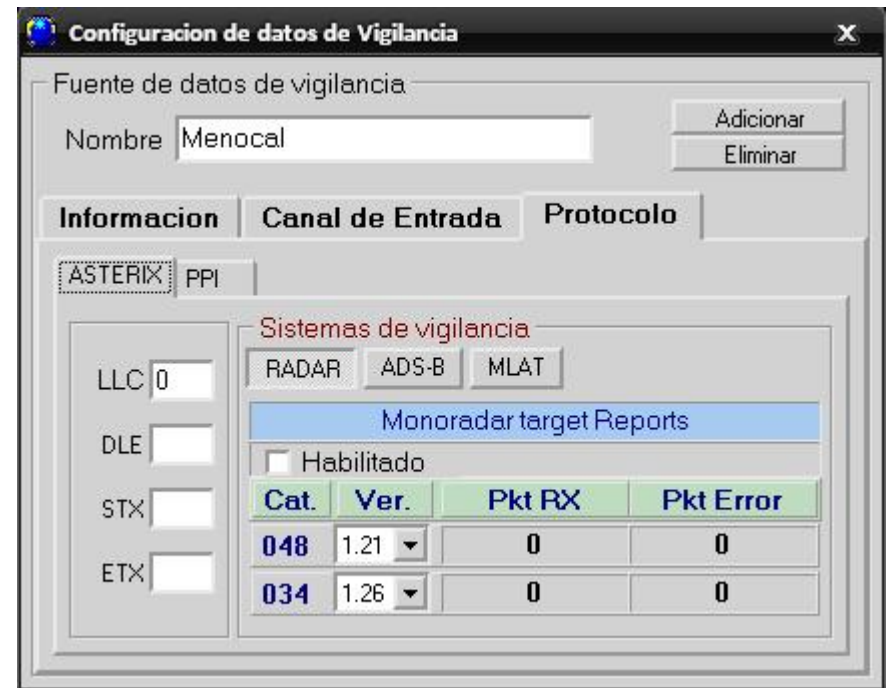
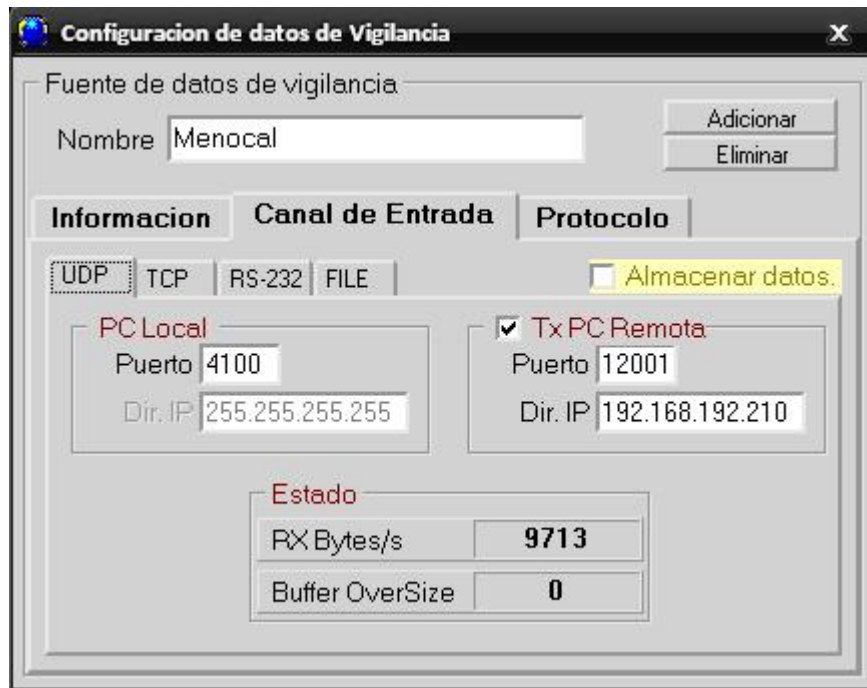
Hora local: 01:57:44
Hora RDP: 01:57:44





Software facilities

Flexibility in the configuration of channels and input protocols of surveillance data.



**Receives data:
UDP/TCP, RS-232 and files.**

Cat 048	Cat 034	Cat 021	Cat 023	Cat 020	Cat 019
v1.14	v1.26	v0.23	v0.11	v1.5	v1.1
v1.15	v1.27	v1.4	v1.2	v1.8	v1.2
v1.17		v1.8			v1.3
v1.20		v2.1			
v1.21					



Software facilities

Personalized representation of the transmitted parameters by the aircrafts.

RADAR ADS-B Tamaño de etiqueta 8

Trazas

Simbolo

Color

Radio 2

Trayecto 800

Degradado

Etiqueta

Radio 3

[24 Bits OACI] - [ID]

[Modo 3/A] - [Altura]

[NIC / PIC] - [DD-260]

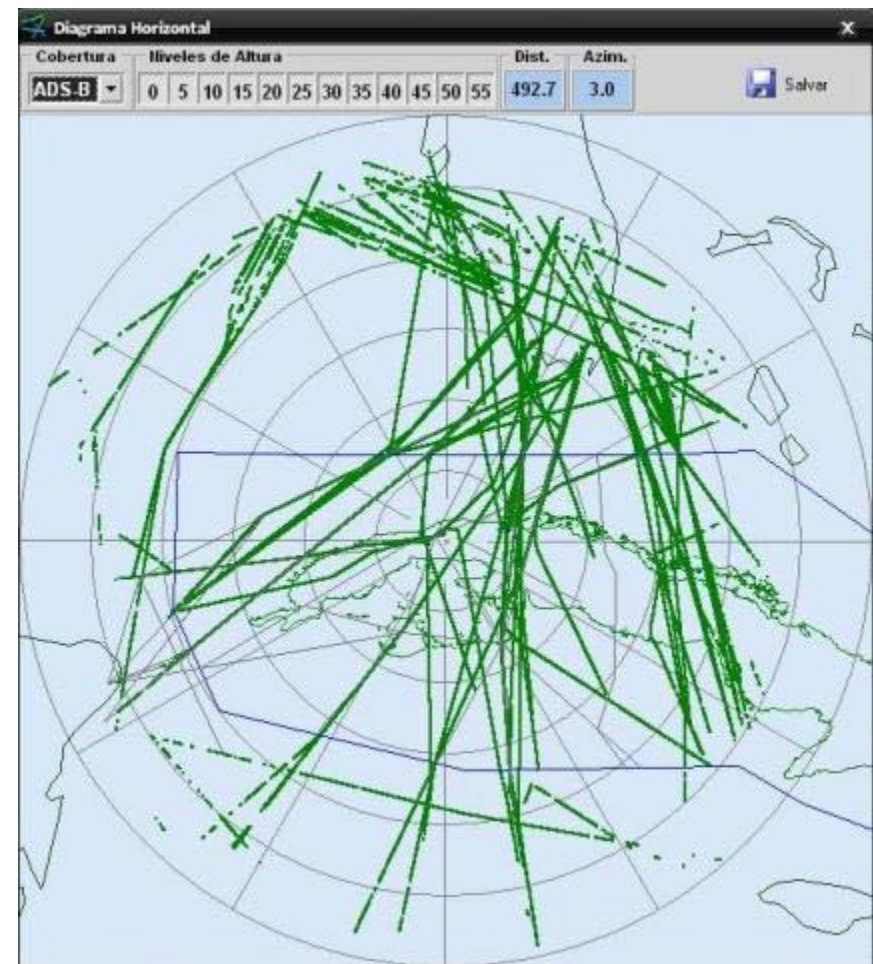
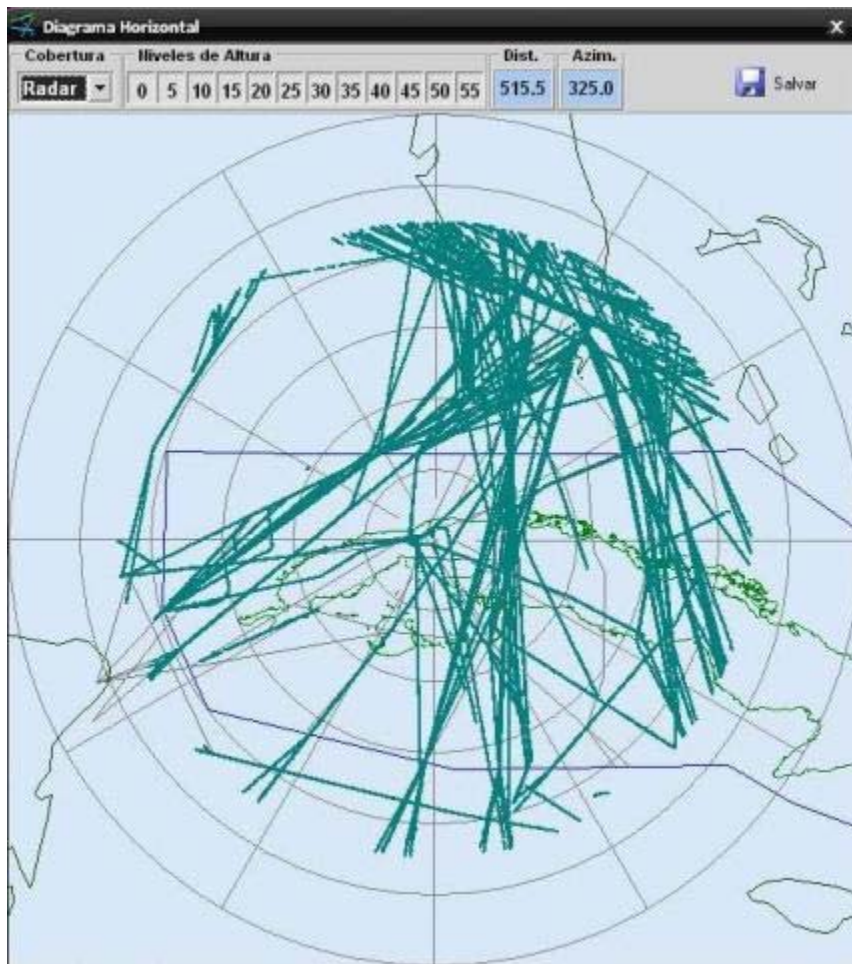
[Bandera] - [Pais]

Radio de Integridad

NIC	Horizontal and Vertical Containment Bounds
0	Unknown
1	Rc <37.04 km (20 NM)
2	Rc < 14.816 km (8 NM)
3	Rc < 7.408 km (4 NM)
4	Rc < 3.704 km (2 NM)
5	Rc < 1852 m (1 NM)
6	Rc < 1111.2 m (0.6 NM)
7	Rc < 370.4 m (0.2 NM)
8	Rc < 185.2 m (0.1 NM)
9	Rc < 75 m and VPL < 112 m
10	Rc < 25 m and VPL < 37.5 m
11	Rc < 7.5 m and VPL < 11m

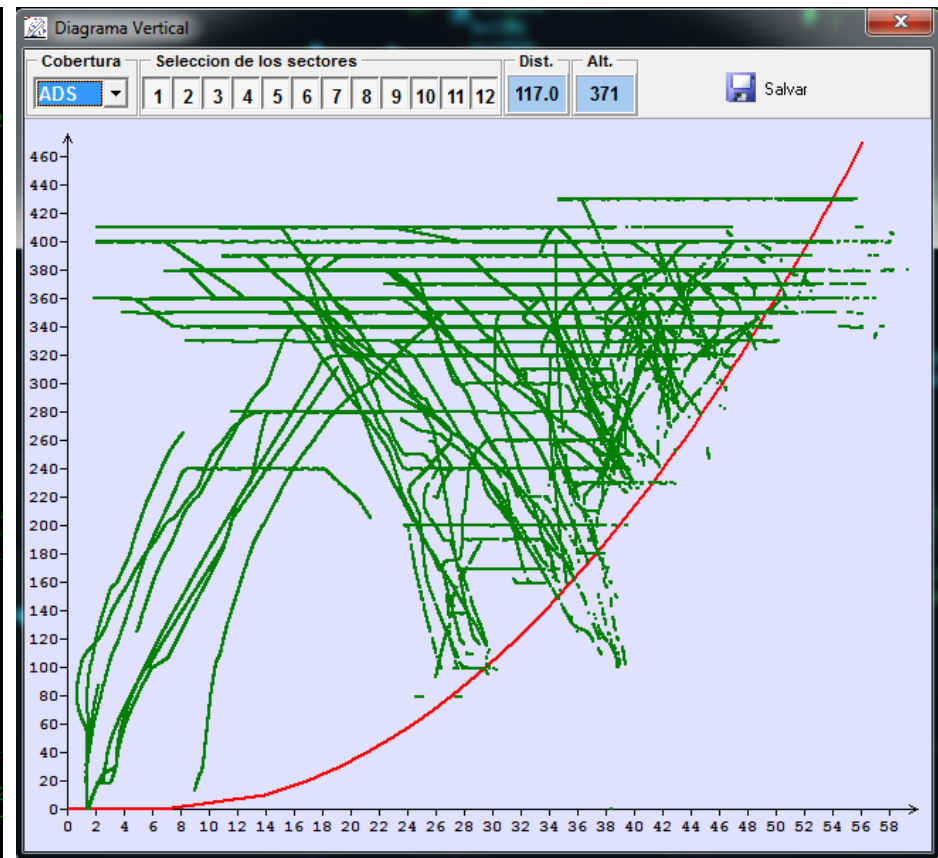
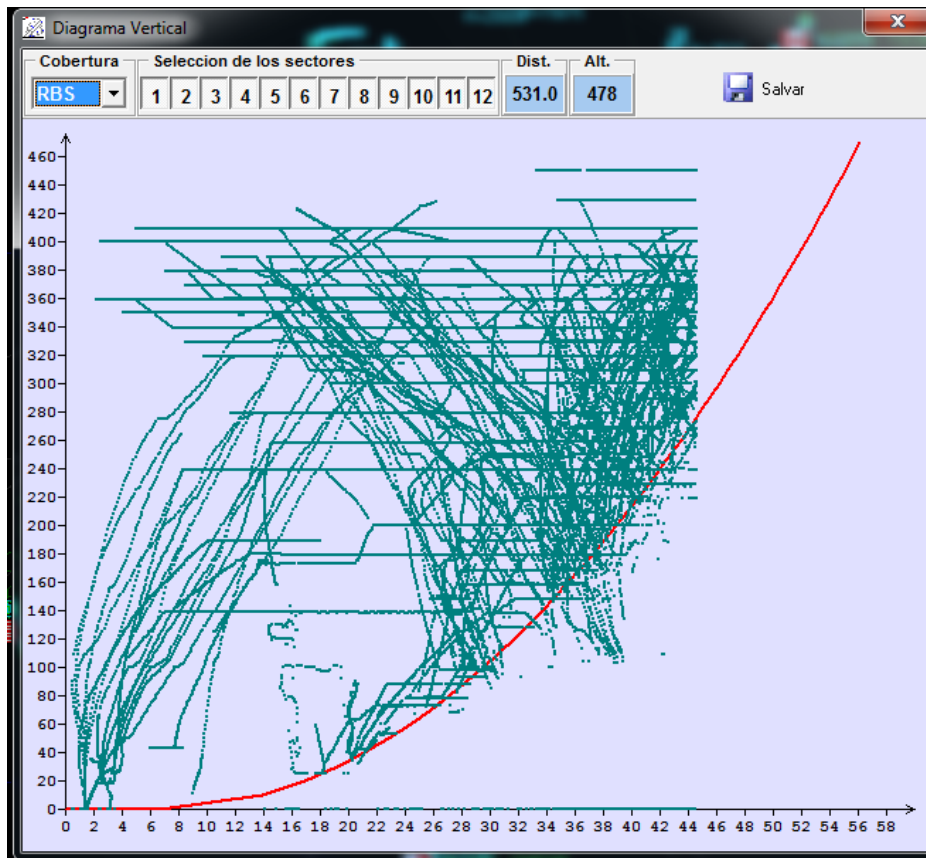
Software facilities

Analysis of the coverage from the radiolocation station on the horizontal plane at different altitudes.

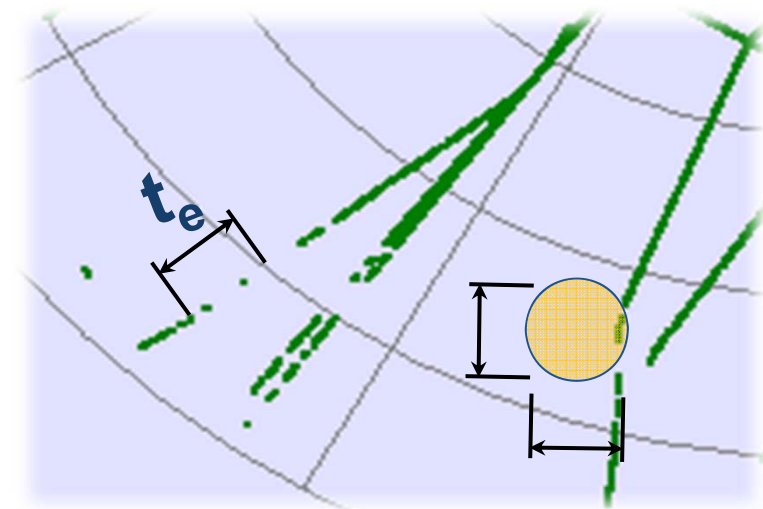
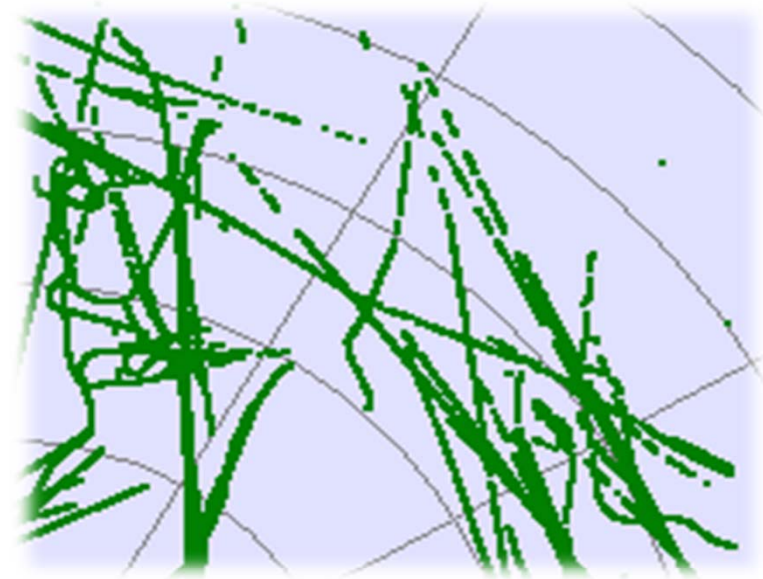
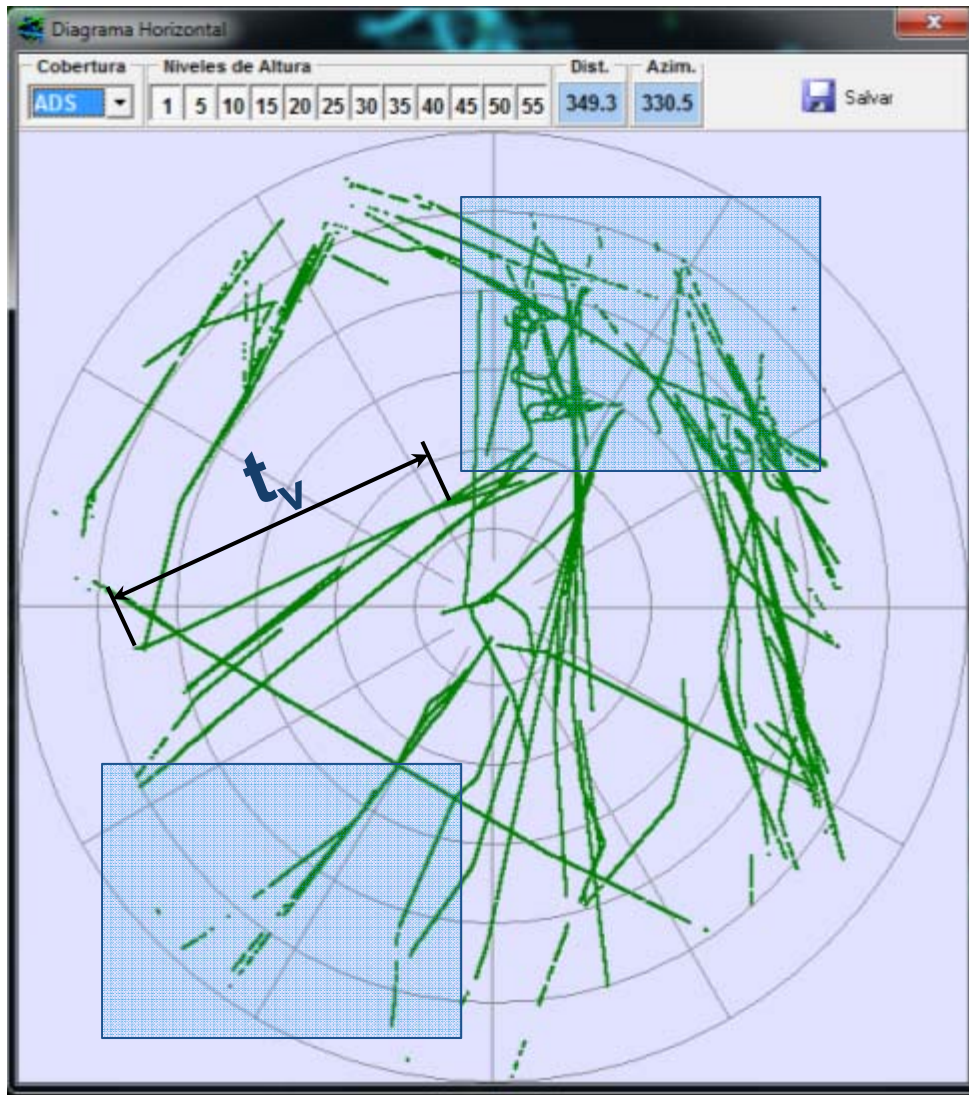


Software facilities

Analysis of the coverage from the radiolocation station in the vertical plane at different sectors.



Análisis de los datos de vigilancia.



Application of the filters of search.

The following filters have been selected in this search:

- Interval of time:
From 2015-01-01 up to 2015-02-01.
- Time of flight:
Major of 00:10:00 Minor of 11:59:59.
- Region:
Area: FIR-HAV Level: 10000 - 55000.
- NICp:
Major of 6 Minor of 11.
- DO-260:
Version from 0 up to 2.



Analysis example of processed data since 01-01-2015 until 31-01-2015.

Surveillance Aircrafts status Report Servicios Aeronáuticos ECASA

Starting time: 2015-01-01 00:00 Ending time: 2015-02-01 00:00

Reporte Radar

Mensajes Recibidos : 401436
Objetivos analizados : 60626
Criterios de filtraje
 T.Vuelo: 40380 (66.61%)
 Área: 26891 (44.36%)
 Nivel de vuelo: 55061 (90.82%)
 En región: 25225 (41.61%)
Objetivos filtrados : 25225 (100.00%)

Reporte ADS-B

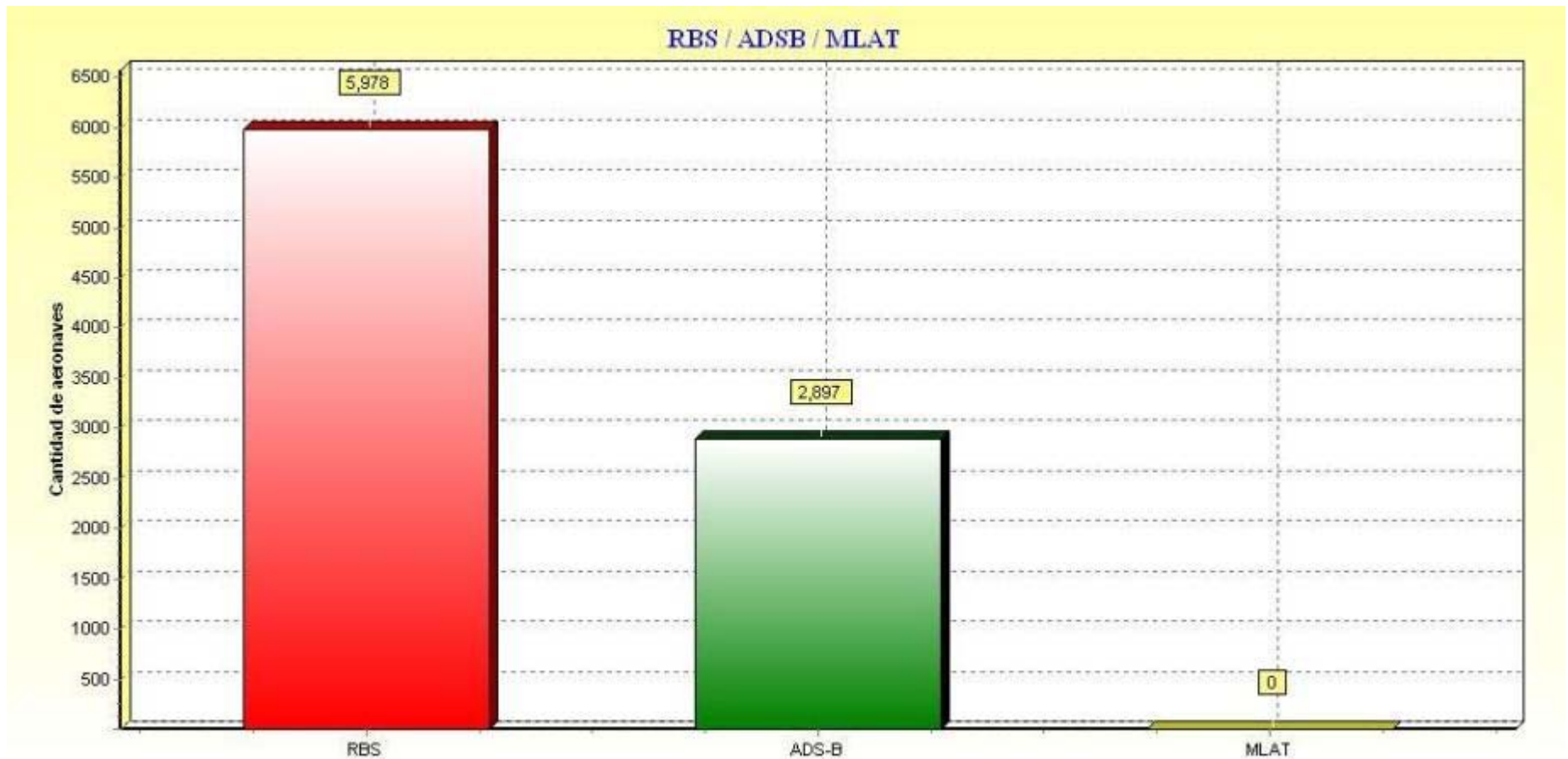
Mensajes Recibidos : 218518
Objetivos analizados : 32303
Criterios de filtraje
 T.Vuelo: 22892 (70.87%)
 Área: 16437 (50.88%)
 Nivel de vuelo: 31222 (96.65%)
 En región: 15267 (47.26%)
 NIC: 12967 (84.93%)
 DO260: 15267 (100.00%)
 Código 24bit OACI: 15267 (100.00%)
Objetivos filtrados : 12967 (84.93%)

General

	A/C	ADSB	
Analizados :	60626	32303	(53.28%)
En región :	25225	15267	(60.52%)
Filtrados :	25225	12967	(51.41%)

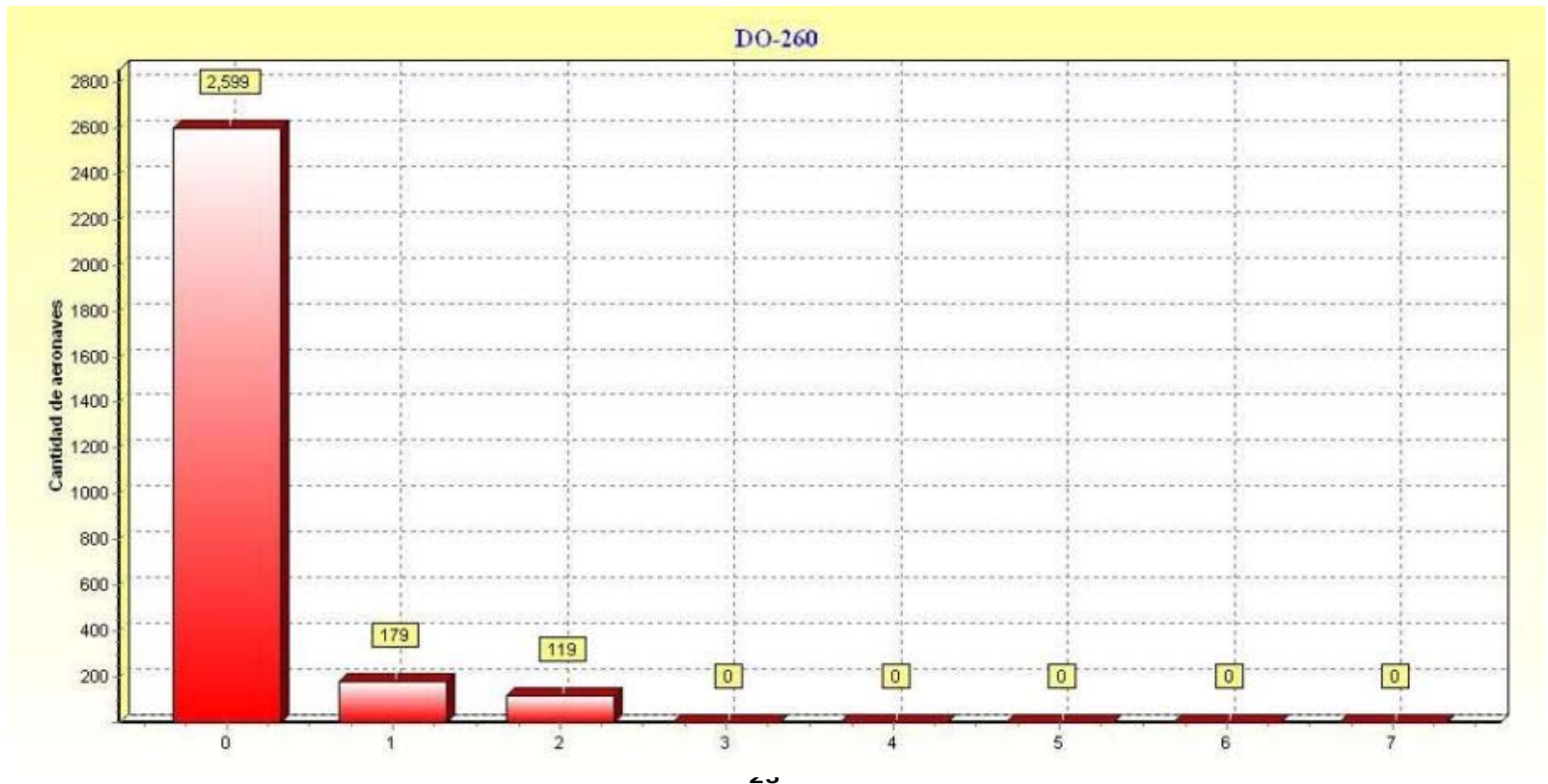
Software features

Graphic of the variations in a period of time of different measurable parameters in the radar total coverage or within the FIR (Radar / ADS-B /MLAT).



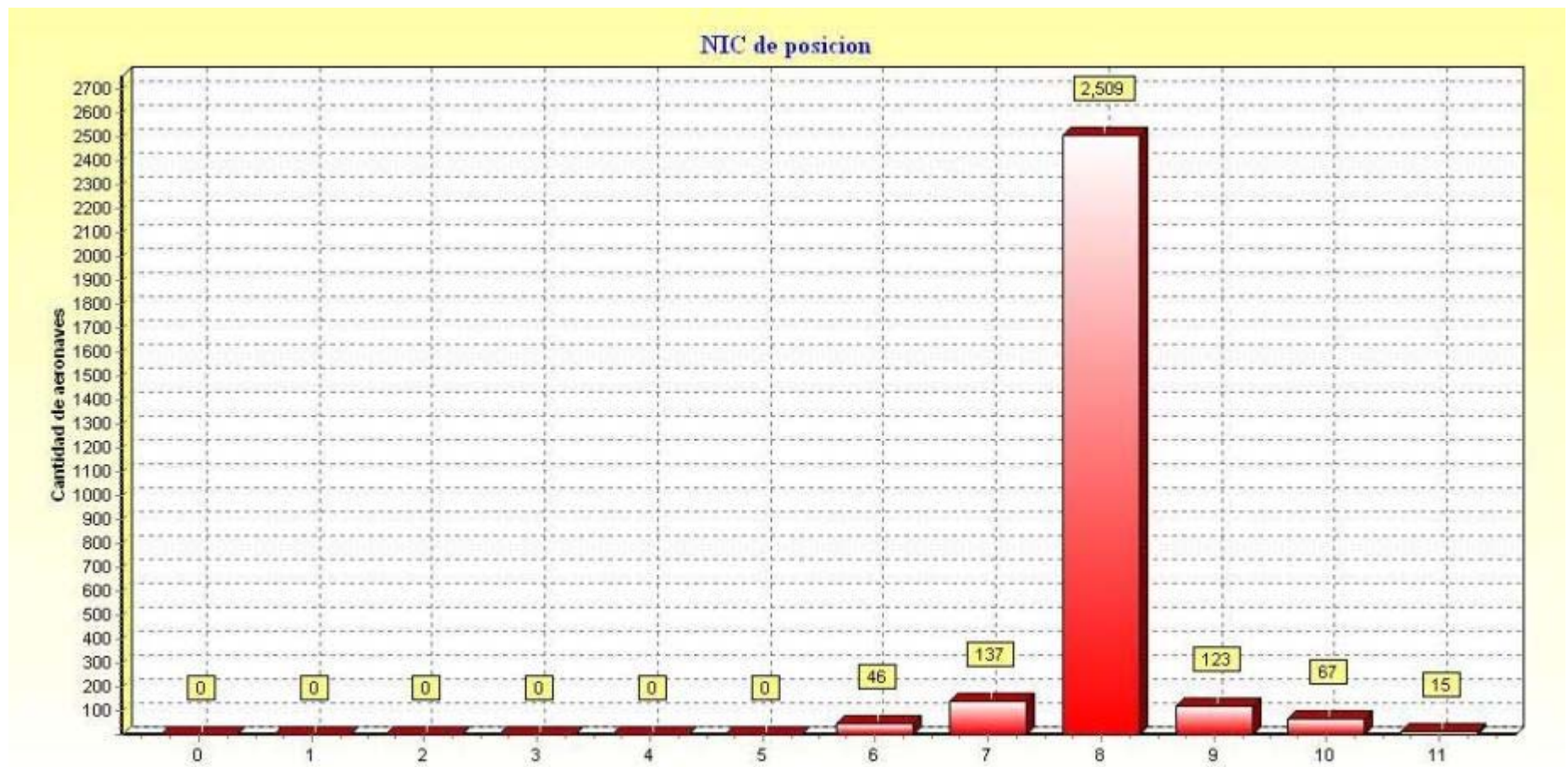
Software features

Graphic of the variations in a period of time of different measurable parameters in the radar total coverage or within the FIR (DO-260).



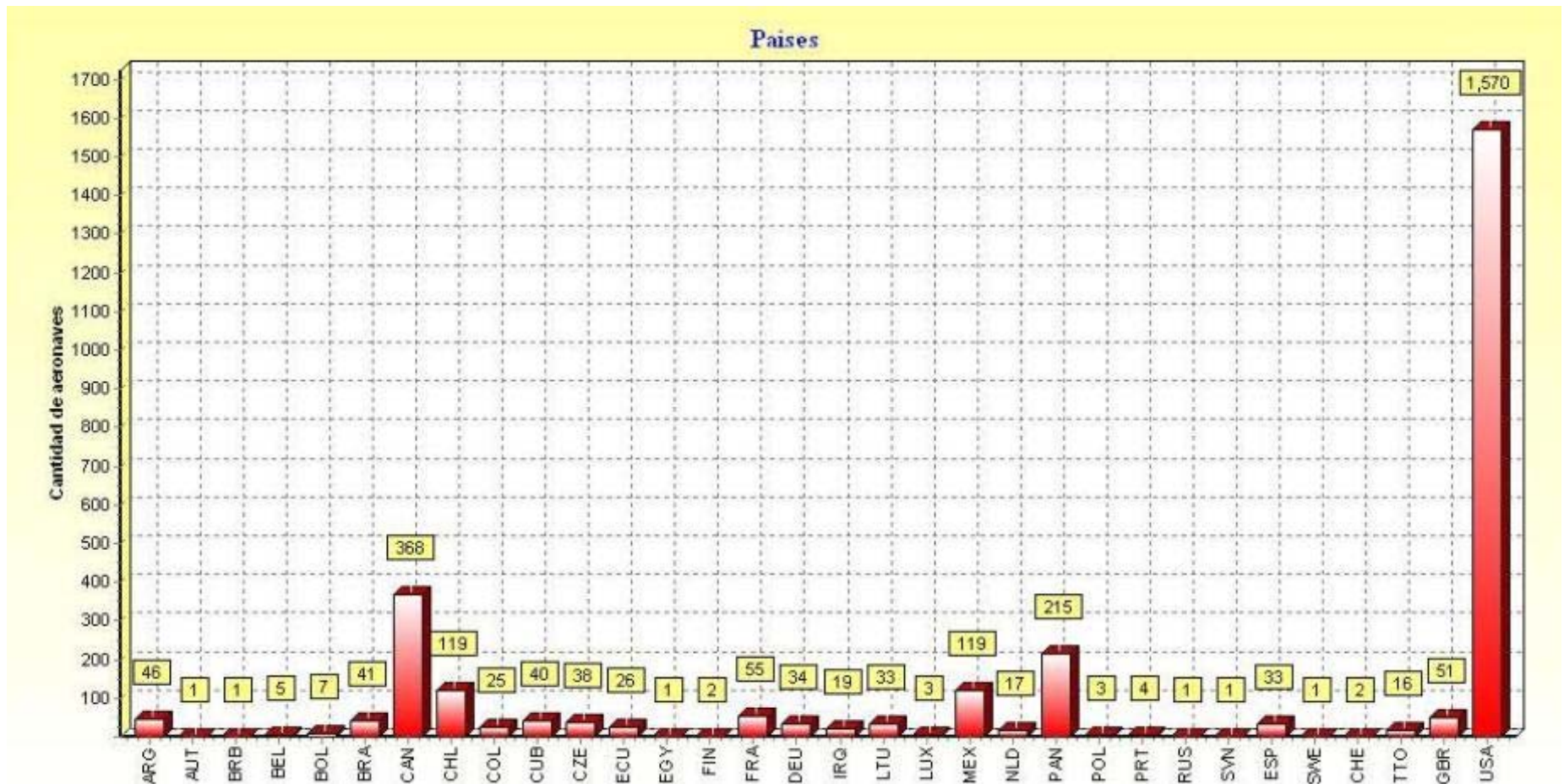
Facilidades del software

Graphic of the variations in a period of time of different measurable parameters in the radar total coverage or within the FIR (NICp).



Facilidades del software

Graphic of the variations in a period of time of different measurable parameters in the radar total coverage or within the FIR (Countries).

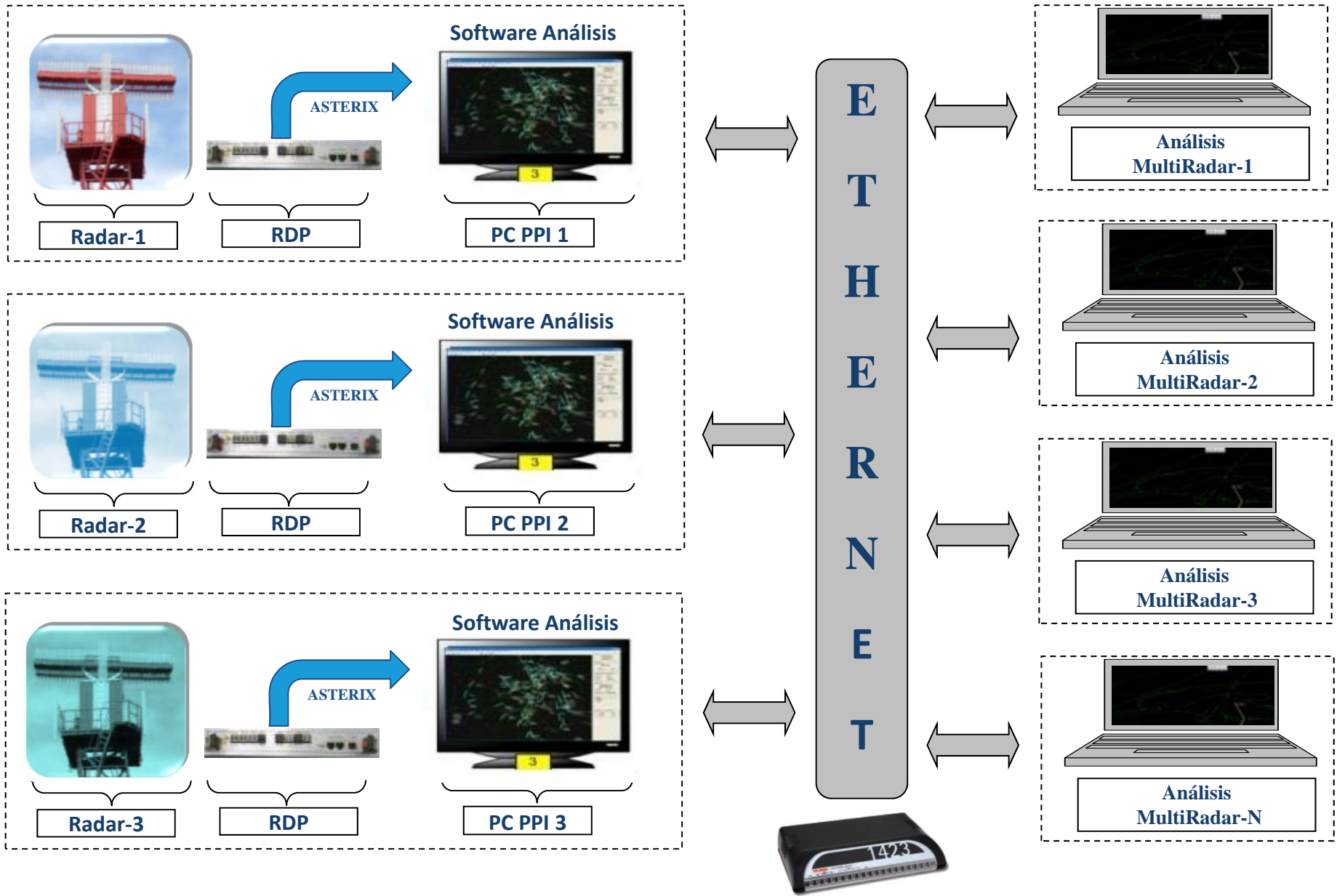




On-going development:

- Statistical analysis by airlines (database).
- Analysis of data received by MLAT.
- Calculation of coordinates accurate levels.
- Analysis with real data with the calculation of the surveillance systems coverage (MLAT Varadero / MSSR Menocal).
- All facilities implementation in the multiradar analysis.

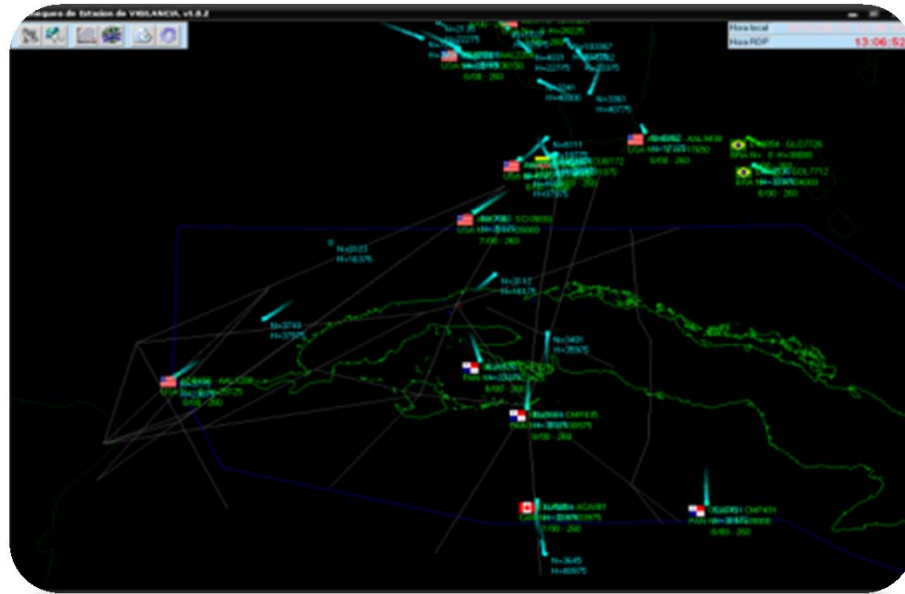
Implementation Proposal





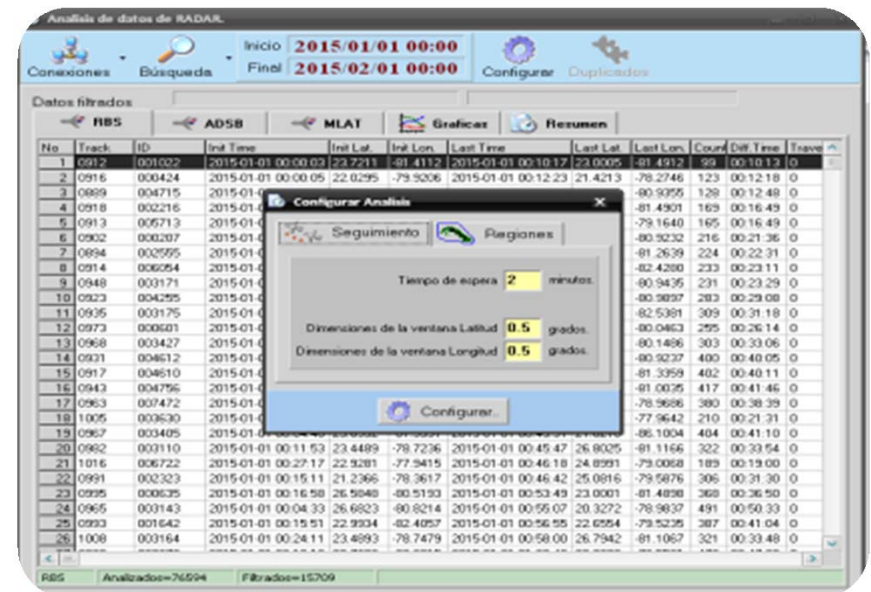
General Structure.

RDAnalysis (Client)



PPI (Server)

- Representation.
- V and H Analysis.
- Processing.
- Storage.
- Transmission.



- Processing
- Statistical calculation.
- Storage.
- Report.
- Graphics



Implementation Advantages

- Flexibility for users in the parameters configuration and the period of time as requested.
- There is no need for further PC investment dedicated to this tasks or connectivity mean to guarantee the access.
- Minimizes the traffic in data network for the analysis.

Cuba



Representation.



Hora local 2015-02-03 19:15:10
Hora RDP 19:15:24

 CC208E CMP246
N=---- H=13550
PAN 8/00 260

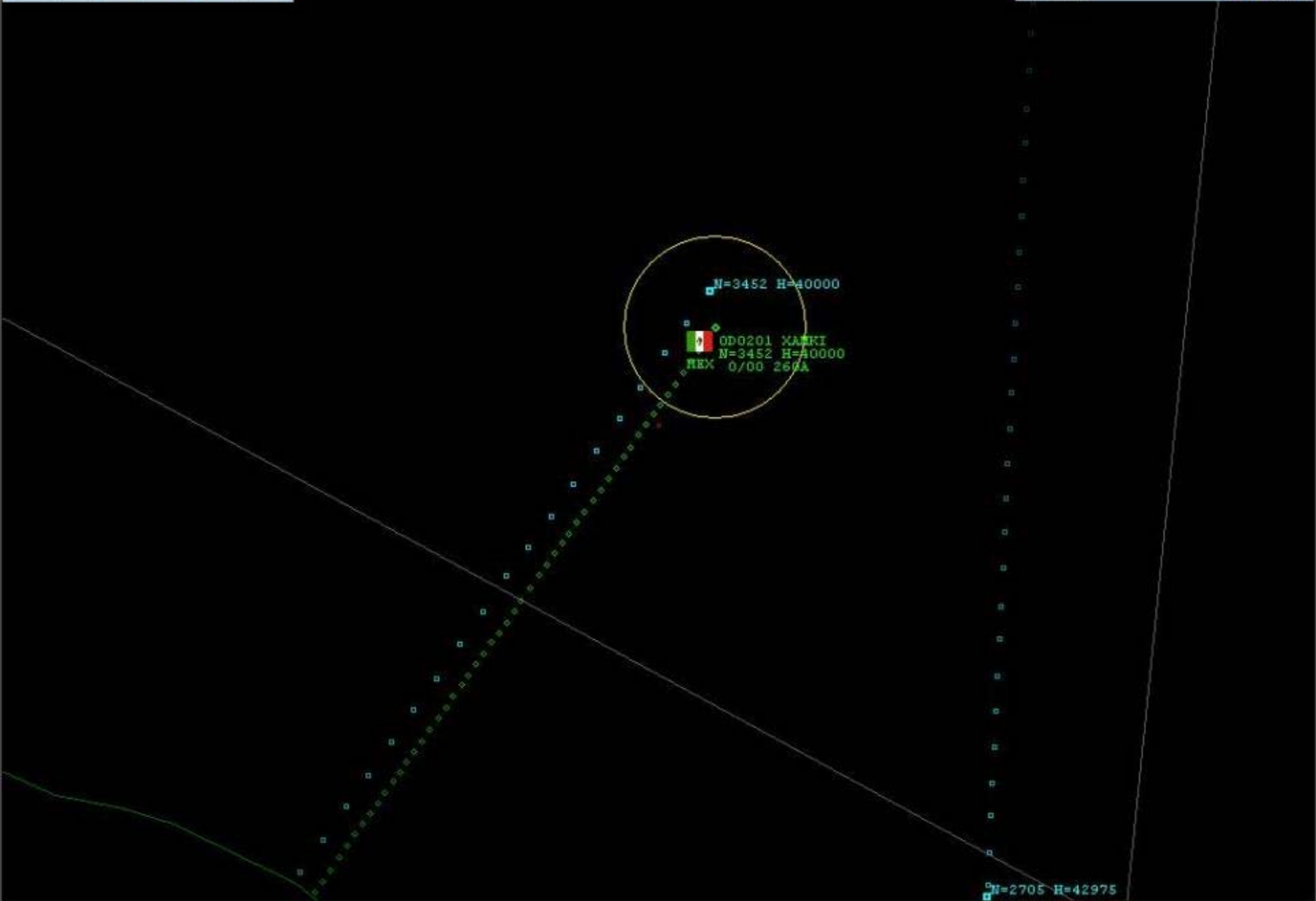
 N=0260 H=13675





Hora local 2015-02-03 19:16:04

Hora RDP 19:16:11






Hora local 2015-02-03 19:20:17
Hora RDP 19:20:40






Hora local 2015-02-03 19:22:11
Hora RDP 19:22:25

 A913BD
N=---- H= CBS
USA 8/00 260

 E06541 ARG1927
N=---- H= CBS
ARG 8/00 260

 E90417 LPE2596
N=---- H= CBS
CHI 8/00 260



Hora local 2015-02-12 13:45:58
Hora RDP 13:28:39

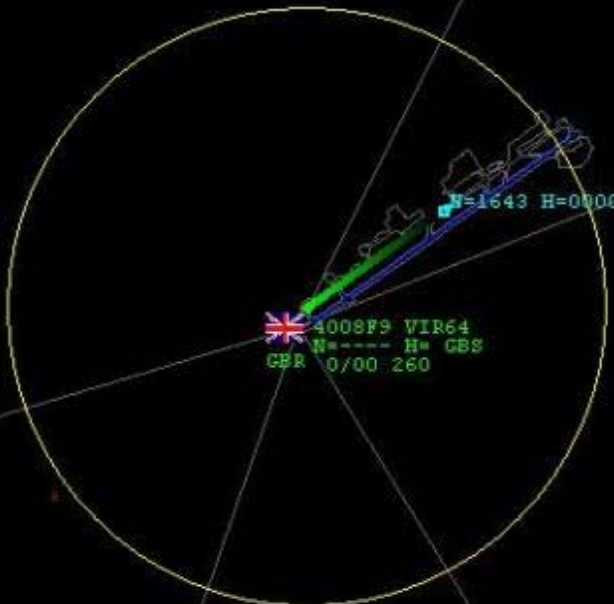




Example of NIC change.



Hora local 2015-02-03 01:09:23
Hora RDP 01:09:52



N=1643 H=00000

4008F9 WIR64
N----- H= GBS
GBR 0/00 260

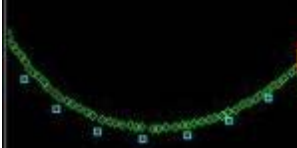
N=2147 H=01875
4444V ARA051
N----- H=01850
ESP 7/00 260



Hora local 2015-02-03 01:11:01
Hora RDP 01:11:04



4008F9 VIR64
N----- H= CBS
CBR 0/00 260




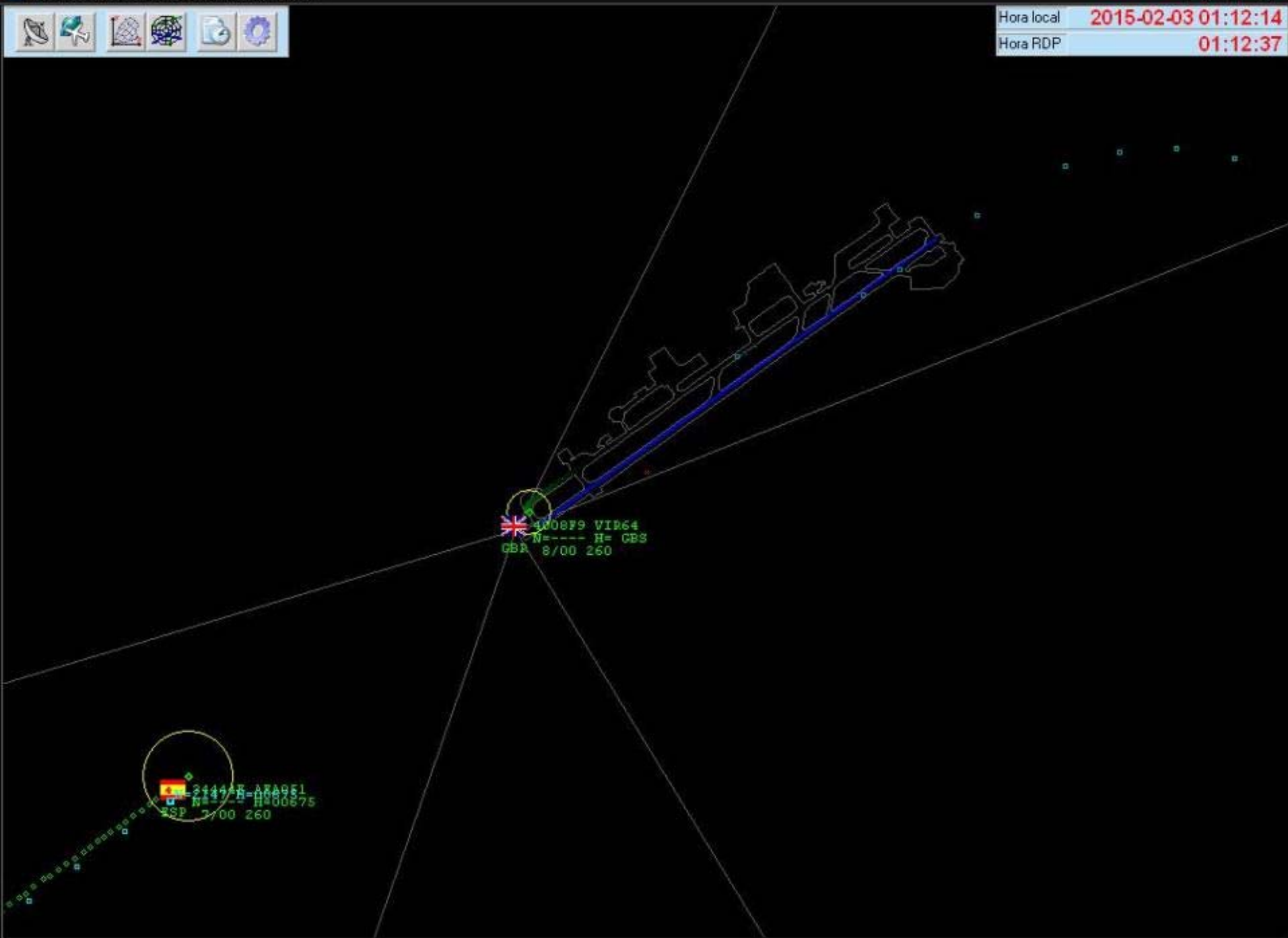
N=2147 H=01775
24444F ARA051
N----- H=01850
ISP 7/00 260



Hora local 2015-02-03 01:12:14
Hora RDP 01:12:37

 400879 VIR64
N----- H= CBS
GBR 8/00 260

 214478 ARA951
N----- H= CBS
ESP 7/00 260



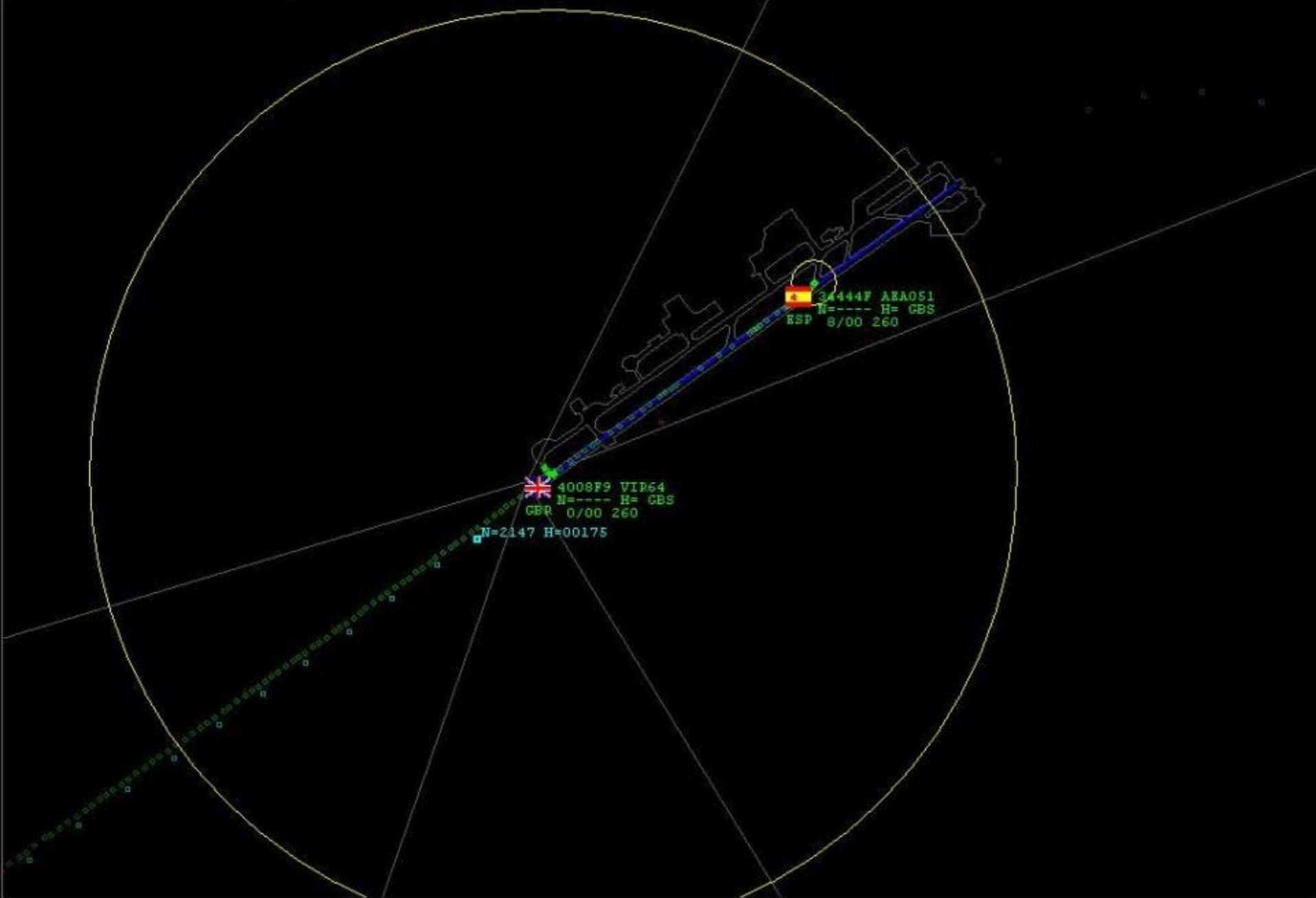


Hora local 2015-02-03 01:13:07
Hora RDP 01:13:19





Hora local 2015-02-03 01:14:12
Hora RDP 01:14:29



34444F AEA051
N----- H= CBS
RSP 8/00 260

4008F9 VIP64
N----- H= CBS
CBR 0/00 260

N=2147 H=00175

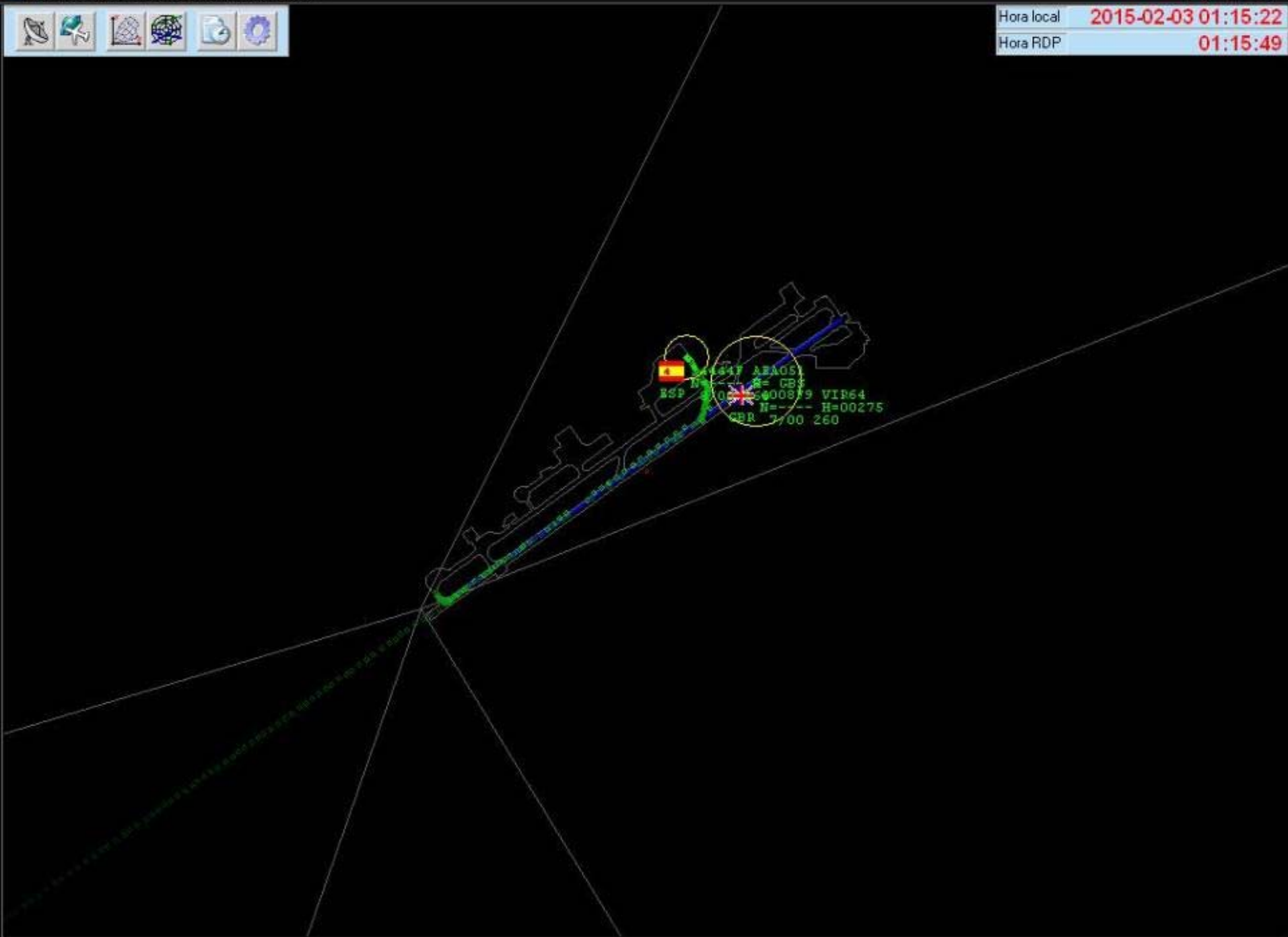


Hora local 2015-02-03 01:15:13
Hora RDP 01:15:29





Hora local 2015-02-03 01:15:22
Hora RDP 01:15:49





Hora local 2015-02-03 01:16:15
Hora RDP 01:16:31



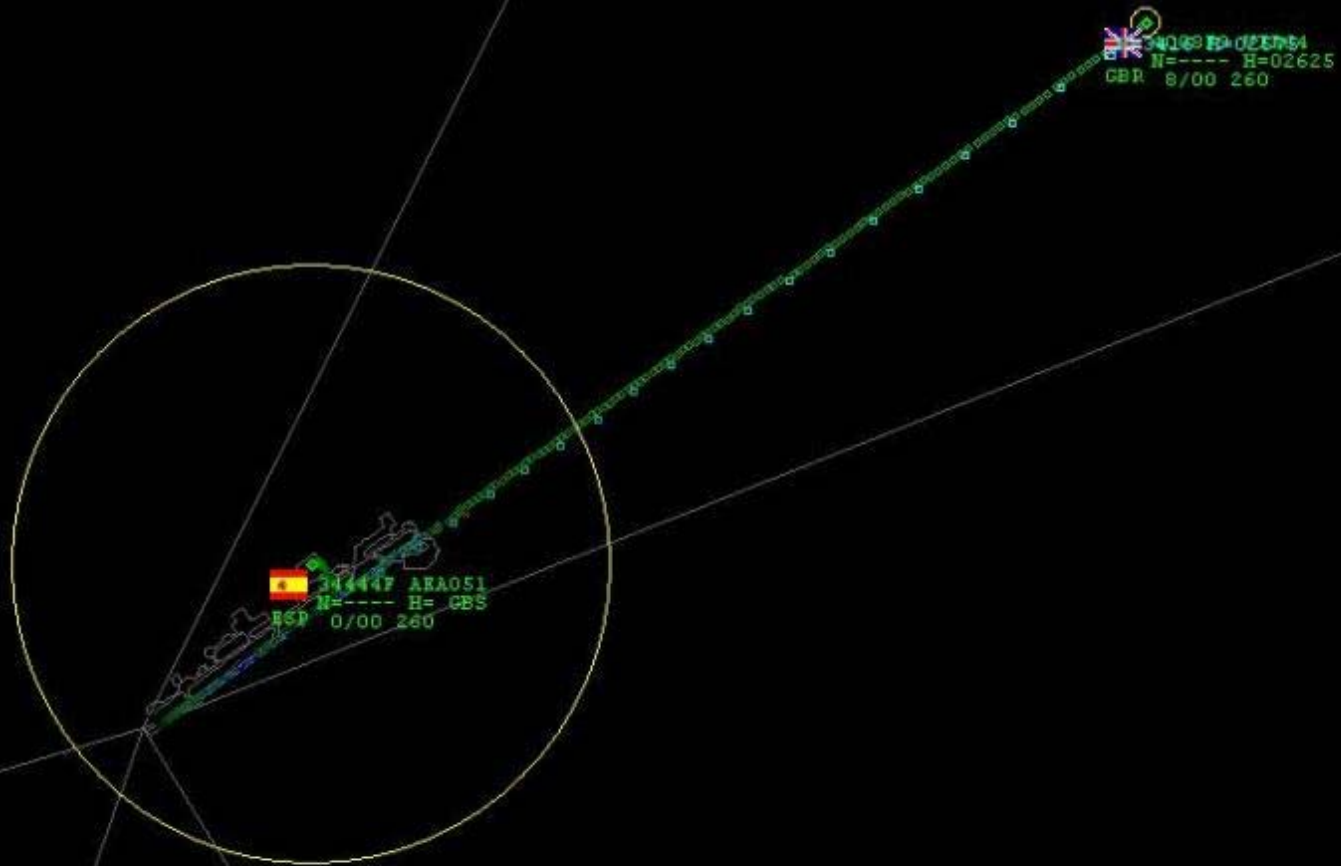


Hora local 2015-02-03 01:17:09
Hora RDP 01:17:19





Hora local 2015-02-03 01:17:21
Hora RDP 01:17:46





Conclusions

- Search criteria are fully customizable, which are used for the processing that will define the tracking of each aircraft, allowing that, in a quantitative manner, only the aircrafts detected by each surveillance station, be evaluated.
- The fundamental premise of not losing a single data transmitted by the station and be able to assess the statistics in a more accurate way, as well as achieving a more thorough analysis to form the detection coverage (vertical and horizontal planes).
- A follow-up on the radar coverage analysis, allows to determine possible faults in the detection.



Recommendations

- Continue the update study of the ADS evolution (DO-260, DO-260A, DO-260B, ...).
- Request an update and global database that contains ICAO 24-bit association code , to aircraft type, airlines, etc.
- Implement a technical task with the demands at different levels to achieve major standardization.
- Enhance the coverage analysis and accuracy on surveillance systems (MSSR, ADS, MLAT).

¡Thank you!

