Final OSED for Madrid TMA (Annex Environmental Assessment)

1.1.1 Introduction

The following document contains the environmental assessment as required by the validation plan of WP5.7.4.

The analysis is based on evaluating the impact the implementation of a P-RNAV TMA in Madrid has on the overall SESAR environmental targets identified . In particular the assessment focuses on fuel burn and emissions, as can be found in Sec. 1.1.5.

The assessment delivers both qualitative and quantitative information. Mostly qualitative when trying to fill the gap between the data sources available.

The assessment is based on comparing data from three exercises on two scenarios with the same traffic sample:

The scenarios being:

- the TMA of Madrid with P-RNAV;
- and Conventional (as currently found).

The exercises [3] being:

- RTS;
- FTS (TAAM);
- Radar[1] data extracted through PALESTRA.

The assessment's aim is to compare the two scenarios using the data/values coming from the exercises by evaluating the KPIs relatively at first and eventually comparing them with the objectives established by SESAR.

[1] Radar data is not an exercise but has been added as the baseline source.

1.1.2 AIM

To evaluate the Environmental performance of a P-RNAV TMA in Madrid, Spain compared to the current Conventional one in place

1.1.3 REFERENCES

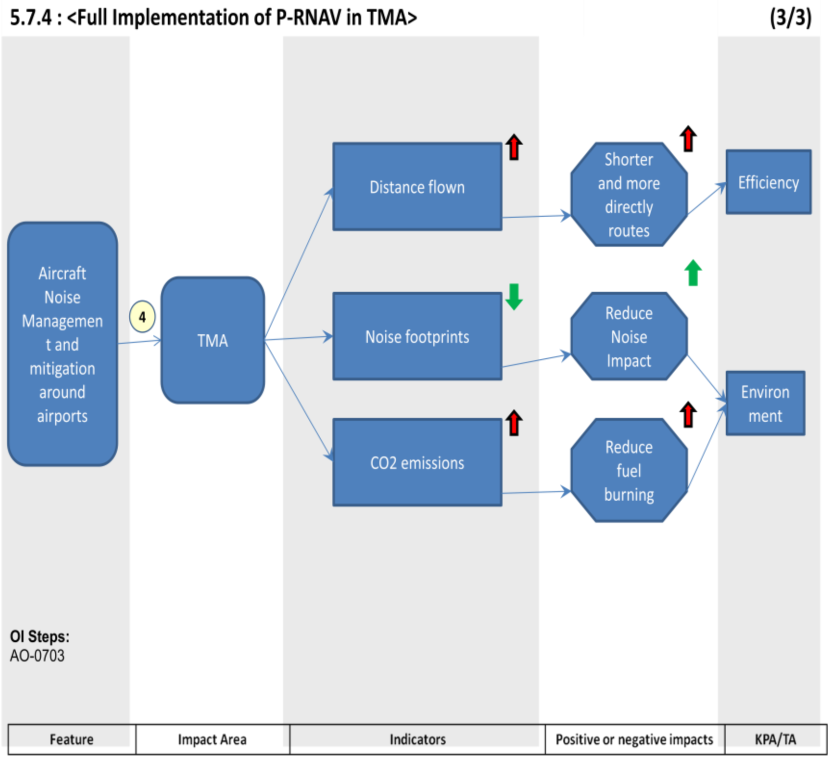
[1] 05.07.04 - D02 - Full implementation of P-RNAV in TMA – Final OSED – Madrid, TMA.

[2] 16.06.03 - D06- ENV Reference Material - ENV-assessment.doc.

[3] Validation Report 05.07.04 AENA D03 02.00.00

[4] http://www.canso.org/CMS/showpage.aspx?id=521

1.1.4 Benefit Mechanisms



The benefit mechanisms highlighted by WP5.7.4 included both the Noise and Emissions impact domain. However for the assessment only the foreseen reduction in fuel burn and emissions was taken into consideration for validation.

1.1.5 Environment KPA –validation objectives

- Stakeholders: Airlines, ANSPs, Community & States
- Grouping: High External Visibility - Effects are societal and of political nature

Indicators and metrics

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I1: Average fuel consumption per flight as a result of ATM improvements	ENV111 O1 I1 T1: -10%
ENV1 -	ENV11 -	ENV111 -			ENV111 O1 I2:	ENV111 O1 I2 T1: -10%

Environmental Sustainability Outcome	Atmospheric Effects	Gaseous Emissions		Average CO2 emission per flight as a result of ATM improvements	
ENV1 - Environmental Sustainability Outcome	ENV12 - Noise Effects	ENV121 - Noise Emissions		ENV121 O1 I1: Total Area of the noise footprint	
ENV1 - Environmental Sustainability Outcome	ENV12 - Noise Effects	ENV122 - Noise Impact		ENV122 O1 I1: Impact Area of the particular noise level	

Table 1: 5.7.4 Environment KPA.

A further indicator which has been proposed is flight time duration; this together with distance and fuel burn can help in understanding the difference in behaviour of the traffic to different operational procedures.

1.2 Scoping of the Environmental Assessment

The assessment covers the introduction of P-RNAV operations to Madrid's TMA. Thus the analysis is limited:

Horizontally - to the TMA and in particular the arrivals in North Configuration, since no difference was found or perceived at an operational level with what is currently done with Departures [REF OSED RTS conclusions].

Vertically - to flights below FL160, limit introduced by the FTS scenario.

Arrivals - Only in North Configuration as shown in Figure 1.

The assessments' scope is also limited to the emissions' domain, in particular the difference in fuel burn and resulting emissions of CO2 between the two scenarios (i.e. Baseline conventional TMA against simulated P-RNAV TMA).

In summary the assessment will include all the flight operations contained in Madrid's TMA performing an arrival from FL160 to touchdown, excluding taxi (i.e. the flight disappears or will have ICAO default values for taxiing).

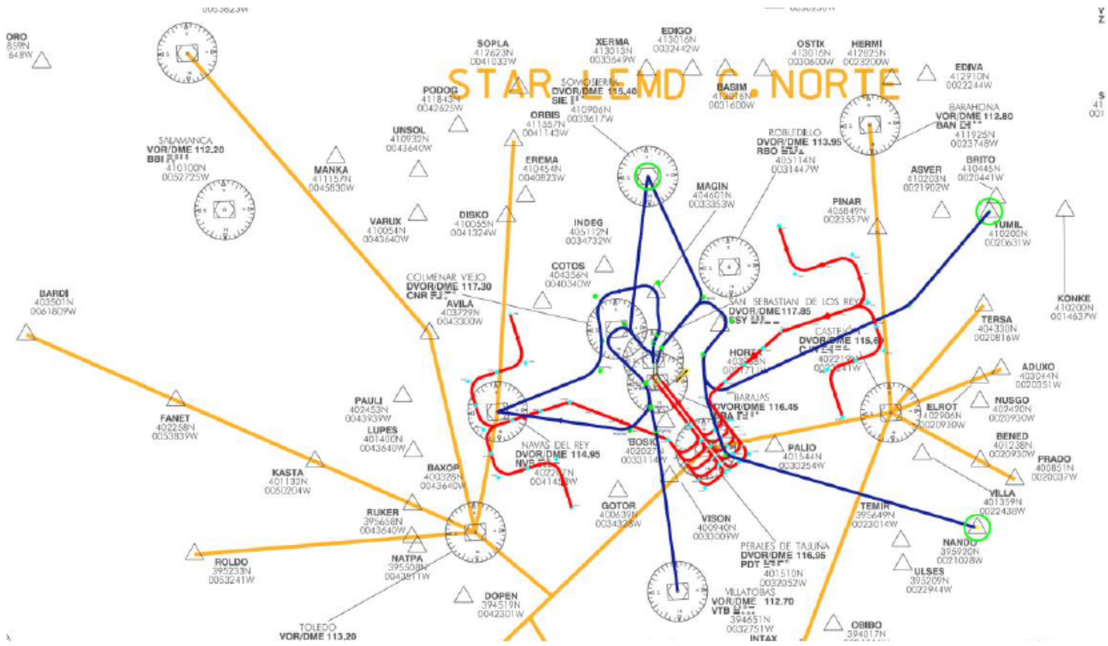


Figure 1 P-RNAV procedures in Madrid's TMA – North Configuration (ARRIVALS in red; Departures in blue).

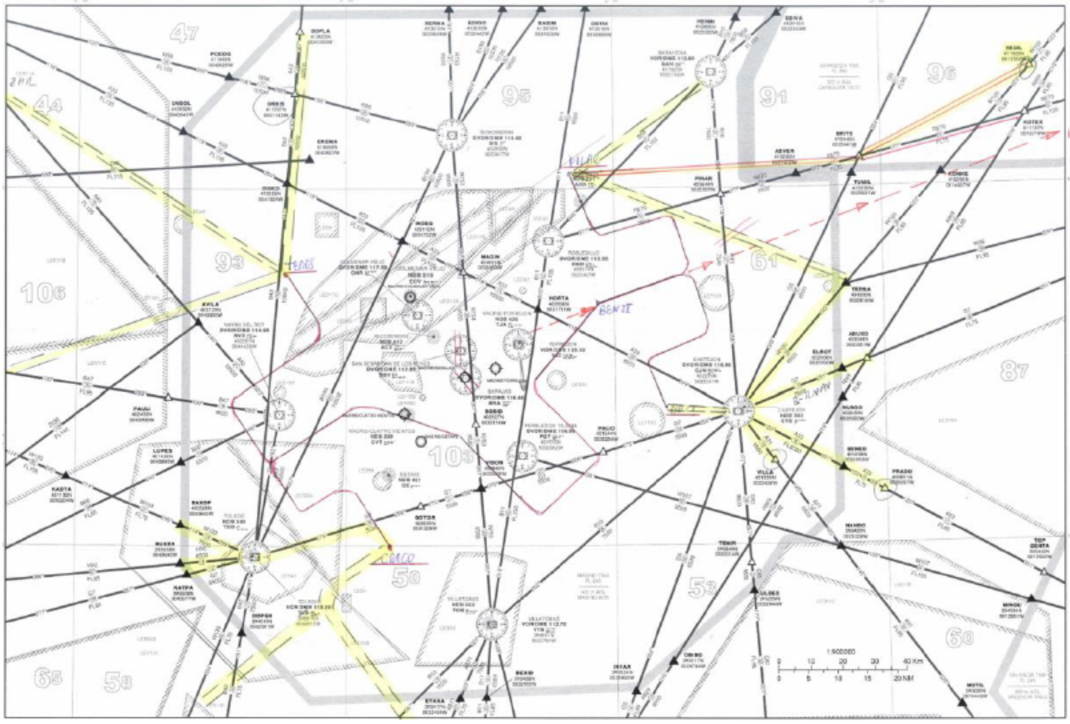


Figure 2 P-RNAV procedures in Madrid's TMA – North Configuration (ARRIVALS in red) superimposed on conventional.

1.3 Baseline and assumptions

Before introducing the baseline it is important to point out the difference in data [2]sources which were made available to the assessment:

- Radar data (from PALESTRA) chosen as the baseline.

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[2] The RTS data was not available in a recorded text format to be used by the chosen software tool.

- TAAM's simulation data (FTS).
- Main conclusions from the RTS.

For all the scenarios the same traffic sample belonging to one whole day of operations to Madrid Barajas Airport was used. This means that RTS as FTS are based on the traffic coming from PALESTRA (Radar processed data).

Radar data, which from now on in the assessment will be referenced as PALESTRA, is a picture of the current conventional operative in Madrid's TMA.

Of the three data sources available only one simulated the current Conventional and the P-RNAV scenarios and that was the RTS platform.

TAAM only simulated the P-RNAV procedures in Madrid.

PROBLEM

Finally we find ourselves with a dilemma in trying to answer the environmental assessment with data and values which are not comparable.

ACTION

The decision was made to follow on with the assessment trying to use this chance to trial the environmental software and the pre processing data module. It was also decided to use the RTS results to give a qualitative assessment of the P-RNAV TMA.

1.3.1 Assumptions between TAAM, RTS and PALESTRA data

The same traffic sample was used, making sure that the following was kept consistent in each scenario:

- Nº of flights;
- Origin;
- Aircraft type;

When for the same call sign two different aircraft types existed, in particular between the traffic list of TAAM and the one of PALESTRA, the decision was made to use the aircraft belonging to the list of TAAM.

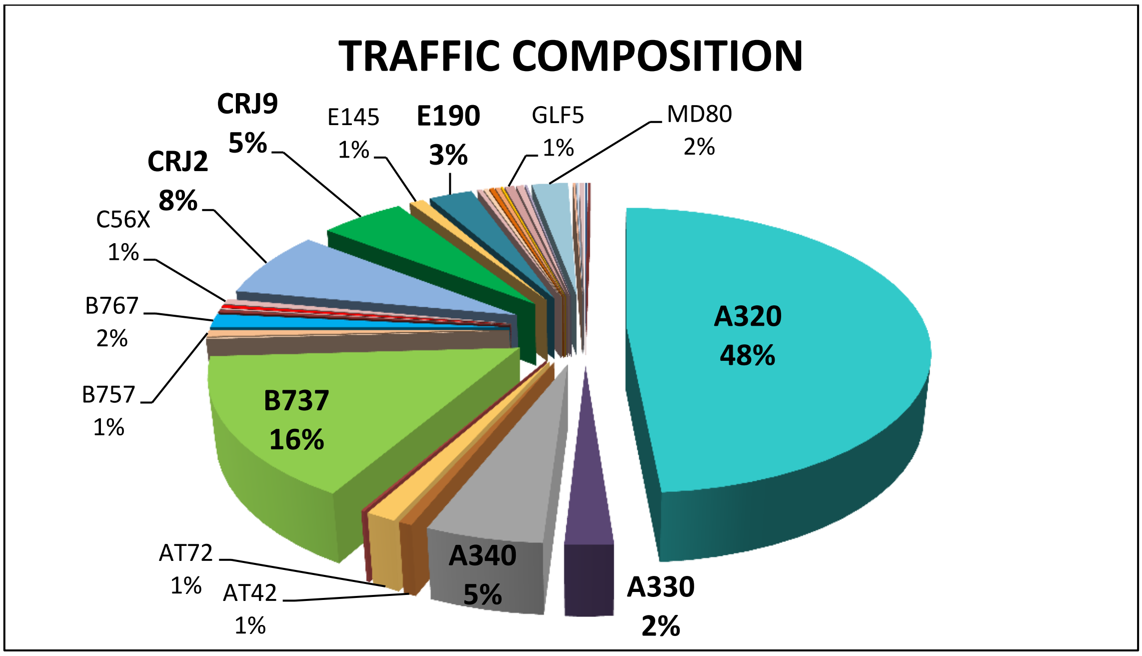


Figure 3 Traffic composition per a/c type

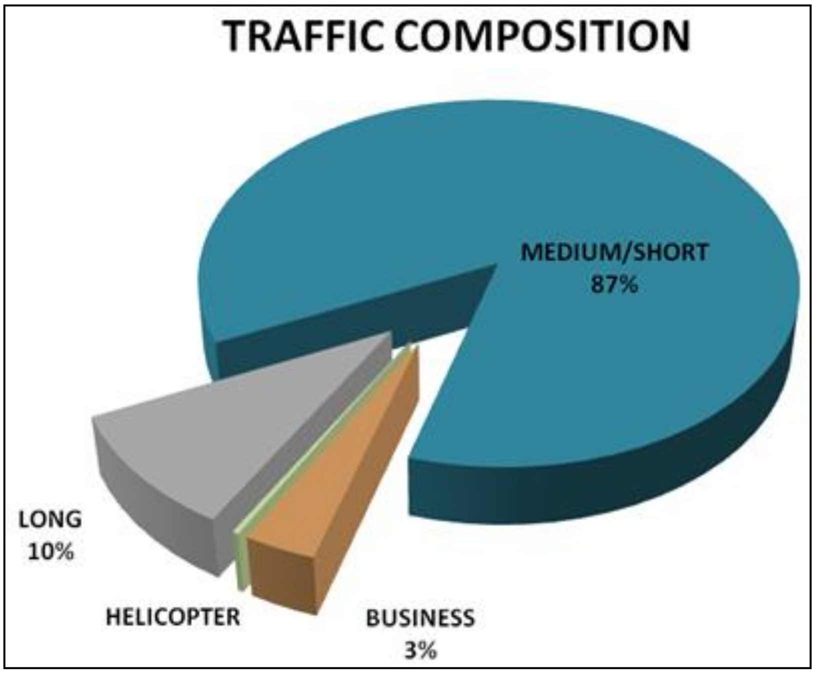


Figure 4 Traffic composition per a/c range

HOLDINGS

Holdings are not present in the FTS exercise as they are not admitted by the design or modelled. This can be appreciated when comparing visually Figure 6 and Figure 7. Anyhow holding patterns would be located before the beginning of the P-RNAV arrival procedures as can be appreciated when superimposing the new design on top of the conventional ones Figure 5.

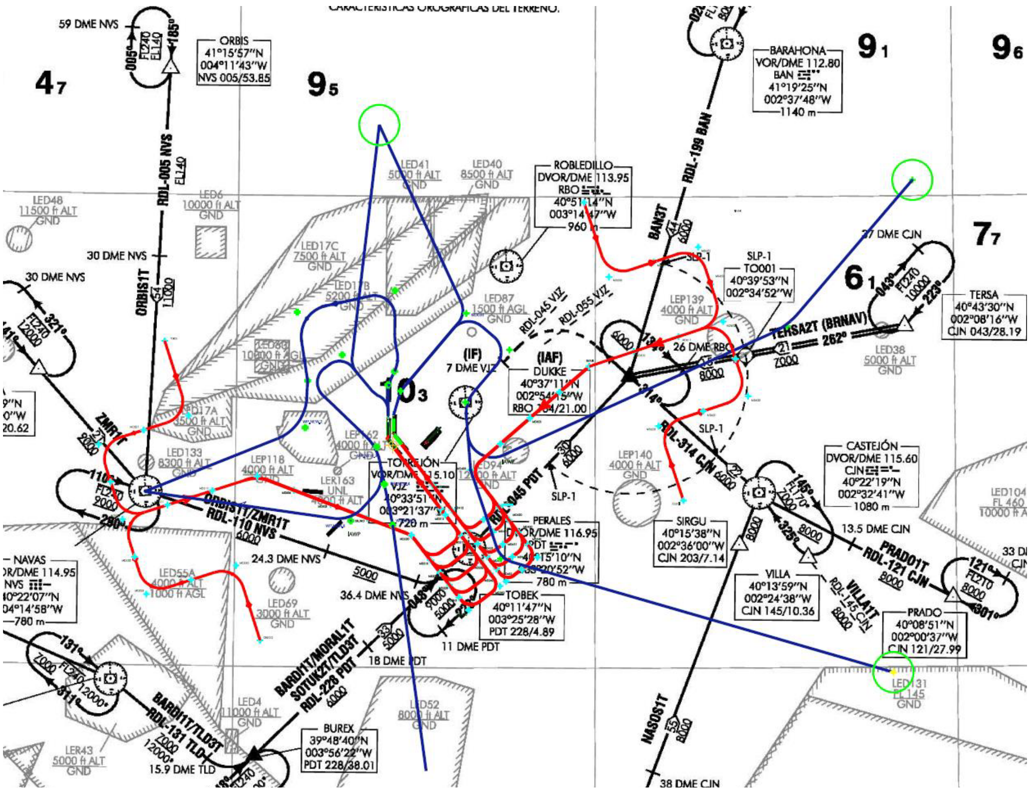


Figure 5 Conventional vs. P-RNAV procedures (holdings before the P-RNAV starting point are kept).

TRAFFIC PATTERN

Below, in Figure 6, one of the main differences in the distribution of the traffic tracks.

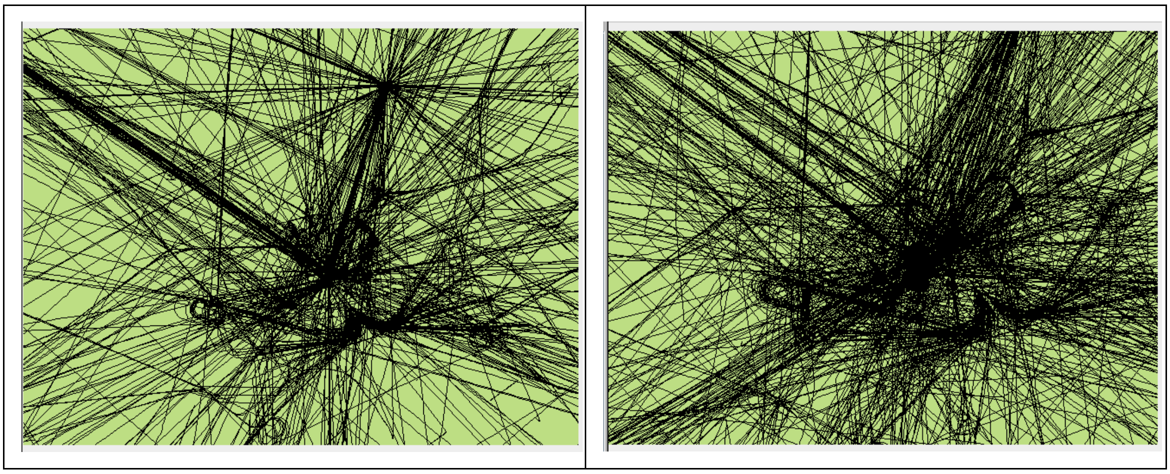


Figure 6 PALESTRA visualisation of the traffic tracks

Growing holdings can be noticed from left to right as the traffic increases during the day. Tracks cover all the airspace inside the assessment (they include deviations, vectoring, direct-to's, holdings, etc...)

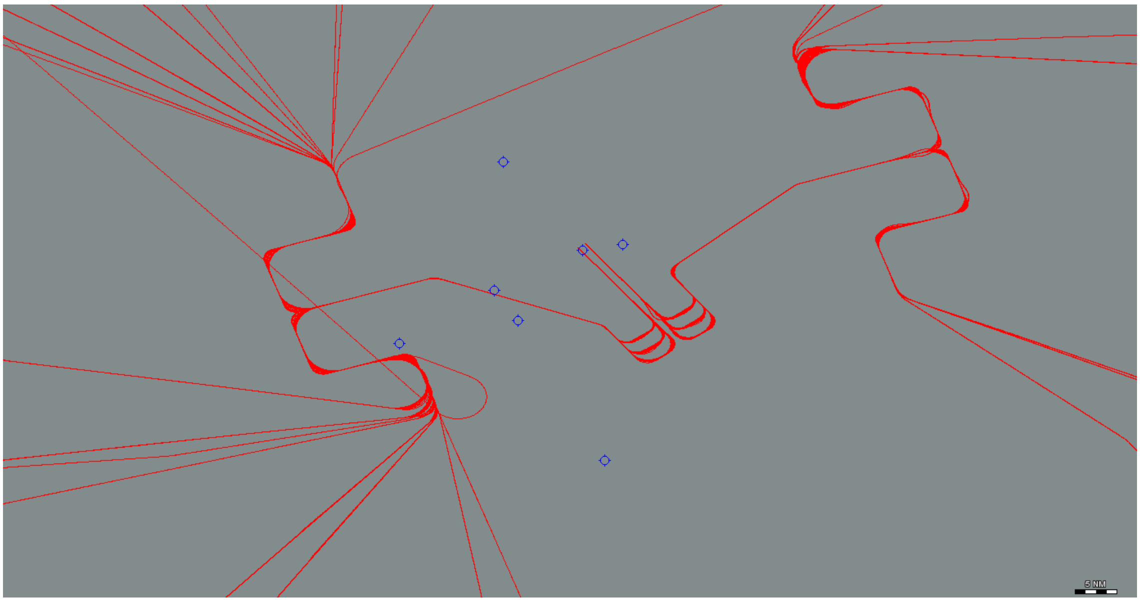


Figure 7 TAAM visualisation of the traffic tracks

On the other hand there is little variability or deviation in the tracks above in the FTS, all the aircraft follow the procedures with only a few small deviations as can be appreciated on one of the STARs located south-west.

Conclusion

Fuel burn values taken lightly: by evaluating only the two scenarios by two different platforms made available (PALESTRA vs. TAAM), lead to incongruent conclusions on the validity or not of the P-RNAV aerospace on environmental (emissions) grounds.

1.4 Type of assessment

Two different types of assessment were envisioned in [2]. The one contained and detailed in this report would have been actually a hybrid since it would at first compared the two scenarios per platform that is realtivelly;

Later it would have compared the KPIs of each platform towards the targets declared in Sec. 1.1.5 (SESAR objectives or validation report objectives).

Absolute Assessment	…… assesses all environmental parameters across all phases of flight and then compares the output to predefined acceptability criteria.
	Advantages: • Comprehensive, robust assessment • Essential if very different operational concepts are to be compared • Provides credible support to "trade-off" discussions
	Disadvantages: • Resource intensive • Acceptability criteria may not be defined • Principles for "trade-off" of different impacts are not yet generally agreed
Relative Assessment	…….assesses all environmental parameters across all phases of flight and then compares the output to the environmental parameters for an operation that is performed today (and by inference is acceptable).
	Advantages: • More resource efficient (only needs to analyse in detail those environmental impacts that change). • Can provide simple information to support the decision making process
	Disadvantages: • May be difficult to apply when environmental impacts of the proposed and the reference concept are very different. • Some stakeholders may dispute the assumption that the situation today is acceptable. • In the absence of an agreed approach to "trade-off" many relative assessments may not provide a clear result (i.e. there will only be a clear result in favourable circumstances).

Table 2: Absolute versus relative assessment

Unfortunately the type of assessment with the dissimilar data sources available can only be a qualitative relative assessment which may confirm the KPI as a benefit or not but cannot be compared to the targets (i.e.: ENV111 O1 I1 T1).

1.5 Tools used for the assessment

The AEM-3 PC software tool suggested (WP16.6.3) for this kind of studies was used with all the constraints, caveats and limitations it inherits[3] [3], [2]. The use of this tool produced quantitative results.

Expert judgement and Actor feedback was also used, and mainly, to gain a better insight into the RTS exercise operations and for the assessment of the OSED. The use of this tool produced the only conclusive qualitative results.

[3] Data pre-processing is time and resource consuming; on top the program is limited in the amount of operations it accepts; no visualizing tool is available; Polygon bug; bug with aircraft data, etc...

1.5.1 Description of the exercise

Only two data sources for two different scenarios were available for quantitative data as shown below in Table 3.

AVAILABLE SCENARIOS	
Baseline Conventional Scenario 1 PALESTRA	P-RNAV Scenario 2 TAAM
Size of traffic sample: **646 flights**	Size of traffic sample: **652 flights**

Table 3 Scenarios available with quantitative data.

1. Scenario 1: Current Conventional procedures;
2. Scenario 2: P-RNAV Scenario.

Only the RTS platform simulated the two scenarios.

1.5.2 Inputs

Two different data formats were adapted to the AEM-3 format. For this aim an in-house module had to be tailored in order to ease the process.

Format of PALESTRA

```
Sesion: Informes automaticos
Periodo de la sesion: 05/11/2010 00:00:00 05/11/2010 23:59:59
Periodo del informe:  05/11/2010 00:00:00 05/11/2010 23:59:59
Comentario:

Fin de comentario

Lista de aeronaves

                     Indicativo Nº est SSR Tipo Pres est Modo_C Pos X    Pos Y    Latitud      Longitud     Vel_mod  rumbo   Vel X    Vel Y    Vel_Z Cal SPI Flt AC AM AE cm org  dst sct_asg stl TA
0x/11/20xx 00:00:03 IBE6831    938 V  4551 EP   S    V   330   -109,100 -106,865 39 03 37 N  07 51 03 W  488,606 246,238 -447,187 -196,875 0     A   N   L   N  N  N  0  LEMD SCEL             N
                    RYR7475    178 V  7650 EP   S    V   219   -113,975 59,828   41 50 11 N  08 03 27 W  361,172 221,843 -240,937 -269,062 -3663 A   N   G   N  N  N  0  LFOB LPPR             N
                    AFR418     1217V  7654 EP   R    V   290   -121,891 131,835  43 01 54 N  08 17 07 W  482,689 226,101 -347,812 -334,687 0     A   N   G   N  N  N  0  LFPG SAEZ             N
                               635            SR    P          -1    -128,104 123,906  42 53 46 N  08 25 13 W  2,812   180,000 0,000    -2,812         B           N  N  N
                    AFR454     689 V  7656 EP   S    V   310   -85,946  166,260  43 37 17 N  07 29 14 W  490,669 226,238 -354,375 -339,375 0     A   N   R   N  N  N  0  LFPG SBGR             N
                    AEA041     525 V  4537 EP   S    V   287   -7,733   -53,716  39 58 14 N  05 41 03 W  479,252 232,950 -382,500 -288,750 838   A   N   R   N  N  N  0  LEMD SAEZ             N
                    DLH510     969 V  0126 EP   R    V   310   -4,594   -9,573   40 42 25 N  05 37 02 W  514,130 220,340 -332,812 -391,875 0     A   N   R   N  N  N  0  EDDF SAEZ             N
                    AFR406     206 V  7652 EP   S    V   310   -30,619  220,733  44 32 34 N  06 13 45 W  487,295 225,857 -349,687 -339,375 0     A   N   R   N  N  N  0  LFPG SCEL             N
                               540 V  5102 ED   S    V   181   -12,518  228,146  44 40 04 N  05 48 31 W  215,045 47,827  159,375  144,375  0     A   N       N  N  N  0
0x/11/20xx 00:00:04 CLF7       310 V  3430 EP   R    V   110   59,304   -14,972  40 36 34 N  04 13 07 W  311,437 143,199 186,562  -249,375 -988  A   N   R   N  N  N  0  EGLL LEMD             N
                    LPE2707    725 V  4525 EP   R    V   190   55,897   -13,681  40 37 55 N  04 17 34 W  406,461 267,091 -405,937 -20,625  2031  A   N   G   N  N  N  0  LEMD SPIM             N
                    NJE568L    670 V  2517 EP   R    V   390   37,612   58,894   41 50 44 N  04 40 40 W  454,145 246,133 -415,312 -183,750 0     A   N   R   N  N  N  0  EDDF LPPT             N
                    AFR442     572 V  7653 EP   S    V   310   50,594   249,862  45 01 25 N  04 19 46 W  495,863 219,861 -317,812 -380,625 0     A   N   L   N  N  N  0  LFPG SBGL             N
                               1118V  2361 ED   S    V   344   68,005   204,700  44 16 03 N  03 56 27 W  438,663 34,199  246,562  362,812  869   A   N       N  N  N  0
                               436            SR    P          -1    104,937  32,867   41 23 29 N  03 11 34 W  0,000   0,000   0,000    0,000          B           N  N  N
                    VLG1685    1308V  6023 EP   S    V   380   167,677  116,345  42 44 41 N  01 43 29 W  451,530 120,025 390,937  -225,937 0     A   N   G   N  N  N  0  LECO LEBL             N
0x/11/20xx 00:00:08            635            SR    I          -1    -128,104 123,902  42 53 46 N  08 25 12 W  2,812   180,000 0,000    -2,812         B           N  N  N
                    IBE6831    938 V  4551 EP   S    V   330   -109,718 -107,137 39 03 20 N  07 51 50 W  488,606 246,238 -447,187 -196,875 0     A   N   L   N  N  N  0  LEMD SCEL             N
                    RYR7475    178 V  7650 EP   S    V   214   -114,309 59,442   41 49 47 N  08 03 53 W  363,195 221,756 -241,875 -270,937 -3925 A   N   G   N  N  N  0  LFOB LPPR             N
                    AFR418     1217V  7654 EP   R    V   290   -122,372 131,373  43 01 25 N  08 17 45 W  482,689 226,101 -347,812 -334,687 0     A   N   G   N  N  N  0  LFPG SAEZ             N
                    AFR454     689 V  7656 EP   S    V   310   -86,435  165,788  43 36 48 N  07 29 53 W  490,669 226,238 -354,375 -339,375 0     A   N   R   N  N  N  0  LFPG SBGR             N
                    AEA041     525 V  4537 EP   S    V   288   -8,260   -54,122  39 57 49 N  05 41 44 W  479,817 232,861 -382,500 -289,687 894   A   N   R   N  N  N  0  LEMD SAEZ             N
                    DLH510     969 V  0126 EP   R    V   310   -5,053   -10,110  40 41 52 N  05 37 38 W  514,130 220,340 -332,812 -391,875 0     A   N   R   N  N  N  0  EDDF SAEZ             N
```

Format of TAAM

```
#History_version V2.0
simulationId= 20120119_1322_1168

          TAAM Flight History File: D:\Data\MADRID_TMA_PRNAV_NORTE/reports/taam/MADRID_TMA_PRNAV_NORTE.hst

  Time       Flight ID   Flight No.  Reg     Type       Status        Head. GS  Alt. Alt_ROC   Lat        Long          Location     Clear  FuelBurn

00,15:44:01     1         IBE6830    None    A346        FLIGHT_START  45 164  1554     0 -33.3900000 -70.7850000            SCEL     290        0
00,15:44:01     1         IBE6830    None    A346         TAKING_OFF   45 164  1554     0 -33.3900000 -70.7850000            SCEL     290        0
00,15:44:01     1         IBE6830    None    A346        SECTOR_CHNG   45 164  1554     0 -33.3900000 -70.7850000 uncontrolled_a/s 290        0
00,15:44:01     1         IBE6830    None    A346      END_OF_CRUISE   45 165  1588  2068 -33.3894616 -70.7843494          NoName     290        1
00,15:44:01     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 165  1588  2068 -33.3894616 -70.7843494          NoName     290        1
00,15:44:43     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 212  3051  2998 -33.3631848 -70.7526491          NoName     290       60
00,15:45:24     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 269  5100  2998 -33.3308892 -70.7137825          NoName     290      115
00,15:47:06     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 310 10188  2481 -33.2325891 -70.5955029          NoName     290      240
00,15:49:04     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 382 15062  2119 -33.0930140 -70.4277959          NoName     290      373
00,15:51:25     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 410 20038  1861 -32.9100826 -70.2099634          NoName     290      518
00,15:53:02     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 426 23043  1602 -32.7772217 -70.0521664          NoName     290      606
00,15:55:32     1         IBE6830    None    A346   PERF_BAND_CHANGE   45 447 27039  1034 -32.5617220 -69.7981324          NoName     290      739
00,15:56:25     2           N143G    None    GLF5        FLIGHT_START  45 130    18     0 47.5300000 -122.3019444           KBFI     400        0
00,15:56:25     2           N143G    None    GLF5         TAKING_OFF   45 130    18     0 47.5300000 -122.3019444           KBFI     400        0
00,15:56:25     2           N143G    None    GLF5        SECTOR_CHNG   45 130    18     0 47.5300000 -122.3019444 uncontrolled_a/s 400        0
00,15:56:57     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 157  1561  2900 47.5461262 -122.2783103          NoName     400        8
00,15:57:27     1         IBE6830    None    A346    START_OF_CRUISE   45 416 29000     0 -32.4044183 -69.6139735          NoName     290      829
00,15:57:28     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 161  3061  3017 47.5623285 -122.2544797          NoName     400       15
00,15:58:08     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 167  5067  2694 47.5838674 -122.2227540          NoName     400       24
00,15:59:59     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 181 10047  2478 47.6472087 -122.1294208          NoName     400       48
00,16:02:49     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 201 17066  2263 47.7536300 -121.9725200          NoName     400       82
00,16:05:54     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 220 24040  2047 47.8808748 -121.7831784          NoName     400      119
00,16:09:19     2           N143G    None    GLF5   PERF_BAND_CHANGE   45 240 31031  1832 48.0345931 -121.5527108          NoName     400      161
00,16:12:22     3         IBE6850    None    A343        FLIGHT_START  41 174  1604     0 -31.3150000 -64.2108333           SACO     290        0
00,16:12:22     3         IBE6850    None    A343         TAKING_OFF   41 174  1604     0 -31.3150000 -64.2108333           SACO     290        0
00,16:12:22     3         IBE6850    None    A343        SECTOR_CHNG   41 174  1604     0 -31.3150000 -64.2108333 uncontrolled_a/s 290        0
```

The Fuel Burn column although available, was not used.

Format of AEM-3[4]

Traffic file format

[4] AEM3UserGuide.pdf

```
040800 BAW138 VABB RWY EGLL RWY B742 Commercial DefaultACNavEquipment 340 340 340
040908 FIN907 EFHK RWY LEBL RWY MD80 Commercial DefaultACNavEquipment 320 320 330
041000 DLH3031 EFHK RWY EDDF RWY A3 19 Commercial DefaultACNavEquipment 360 360 150
041000 VKG203 ESGG RWY LEPA RWY A30B Commercial DefaultACNavEquipment 320 320 330
041109 BAW2148 OEDR RWY EGKK RWY B772 Commercial DefaultACNavEquipment 400 400 270
041253 AFR255 WSSS RWY LFPG RWY B772 Commercial DefaultACNavEquipment 380 380 200

041536 AFR2497 LHBP RWY LFPG RWY A320 Commercial DefaultACNavEquipment 380 380 380
```

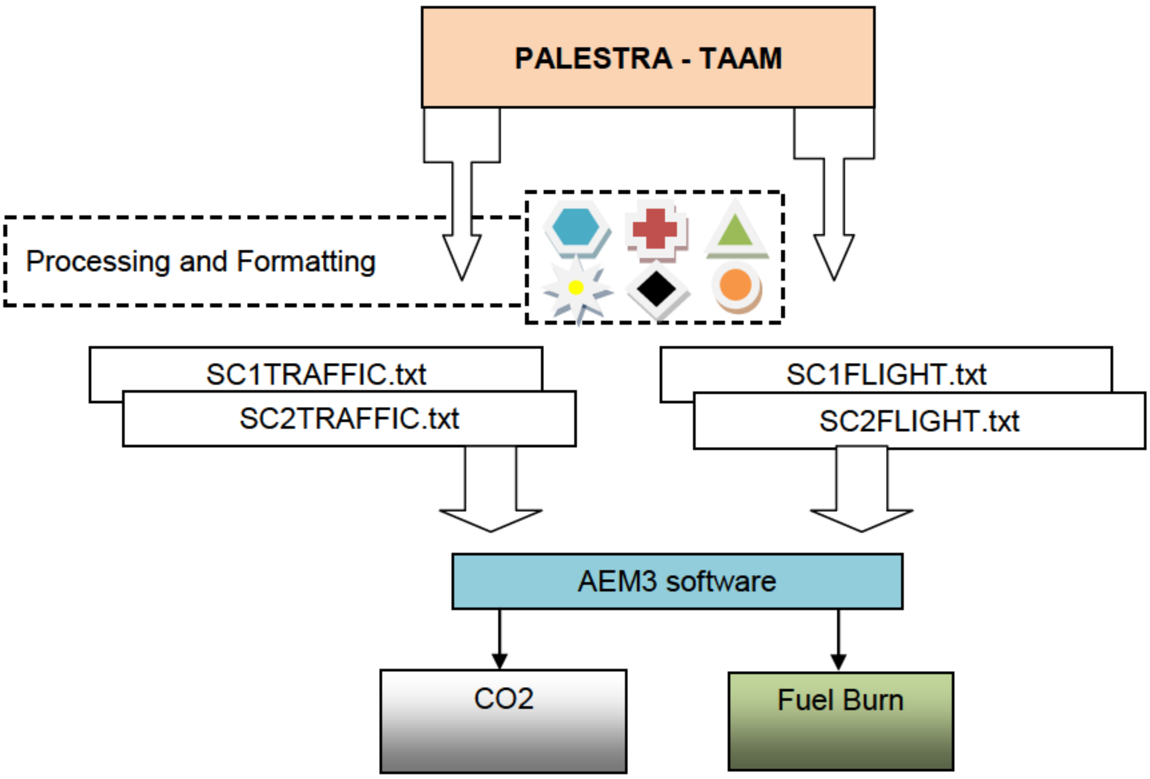
Flight file format

```
KEY;AZA465;05:49:18;Cruise;HEIDL;Navaid;FALSE;FALSE;445.00;0.00;49.3 50318;8.483338;350.00
;350.00;350.00;FlightPhaseEnroute;350.00;60.00;
KEY;FFR3501;05:49:19;Cruise;DINKE;Navaid;FALSE;FALSE;430.00;0.00;49.016983;9.950007;350.0
0;350.00;350.00;FlightPhaseEnroute;350.00;60.00;
KEY;RMC617;05:49:20;Climb;SPEZL;Navaid;FALSE;FA LSE;370.00;1000.00;50.066985;9.516674;369.
52;370.00;370.00;FlightPhaseEnroute;370.00;70.00;
KEY;DLH4173;05:49:20;Descent;HOFEN;Navaid;FALSE;FALSE;420.00; -
2500.00;49.650318;10.116675;372.23;100.00;100.00;FlightPhaseDescent;100.00;50.00;
KEY;CPA057X;05:49: 21;Cruise;TULSI;Navaid;FALSE;FALSE;480.00;0.00;47.916981;11.916677;380.
00;380.00;380.00;FlightPhaseEnroute;380.00;60.00;
KEY;TYR411X;05:49:21;Climb;#FB;FALSE;FALSE;FALSE;210.00;2500.00;48.306842;13.958536;75.00

;320.00;320.00;FlightPhaseClimb;320.00;175.00;
```

Input processing

Processing was needed to automate the creation of the two .txt files required by AEM-3.



Traffic sample control

The traffic sample used by TAAM was the same one as found in PALESTRA, however in order to maintain certain possible deviations under control, the traffic was rechecked.

The rechecking included the total amount of arrivals and the correspondence of call signs and aircraft type.

In a few cases (example below in Table 4Table 1), to the same call sign two different aircraft were found between the TAAM and the PALESTRA (changes in operating aircraft do occur). For such cases the decision was made to swap the PALESTRA aircraft type for the TAAM.

Correspond		TAAM		PALESTRA	
Aircraft Type	Call sign	Call sign	a/c type	Call sign	a/c type
TRUE	TRUE	AAL36	B763	AAL36	B763
TRUE	TRUE	AAL68	B763	AAL68	B763
TRUE	TRUE	AAL94	B752	AAL94	B752
FALSE	TRUE	ADR3002	A319	ADR3002	CRJ9
FALSE	TRUE	ADR3232	CRJ9	ADR3232	CRJ2
FALSE	TRUE	AEA042	A332	AEA042	A330
TRUE	TRUE	AEA052	B763	AEA052	B763
TRUE	TRUE	AEA064	A332	AEA064	A332
TRUE	TRUE	AEA072	A332	AEA072	A332
TRUE	TRUE	AEA084	A332	AEA084	A332
TRUE	TRUE	AEA088	A332	AEA088	A332
TRUE	TRUE	AEA098	B763	AEA098	B763
TRUE	TRUE	AEA1014	B738	AEA1014	B738
TRUE	TRUE	AEA1016	B738	AEA1016	B738
TRUE	TRUE	AEA1022	E190	AEA1022	E190
TRUE	TRUE	AEA1024	B738	AEA1024	B738
TRUE	TRUE	AEA1026	B738	AEA1026	B738
TRUE	TRUE	AEA1028	B738	AEA1028	B738
TRUE	TRUE	AEA1042	B738	AEA1042	B738
TRUE	TRUE	AEA1044	B738	AEA1044	B738
TRUE	TRUE	AEA1084	B738	AEA1084	B738
TRUE	TRUE	AEA1154	E190	AEA1154	E190
TRUE	TRUE	AEA1156	E190	AEA1156	E190
TRUE	TRUE	AEA1158	E190	AEA1158	E190
TRUE	TRUE	AEA1322	B738	AEA1322	B738
FALSE	TRUE	AEA1344	E190	AEA1344	B738
FALSE	TRUE	AEA2003	B738	AEA2003	E190
TRUE	TRUE	AEA2153	B738	AEA2153	B738
FALSE	TRUE	AEA2154	B738	AEA2154	E190
TRUE	TRUE	AEA2159	E190	AEA2159	E190
TRUE	TRUE	AEA6012	B738	AEA6012	B738
TRUE	TRUE	AEA6024	E190	AEA6024	E190
FALSE	TRUE	AEA6030	B738	AEA6030	E190

Table 4 Comparing traffic lists for call sign and a/c type

Of more difficult nature were those cases where the call sign did not agree between the two traffic samples or the flight was completely missing. The difference in total traffic turned out to be however small: 6 flights more in the TAAM traffic or, which is the same, 6 less in the PALESTRA.

Finally the decision was made to take the flights (0.9% of total) out of the AEM3 TAAM traffic results[5]. The proportion of aircraft type was kept the same.

1.5.3 Execution and results

Below, the results from AEM-3 when the data from both traffic sources are used.

Source	Duration	Distance	Fuel	CO2
PALESTRA(1)	184	85179	138	433
TAAM P-RNAV(2)	253	74270	192	604
	69	-10909	54	171
	hr	Nm	tonne	tonne

Table 5 AEM-3 Results for the TAAM and PALESTRA Output

In principle what we notice is that P-RNAV *increases* the flight duration, *decreases* the distance and *burns* more fuel, thus *producing* more CO2 emissions.

Again the reader is advised that this is only an exercise of what could have been the results if the data sources and the scenarios were carefully chosen and not just mixed.

The results have no validity for the validation.

1.6 Analysis of Results

1.6.1 INTRODUCTION

A paramount problem found by this assessment is the inconvenient mix of data sources used.

The inadaptability of the RTS output to the assessment model resulted in the decision to use real data for the baseline and to compare this with FTS data.

The problem is that by doing so the human factor, managing the traffic (radar and RTS) - thus influencing the aircrafts' performance - is not comparable.

Even so, and only as an exercise for the future, great care was taken to make sure any characteristic which was controllable by the post processing of the data, could be made (such as using the same traffic sample). However a great degree of uncertainty is still present.

1.6.2 Quantitative Analysis

Analysis of AEM output

In a line: *"The AEM-3 results for the TAAM P-RNAV flight scenario show that flights have more duration while doing less distance but using more fuel"* compared to the baseline situation.

The assumptions made by the FTS and the picture given by the PALESTRA data together with the results of the RTS show univocally that these sources are not comparable in absolute and that even trying to identify the "Whys" in each exercise would only lead to making more assumptions hindering or even moving the reference

[5] These where mainly military aircraft (F18, C130, etc…), which were not present in the PALESTRA traffic.

line needed for a robust assessment to be made. These results were estimated not robust enough for a validation.

1.6.3 Qualitative analysis

The qualitative analysis is based upon assessing the main changes introduced by the P-RNAV operations and correlating these to performances that can increase or decrease the fuel combustion.

Hereafter three main macroscopic differences are commented with information coming from the different sources available, giving special attention to the RTS conclusions:

1) Holdings;
2) CCDs;
3) AEM3 Arrivals Output.

Holdings

RTS conclusions: *"The delay times due to holding have been reduced [3]".*

FTS: there are no holdings or holdings present, since they are not modelled by the FTS.

PALESTRA: there are holding patterns but delay times cannot be compared since there is no number to compare it with.

Qualitative result: Knowing that RTS is referenced to current Conventional Operations, although we have no quantitative data, if delay times due to holding have been reduced by P-RNAV [1], this automatically converts to reductions in fuel burn thus emissions.

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P-RNAV Departures with CCD
With the same restrictions as for the ARRIVALs to obtain congruent data, there was no point in assessing CCDs based on theoretical improvement of a/c performance on literature review as has already been done in the past.

Nevertheless, from the RTS conclusions [2]:"*The continuous climb departures are enabled by the enhanced horizontal performance of P-RNAV*".
We may derive that by having P-RNAV in place, CCD[6] procedures can be used/allowed thus delivering environmental and economical benefits not currently accessible.

AEM3 Arrivals Output[7] (Sec. 1.5.3)

The assessment here tries to explain by data fusion the possible cause for the differing data in Table 5, but only suggests a qualitative result.

The output of AEM3 for the FTS and PALESTRA only shows the difference between the modelled ATM behaviour and the real one, unfortunately based on two different operational scenarios (P-RNAV versus current Conventional).

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[6] This gets aircraft as high as possible as quickly as possible, reducing noise and local air quality impacts on the ground, and getting the aircraft to the more fuel efficient cruise altitudes earlier [4].
[7] No comparison was possible on the vertical performance of the traffic.

These differences are evermore highlighted when having the RTS and FTS exercises compared. For the same P-RNAV scenario it was found that shortcuts during the arrival procedures, when available, were used by ATCos in the RTS, on the contrary FTS could not (see**Figure 8 Difference between RTS actions and FTS** .

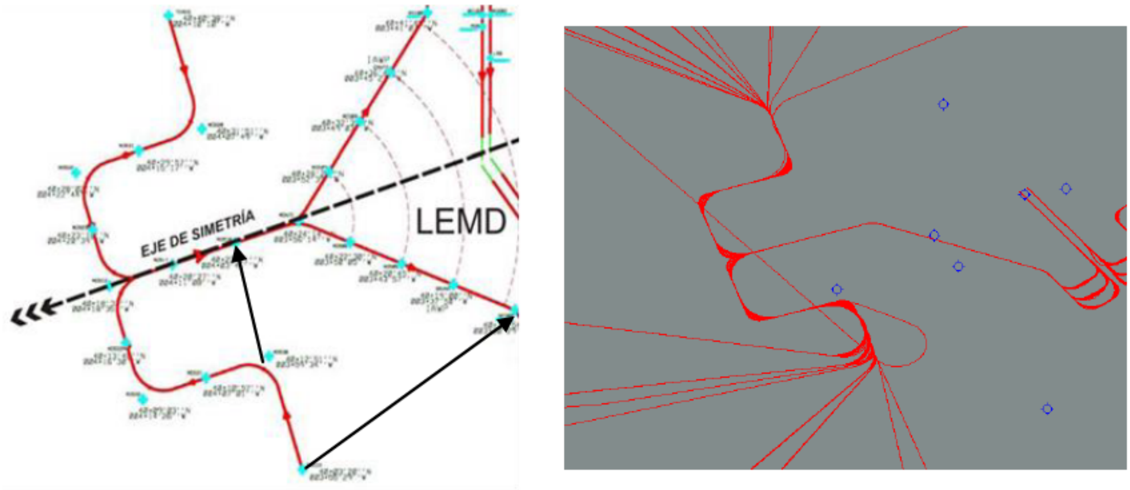

Figure 8 Difference between RTS actions and FTS

Main differences between the RTS exercise and the FTS:

1) Aircraft were not supposed to always fly a level segment along the P-RNAV route;
2) Aircraft did not always have to follow the whole P-RNAV route but were offered shortcuts when available.

These two variables are possibly the cause for the AEM-3's TAAM output been higher for Flight duration, Fuel burn performance and Fuel consumption (Table 5). This result assumes that the extra miles are due mainly to holdings and vectoring, and that traffic is moving at an average higher speed in reality.

Qualitative result: when available and under strict monitoring, shortcuts and even CDOs[8] were given to traffic, these consequently lowered the flight duration and the fuel consumption.

KPIs

Although no number can be provided, qualitatively it may be said that an improvement to the ENV KPIs can be assumed.

ENV KPI	Results
ENV111 O1 I1: Average fuel consumption per flight as a result of ATM improvements	POSITIVE improvement
ENV111 O1 I2: Average CO2 emission per flight as a result of ATM improvements	POSITIVE improvement

[8] CDO in high traffic periods still seems to be not feasible [3].

2 CONCLUSIONS

The Environmental assessment can only conclude that **qualitatively** the P-RNAV procedures in the Madrid's TMA (with all the limits and recommendations coming from the RTS and FTS validation exercises) can deliver reductions in Fuel burn and Emissions mainly by reducing:

- the holdings and obviously the delays related to them;
- by allowing CCDs;
- and not hindering the performance of CDOs (although not in heavy traffic).

However, quantitatively there was no possibility of comparing the data sources provided since it would have been like: "mixing apples and oranges[9]". **Thus the quantitative analysis is inconclusive**.

For the future it is advisable to simulate (as was the case) both a baseline scenario and a P-RNAV scenario on the same RTS platform. And (which was not the case) be able to extract data from the RTS exercises in a format usable by any analytical software for later analysis and comparison.

Again the same as above should be said for the simulation of both a baseline scenario and a P-RNAV scenario on the same FTS platform.

These conclusions do not invalidate either the RTS or the FTS, since they were used for the objectives they were built for. These conclusions highlight the difficulty of trying to extrapolate answers and numbers from different sources without having for each platform a baseline scenario to compare it with.

[9] English expression.

3 Intellectual Property Rights (Foreground)

The foreground of this deliverable is owned by the SJU.