THE EUROPEAN PERSONAL AIR TRANSPORTATION SYSTEM (EPATS) STUDY PROJECT: A SYSTEMATIC APPROACH BASED ON SMALL AIRCRAFT AND SMALL LOCAL AIRPORTS

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Executive summary

This paper describes the European Personal Air Transportation System (EPATS) STUDY project realized in the Sixth Framework Programme.

It consists of two parts:

First part includes basic information about the EPATS STUDY project: project objectives, list of partners, project structure and deliverables.

Second part contains results of the project. There are presented conclusions referring to the accessibility and suitability analysis of European airports, the EPATS demand forecasting, general requirements, environmental and safety aspects, business models and recommendations.

Results of the EPATS STUDY project show that it is possible to replace car trips on a distance longer than 300 km by personal air transport based on small aircraft and small local airports in Europe.

1. INTRODUCTION

The proposal of the European Personal Air Transportation System (EPATS) Study was prepared in response to call in the area of aeronautics Specific Support Actions (SSA), Priority 4: Aeronautics and Space - Integrating and Strengthening the European Research Area (Call identifier: FP6-2002-Aero-2) published by European Commission within the Sixth Framework Programme.

Considering the aeronautics research work programme [1] of the thematic priority “Aeronautics and Space”, the EPATS proposal was oriented basically to two research areas: Research Area 1 Strengthening Competitiveness, Objective 3: To increase passenger choice with regard to travel costs, time to destination, onboard services and comfort.

Research Area 4 “Increasing the operational capacity and safety of the air transport system”. Objective 2. Increase system capacity. Objective 3. Improve system efficiency. Objective 4. Maximise airport operating capacity in all weather conditions to support increasing traffic.

The EPATS proposal was addressed to under mentioned call topics:

- Realising the European Research Area.
- Stimulating international cooperation.
- Developing a EU research strategy in the sector.

Considering The Vision For 2020 report [2] and The Strategic Research Agenda (SRA) [3] prepared by the Advisory Council for Aeronautics Research in Europe (ACARE) setting out the directions for European research in the next decades, the EPATS proposal fitted to the High Level Target Concepts for the work to 2020 especially to:

1. The Highly Customer Oriented Air Transport System.
2. The Highly Time Efficient Air Transport System.
3. The Highly Cost Efficient Air Transport System.

For example the first HLTCs is defined[1]: *"The Highly Customer Oriented Air Transport System proposes a quantum leap in passenger choice and schedule flexibility. With a trend away from hub-oriented operations to more convenient point-to-point travel, increasing numbers of individuals on leisure and business travel fly in small to medium size aircraft …"*.

The EPATS proposal was accepted by European Commission and realized as Specific Support Action (SSA) project under contract no. ASA6-CT-2006-044549-EPATS.

2. EPATS STUDY PROJECT SYNOPSIS

The EPATS (European Personal Air Transportation System) focuses on the future Highly Customer Oriented and Time, and Cost Efficient Air Transport System. It fills a niche between Surface and Scheduled Air Transport. Future mobility cannot be satisfied only through investments in hub and spoke, or rail - and highway systems.

This future EPATS system will provide a wider use of small aircraft, served by small airports, to create access to more communities in less time.

The goal of the EPATS study was to demonstrate the needs and potential of small aircraft business development and to propose recommendations for the introduction of this new European Air Transportation System in the context of the European Research Areas.

The EPATS study was oriented toward the following issues:

- The potential new markets for personal aviation up to 2020.
- The potential impact of this new way of transport on the European ATM, and airport infrastructures, as well as the environmental, safety and security issues involved.
- The EPATS general specification and R&D Roadmap.

2.1 Project objectives

The objectives of the EPATS project were:

1. To identify the new market for personal aviation in Europe as the result of technology development and society needs. Characteristics of this travel mode are reduced door-to-door travel time by using small airports and small aircraft at low cost, operating in all weather conditions, serving also the suburban, rural and remote locations, and particularly the population that do not have access to high speed transportation networks.

2. To understand the impact of this potential market on the European ATM and airport infrastructures and to specify issues to be solved. The study addressed the need for special ATM system developments linked to the potential market demand in the context of the Single European Sky initiative. This work was fed into the SESAR (Single European Sky ATM Research) project.

3. To quantify the economic impact of implementing a new European personal air transport system in terms of transportation effectiveness and job creation.

4. To identify and assess mission's requirements for possible new classes of aeroplanes based on advanced technologies, which will satisfy the society needs for flexible, fast, easy to use, efficient, low cost, near all weather, safe and environmentally friendly air travel.

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[1] *Strategic Research Agenda [3] Volume 1 p. 34*

5. To identify the step changes in European industry development of engines and avionics for small aircraft, and in technologies that need to be researched urgently in order to ensure a competitive position of the European aircraft industry, which is composed of many small and medium sized companies in this market segment.

6. To propose recommendations (in terms of the EPATS research and development roadmap) for the introduction of this new European Air Transportation System in the context of the European *Research Areas and European* partnership.

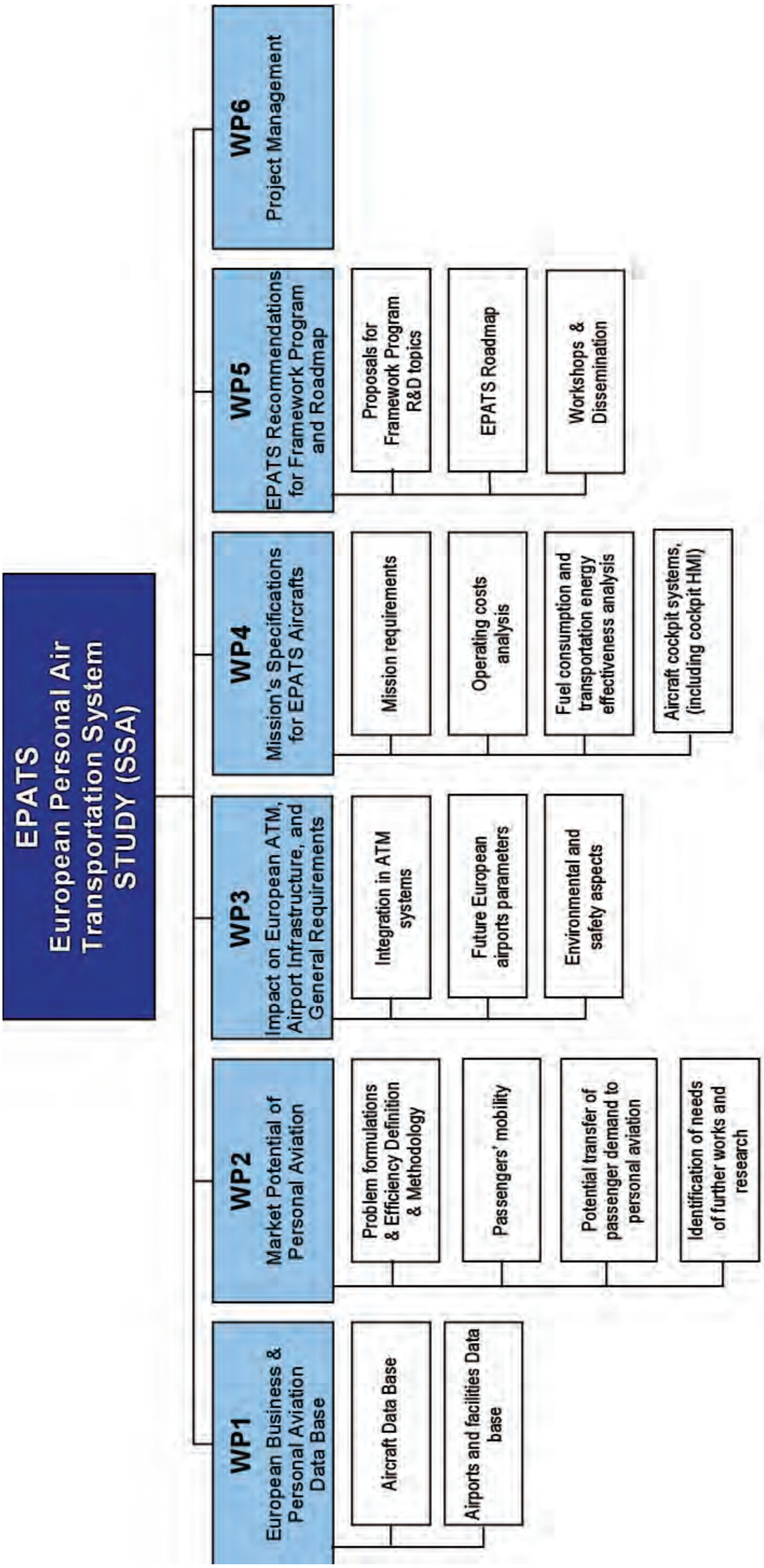
7. To disseminate the conclusions of the study amongst the European stakeholders, to increase interest in the potential new market, and to promote the revitalisation of the European General Aviation industry.

2.2 Detailed information

Contract number: ASA6-CT-2006-044549
Instrument: Specific Support Action
Call: FP6-2002-Aero-2
Starting date: 1 January 2007
Ending date: 30 June 2008
Duration: 18 month
Research domain: Thematic call in the area of Aeronautics Specific Support Actions
Website: http://epats.eu/
Coordinator: Krzysztof PIWEK, Institute of Aviation.
The studies were carried out by a Consortium supported by representative experts of the EPATS stakeholder community.
EPATS partners are listed below (No 1 – coordinator):

Partner No.	Organisation name	Partner short name	Name of the Partner's Project Manager	Country
1	Institute of Aviation	IoA	Krzysztof PIWEK	Poland
2	Eurocontrol Experimental Center	EEC	Marc BROCHARD	Europe
3	M3Systems	M3S	Isabelle LAPLACE	France
4	National Aerospace Laboratory	NLR	Frans VAN SCHAIK	Netherlands
5	Polskie Zakłady Lotnicze sp. z o.o. w Mielcu	PZL M	Janusz PIETRUSZKA	Poland
6	Rzeszów University of Technology	RzUoT	Andrzej MAJKA	Poland
7	WSK PZL Rzeszów S.A.	PZL Rz	Antoni GNOT	Poland
8	Budapest University of Technology & Economics	BUTE	Jozsef ROHACS	Hungary
9	Windrose Air Jet Charter GmbH	Windrose	Maciej WALKOWIAK	Germany
10	AD Cuenta	AD Cuenta	Adriaan DE GRAAFF	Netherlands

2.3 EPATS Project Structure



2.4 EPATS Project Results

The deliverables of these studies were reports containing a joint vision on the personal air transportation system in Europe of 2020 and proposals for developing this new small aircraft business at a European level.
The EPATS reports are listed below:

WP	Title	Organization Responsible
WP1	D1.1 Report on European Business & Personal Aviation Database and Findings [4]	IoA
	Aircraft Data Base [5]	IoA
	Airports and Facilities Data Base [6]	RzUoT
WP2	D2.1 Potential transfer of passenger demand to personal aviation by 2020 [7]	M3S
	Mobility in European Countries [8]	M3S
	Potential transfer of passenger demand to personal aviation by 2020 and first estimation of EPATS fleets [9]	M3S
	Synthesis of the EPATS estimation method and results. Inputs for WP3 [10]	M3S
	Identification of needs of further works and research [11]	M3S
WP3	D3.1 EPATS ATM General requirements & related issues to be solved [12]	EEC
	D3.2 EPATS Airports General Requirements including Safety and Environmental Issues [13]	NLR
WP4	D4.1 EPATS aircraft missions specification [14]	IoA
	D4.2 Operating Cost Analysis [15]	IoA
	D4.3 - Fuel Consumption and transportation energy effectiveness analysis [16]	RzUoT
	Reference Vehicle and EPATS Aircraft Mission's Characteristics to be Used for Demand 2020 Calculation [17]	IoA
	Small aircraft propulsion development [18]	PZL Rz
	Small aircraft propulsion manufacturers [19]	PZL Rz
	Assessment of Production Capabilities of EPATS Aircraft in Europe [20]	PZL M
	EPATS Aircraft Production Costs [21]	PZL M
WP5	D5.2 EPATS Roadmap [22]	IoA
	D5.6 ILA Air Show Conference [23]	Ad Cuenta
	Small Aircraft Requirements & Potential Demand methodology & Assumptions, Synergy Need [24]	IoA
WP6	D6.1.3- EPATS Activity Report Final [25]	IoA

All reports are accessible on EPATS Website or in Institute of Aviation archives. (Contact person - Krzysztof PIWEK, e-mail: , phone: (+48) 22 868 56 81, fax: (+48) 0 22 846 44 32)

3. EPATS STUDY RESULTS SYNTHESIS

The above-cited reports contain both results of particular matters in area of personal air transport based on small aircrafts and small local airports and summary included roadmap, requirements and conclusions.
However the fundamental question for EPATS Study was:

Is the personal air transport based on small aircraft and small local airports (EPATS) likely to have a future in Europe or not?

The answer this question is connected with the following questions:

1. What is the accessibility and suitability of European airports?
2. How much could be the potential transfer of traffic from road to the EPATS?
3. How to integrate EPATS traffic with future ATM projected by SESAR?
4. What will be impact on Airports?
5. What are the EPATS environmental and safety aspects?
6. How to define Missions Requirements for EPATS Aircraft?
7. What should be Roadmap and recommended R&TD for next Frame Programs and Strategic Research Agendas?

The following chapters are described critical issues result from studies in EPATS Project and answers the above-mentioned questions.

3.1 What is the accessibility and suitability of European airports?

The accessibility and suitability analysis of European airports was conducted by Majka A., Brusow V., Klepacki Z. from Rzeszów University of Technology [6]. They researched airports and airfields in 34 European countries (27 countries that have joined the European Union and 7 other countries). There are about 1270 airports which have an ICAO code and 1300 landing fields (all together 2567) in 34 European countries (tab. 3.1).

Table. 3.1. Number of airports and all landing fields in Europe. Source [6]

No.	Country	Number of Airports	Number of Airfields
1	Austria	9	20
2	Belgium	18	36
3	Bosnia and Herzegovina	4	4*
4	Belarus	7	7*
5	Bulgaria	36	36*
6	Croatia	14	14*
7	Cyprus	3	3*
8	Czech Republic	18	90
9	Denmark	23	41
10	Estonia	6	6*
11	Finland	51	84
12	France	199	454
13	Germany	154	434
14	Greece	52	58
15	Hungary	12	12*
16	Iceland	12	12*
17	Republic of Ireland	11	36
18	Italy	78	116
19	Latvia	3	3*
20	Lithuania	7	7*
21	Luxembourg	1	2
22	Malta	1	1*
23	Kingdom of the Netherlands	17	27
24	Norway	37	67
25	Poland	118	222
26	Portugal	31	61
27	Romania	22	22*
28	Slovakia	8	25
29	Slovenia	6	10
30	Spain	66	113
31	Sweden	74	158
32	Switzerland	19	57
33	Ukraine	25	25*
34	United Kingdom	126	304
	Sum	**1268**	**2567**

* No detailed data

The airports and landing field data was analysed statistical in view of location, runway characteristics (fig. 3.1), distances from the main 256 European cities to the nearest airport (fig. 3.2) and the population was quantified within particular radius of aerodromes (fig. 3.3).

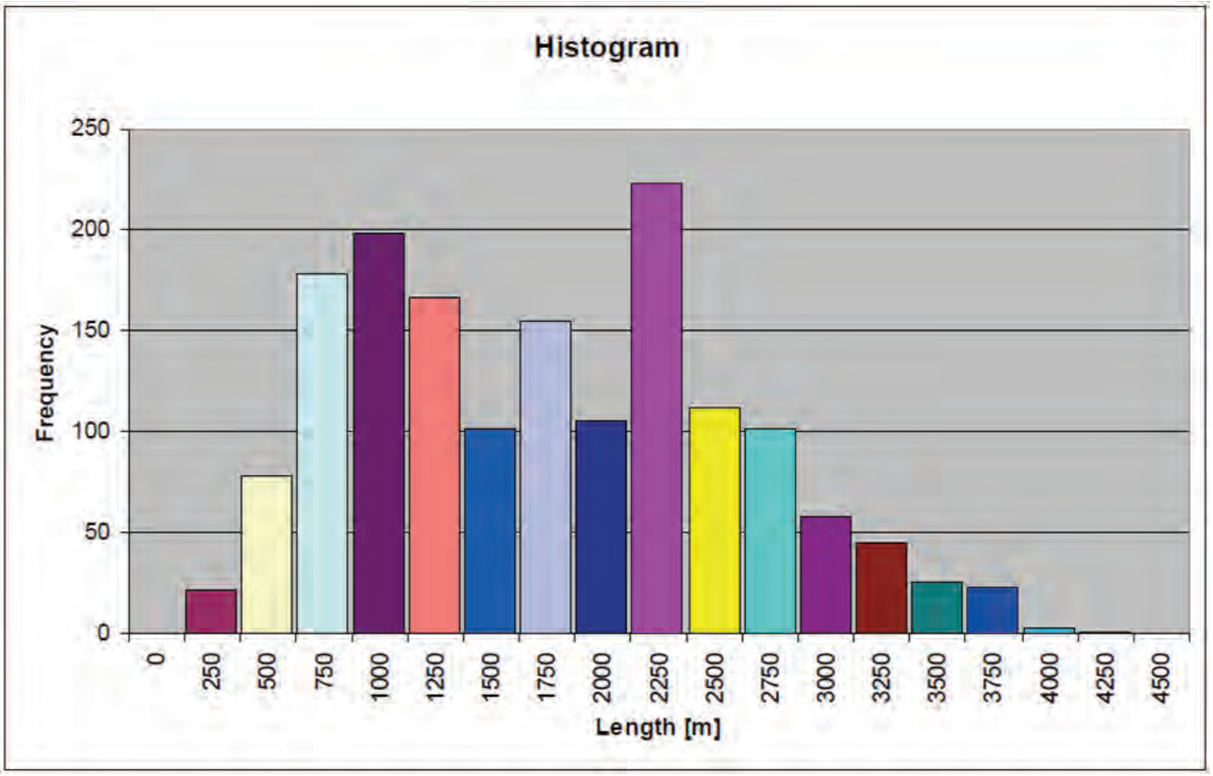


Fig. 3.1: All European airports runways length histogram. Source [6]

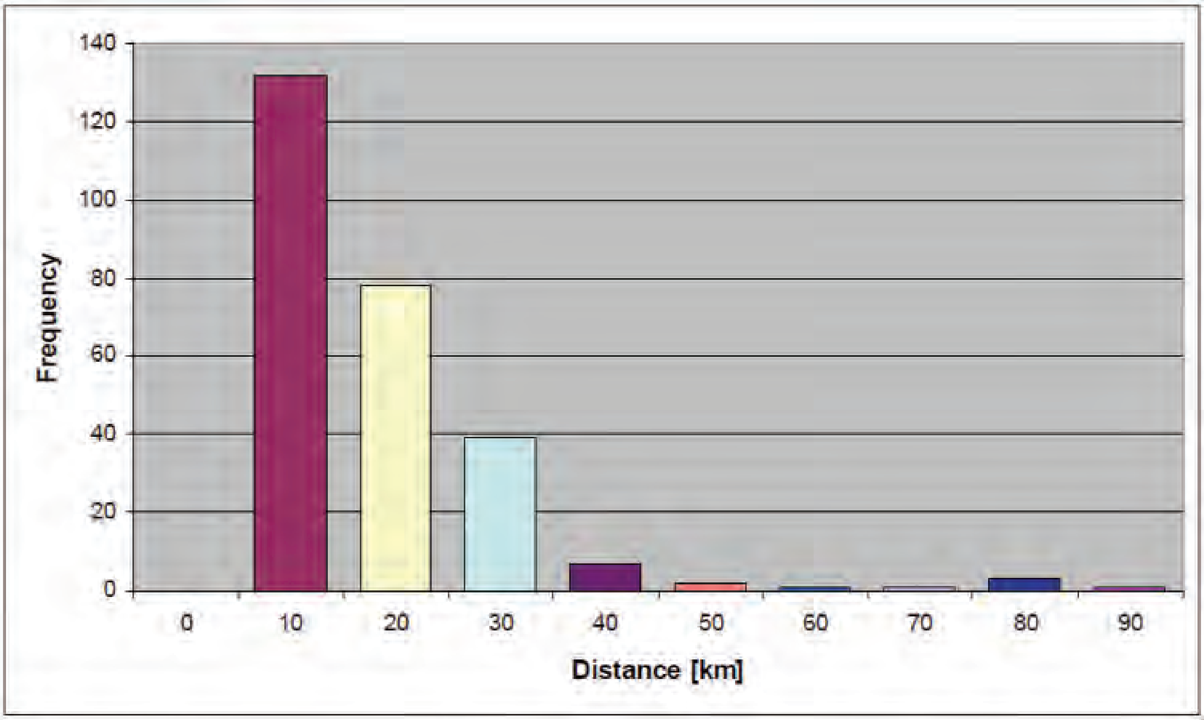


Fig. 3.2: The distances from main European city to the nearest airports histogram. Source [6]

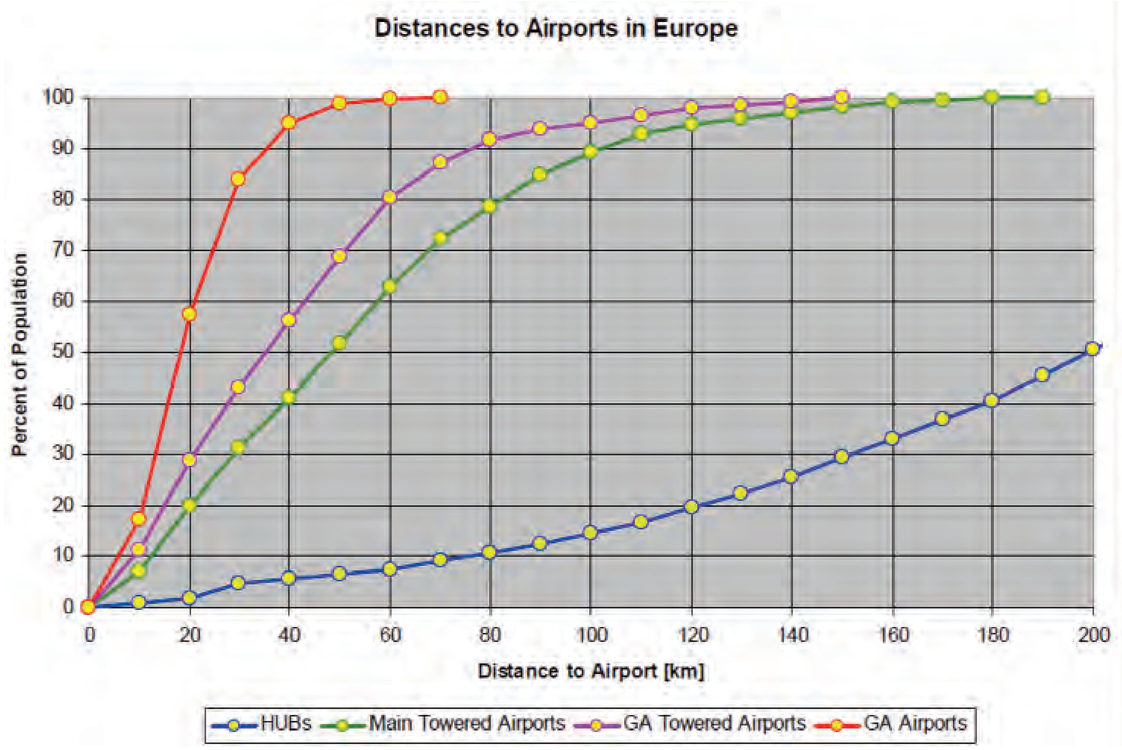


Fig. 3.3: Cumulative distribution function of population within particular radius of aerodromes in Europe. Source [6]

The final conclusions based on the analysis of current airport characteristics overview are[6]: Europe is a special area with unique features favouring the development of regional passenger air transportation system, since:

- it has about 1,270 airports and 1,300 landing fields, which means that for the most densely populated regions there is one airport per 2850 km2 (one landing field per 1200 km2), and 390 000 inhabitants per one airport (170 000 inhabitants per one landing field),
- in the most densely populforecastingated regions, the nearest airport lies within a distance of less than 40 km for more than 95 % of population (within less than 20 km for 60 % of population),
- for most European cities, the nearest airport is located within 15 km (90 % of cities),
- there are many airports in the vicinity of the greatest European cities (not fewer than 10 airports within 50 km radius of each city) – passengers can freely choose the most suitable airport,
- a lot of European population (potential passengers) live close to airports – approximately 1 mln inhabitants within 40 km radius of aerodromes,
- most European airports have sufficient technical conditions for being utilized for normal operational purposes by GA aircraft (other landing fields should be modernized).

3.2 How much could be the potential transfer of traffic from road to the EPATS?

The problem of EPATS demand forecasting was analysed by the research team from M3Systems and Institute of Aviation in charge of Laplace I. [7, 8, 9, 10, 11].

They applied the generalized cost minimisation method, meaning that they compared the generalized cost for each mode of transport. The concept of generalized cost based on assumption that a traveller does not choose between 2 modes by comparing only prices; s/he also takes into consideration several qualitative factors such as transport time, frequency of the train or aircraft, comfort, or reason for travelling. These parameters are subjective: they are not perceived the same way from one passenger to another.

The concept of generalized cost assigns a monetary value for all these parameters [7]:

$$C_g = C_{travel} + \sum C_i \qquad \text{(in €)}$$

With C_g = Generalized Cost

C_{travel} = Travel Cost = monetary cost = Direct cost borne by the traveller

C_i = Non-monetary Cost

Because of the difficulty in evaluating aspects such as comfort, frequency, etc, they took into account only "time cost", which depends on the time spent in travelling and on the value of time, i.e. the value that a passenger attributes to his time.

The following formula of generalized cost were used:

$$C_g = C_{travel}(d) + \underbrace{V_t \times T_{travel}(d)}_{\text{Time Cost}}$$

With C_g = Generalized Cost

C_{travel} = Travel Cost = Out-of-pocket Cost

d = Travelled Distance

V_t = Value of time

T_{travel} = Travel time = time spent in travelling or waiting

The comparison of the generalized costs enables to compare modes and to choose the one that minimizes generalized cost for a given journey.

When a traveller with a value of time V_t compares two transport modes, mode i and mode j, he will choose the one having the smallest generalized cost, i.e.:

The traveller chooses the mode i if: $Cg_i < Cg_j$

Or if:

$$Ctravel_i + V_t \times Ttravel_i < Ctravel_j + V_t \times Ttravel_j$$

Or else if:

$$Ctravel_i - Ctravel_j < V_t \times (Ttravel_j - Ttravel_i)$$

Introducing the notion of "Indifference time value" Vt_I, such value of time that $CgI_i = CgI_j$

or

$$\boxed{Vt_I = \frac{Ctravel_i - Ctravel_j}{Ttravel_j - Ttravel_i}} \qquad \text{(in € / h)}$$

The traveller (with a value of time V_t) will choose the mode i if

$$V_t > Vt_I \quad when \quad Ttravel_j - Ttravel_i > 0$$

$$V_t < Vt_I \quad when \quad Ttravel_j - Ttravel_i < 0$$

In addition, the value of time can be expressed as a function of the distance since cost and time depends on the distance. The idea is therefore to construct indifference curves, or in other words to plot "indifference time value" versus "travelled distance". These indifference curves enable to see clearly the preferred mode for a segment of the market, i.e. for a distance and a value of time given.

The second part of the method consists in linking the indifference curves to the expected results i.e. to the potential transfer of passenger-km. The Indifference Curve is a representation of "value of time" versus "distance". Therefore it is needed to get a table providing passenger-km distribution versus value of time and travelled distance, for each transport mode (aircraft/car).

The combination of both previous elements (indifference curves between two modes and passenger-km distribution by value of time and distance) can be used to obtain a modal split. They can use a model split to compare EPATS with another transport mode, and determine a passenger's preferred choice.

They considered six EPATS aircraft types in the estimations:

- ACP-1 – Single-Engine Piston
- ACP-2 – Twin-Engine Piston
- ACT-1 – Single-Engine Turbo-prop
- ACT-2 – Twin – Engine Turboprop
- ACJ-1 – Twin-Engine Very Light Jet (<5000 kg)
- ACJ-2 – Twin-Engine Light Jet (< 7000 kg).

They considered to perform estimations in the context of ASSESS scenarios that have been developed in order to evaluate the effects of the White Paper measures [26]. There are the Null, the Partial, the Full and the Extended scenarios.

Estimations of the number of flights as well as estimations of the EPATS fleet have been derived from the estimated number of transferred passengers to EPATS and from the category of EPATS aircraft that is considered on each connection. They attributed one category of aircraft per NUTS 2 connection using the following rule:

- Piston aircraft used for trip distances between 200 and 300 km
- Turboprop aircraft used for trip distances between 300 and 1000 km
- Jet aircraft for trips between 1000 and 2500 km.

The next articles of this edition described in detail the method of demand forecasting and results of estimation.

Here we cited main conclusions result from the analyse of the potential transfer of traffic from road to the EPATS [10] and modal split for interregional trips in Europe in 2020 [22]:

1. The total transfer of traffic from road and air transport modes to EPATS would reach 50 million flights in Europe in 2020.
2. In order to meet this demand it would necessary to have a fleet of around 110 000 personal aircrafts.
3. Estimated EPATS fleet: 66% of it would be Piston aircraft, 13% Turboprop aircraft and 21% Jet aircraft.

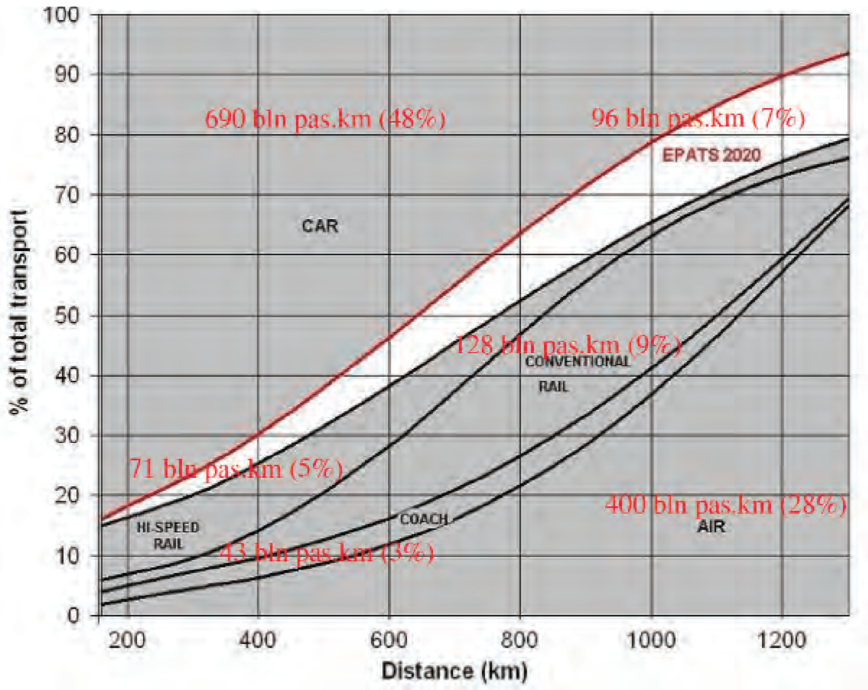


Fig. 3.4: Vision 2020 of modal split for interregional trips in Europe. Source [22]

3.3 How to integrate EPATS traffic with future ATM projected by SESAR?

The EPATS ATM general requirements was conducted by Brochard M. from EUROCONTROL [12].

At first he analysed current EPATS flights in Europe according to above specify classes of aircraft and based on one typical day in 2007. The Fig. 3.5 shows the geographical distribution of movements over one day. Small aircraft movements are non-homogenously distributed and the most crowded regions are matching with those of traditional traffic.

To conclude, EPATS flights accounts in average for 2661 flights a day (or 839 500 movements a year) in 2007 and it represents 8.1% of the total traffic in 2007. So, the impact of EPATS on ATM is limited in 2007.

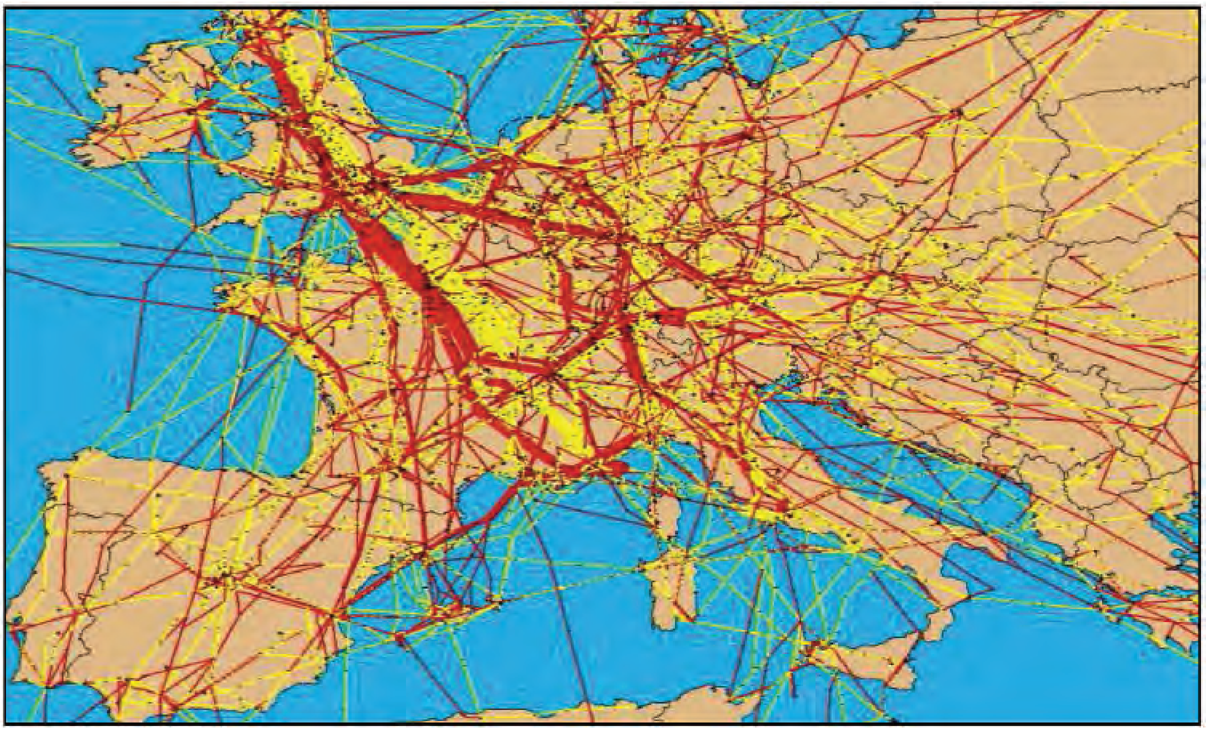


Fig. 3.5: One typical day of EPATS flights in 2007. Source [12]

The flight analysis for 2020 was based on the EPATS prediction model [9] and take into account two cases (Case A and Case B). This cases differ in limits of application for trip distance with respect to the jets (Case A – up to 800 km and Case B – up to 1000 km).

The fig. 3.6 shows one typical day of EPATS flights in 2020 for Case B. The most preferred area of EPATS doesn't overlap with those of the traditional flights. EPATS keeps off the most crowded regions of the traditional flights. However, the biggest EPATS traffic takes place in Italy, Greece, Portugal, Spain, the Southern regions of France, England, the South-Eastern areas of Poland and the North-Western locations of Germany.

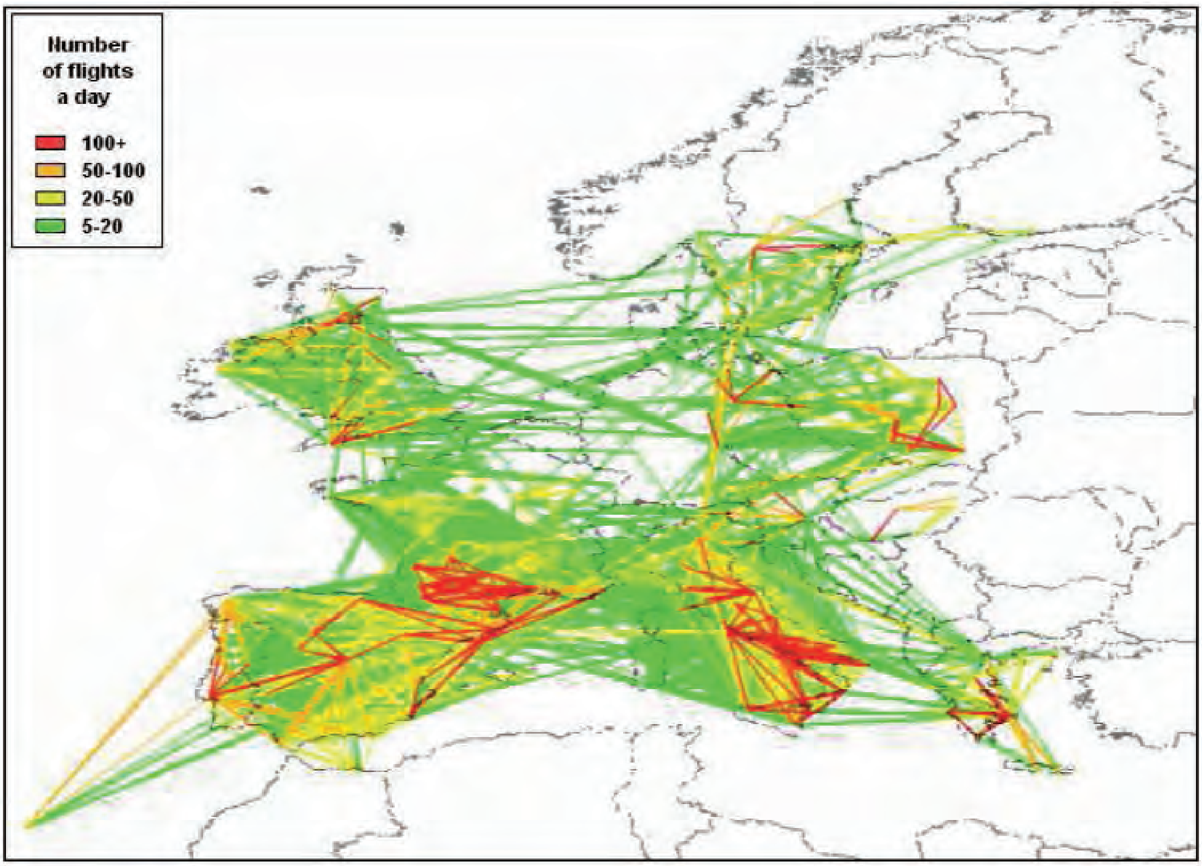


Fig. 3.6: One typical day of EPATS flights in 2020. Case B. Source [12]

To consider cruising altitudes (see Fig. 3.7), piston and turboprop aircraft are estimated to take the lower regions of airspace, between FL 20 and FL 250 and jets are assessed to use FL 350.

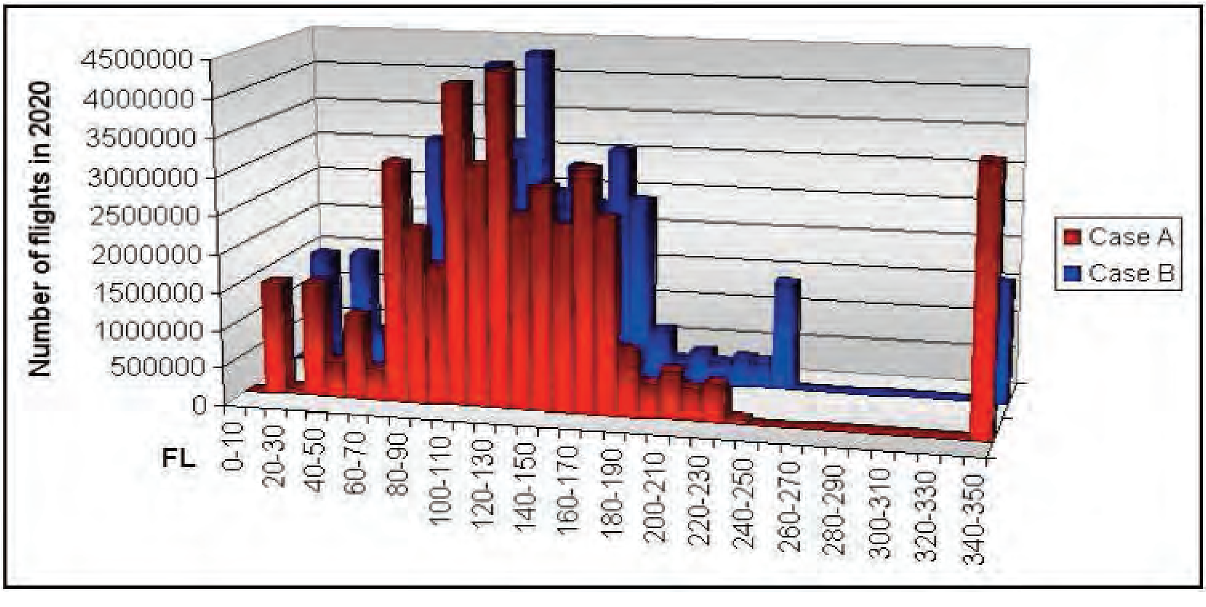


Fig. 3.7: The distribution of the cruising altitudes of the EPATS flights in 2020. Source [12]

The distribution shows that the impact of the EPATS flights on the cruising altitude of the traditional traffic is most concerned between the FL 100 and FL 190. Above FL 190 the interaction decreases to zero, expect the vicinity of the FL 250 and FL 350.

The final conclusions resulting from the analyse of the impact of the EPATS on ATM are the following [12]:

1. The predicted EPATS IFR (Instrumental Flight Rules) flights are found to grow from less than 1 million (as in 2007) to 2 944 105 or 2 860 539, respectively for the Case A and Case B projections. Knowing the targets of SESAR, it is clear that these personal IFR flights fit in the capacity targets defined by SESAR.

2. The EPATS VFR (Visual Flight Rules) segment is expected to grow from about 15 million flights a year (as in 2007) to 41.2 million for the Case A and 40 million with respect to the B prediction. The impact of the personal VFR flights on the ATM is an unknown problem, since these movements are not clearly addressed in the targets of the coming ATM. Nevertheless, this investigation showed that personal VFR movements flying at low altitude will meet the arrival / departure flows of the traditional traffic at the airport vicinities. Therefore, EPATS VFR will affect these regions, and call for advanced methods to cope with the two classes of traffic together (EPATS and traditional). If not feasible, the deviation or the separation of the flights will be needed.

3. With respect to the total EPATS traffic, this investigation showed the evidence for the fact that the geographical distribution of the envisioned EPATS flights is different from those of the rest of the airspace users. More particularly, the results indicate that generally personal movements keep off the most crowded regions of the traditional flights. However, EPATS will influence the rest of the airspace users in Italy; Greece; Portugal; Spain; the Southern regions of France, England; the South-Eastern areas of Poland and the North-Western locations of Germany. With respect to the impact of EPATS on the most preferred airports of the traditional flights, Athens, Rome, Madrid Barcelona, Warsaw, London are found to be the most influenced, while the most congested locations such as Frankfurt, Amsterdam or Paris are indicated to be less concerned. The cruising altitude distribution showed that 60 % of the personal movements take place in the airspace below FL 100, in which only 2 % of the traditional flights are present.

4. Major findings of the analysis suggested that future decisions concerning the airspace organization should take into consideration that (in 2020) about 40 million personal flights would rely on the see-and-avoid concept, from which a significant percentage would take place below FL 100. Beside, a particular focus on the terminal area management is also proposed to cope with the EPATS and the traditional flights at the airport vicinities. Finally, it is also suggested to address the business model of EPATS in order to clarify whether the flights will take place by scheduling or by request, and how these will fit in the SESAR business trajectory process.

3.4 What will be impact on Airports?

The EPATS Airports General Requirements was analysed by van Schaik F. J., Hogenhuis R. H. and Waver R. from National Aerospace Laboratory, Netherlands [13]. The EPATS Study recommends and concludes on the following airport infrastructure topics [13, 22]:

Airports:

- It seems that Europe has enough small airports to accommodate 100.000 plus small aircraft.
- Some economic growth centres will be places to create or modernise small airports, especially in areas where other more traditional means of transport are absent. The local economy will be the driving factor because it will have direct benefit.
- Each region NUTS 2 and NUTS 3 airport will have good chances become the home base of EPATS operators. These airports need more facilities and probably Air Traffic Control to service safe flight operations during peak hours. Examples in the US demonstrate that air taxi operators could service their own airport with tower control.
- EPATS aircraft may fly under rules that are neither IFR nor VFR. Their avionics may allow self separation as if EPATS are flying VFR. Research is recommended to what traffic quantities Self separating EPATS flights can be maintained on non-towered airports.

Runways and Approach / Departure:

- One runway per airport could accommodate up to 400 movements a day, which is the average rate estimated for 100.000 small aircraft, 1000 European airfields of interest and equal numbers of home based aircraft and visiting aircraft. Noise and environment may restrict the airport to lower numbers, but from air traffic and safety reasons 400 movements per runway are certainly possible.
- Punctuality of air transport services will benefit from Autoland facilities, satellite based local area augmentation systems and extra beacons although the EPATS aircraft will probably operate rather independently from VOR, NDB and DME. Satellite based Autoland systems still need certification. Autoland systems should be available on pilot demand either by calling the local airport operator or by remote ATC operations. Autoland will need additional certification if the airfield is not controlled and if a fire brigade is not available on the spot. In conclusion research is recommended on cheap and safe Autoland facilities for EPATS aircraft.
- EPATS operations during night and low visibility need approach lighting and runway lighting, preferably systems that can be ignited on pilot demand either by local airport operators or remotely. Research is recommended on remote control of airports, including approach and runway lighting.
- Quiet airports are also places where wildlife likes to live. Safe EPATS operations require protection against wildlife and birds. It is inevitable to take care of this aspect. Local airport operators could be trained to inspect the runway short before landing. Research is recommended on animal friendly protection of runways and taxiway against bird and wildlife.

Taxiways and parking:

- The existing 2000 small European airports possess probably sufficient taxiways with sufficient quality.
- Extra parking and hangars may be needed to host the extra 100 of EPATS aircraft on average per airport. Airfields with one runway and subsequent taxiway and aprons will occupy a rectangle of land with about 1 km length and about 500 m width. This should be enough space to create extra parking stands for engined taxi in and taxi out parking of about 100 extra small aircraft.
- Taxiway guidance (markings, painting, lighting) should serve the EPATS pilots according to ICAO standards and up to a level that taxi operations can happen uncontrolled and punctually. Research on certification of moving map cockpit displays is recommended.

Air Traffic Control and flight preparations

- Airports with low traffic will not need control. In comparison much of the VFR general aviation happens on uncontrolled airfields and procedures guarantee safe operations there.
- It will save the cost of personnel if airports are controlled remotely. Applied research and development is needed for optimal ways of remote airport control.
- The availability of meteo data for flight preparation is of utmost importance. Present day European meteo data systems are already available but may need further development and certification to allow use for flight preparation.

Airport facilities:

- The runway(s), taxiways and aprons should be free of snow and ice for safe operations. Local airport operators (services) should take care of this aspect of airport accessibility and reliability. Research is recommended to predict local ice forming and snow several hours before landing. Research and development is needed how to protect runways and taxiways longer against snow and ice than present day methods.
- The EPATS aircraft should be free of snow and ice before take off. Methods could be developed

for simple removal of snow and ice on small aircraft. Off course indoor parking in heated hangars will solve the problem.

- Provision of electrical power would be needed, but if not available, EPATS aircraft could use there own battery power for starting up the engines.
- Various types of fuel should be available on small airports to prevent extra refuel stop overs. It might be futuristic but technology for in flight refuelling exist!
- Small repair and maintenance would benefit flight operational reliability.

Passenger facilities:

- Connectivity (car, public transport) is needed to fulfil the EPATS goal of spending as little time as possible in the transport system.
- The need for restaurants, waiting room, parking and shops will grow with the traffic.
- Simple but secure check in and customs procedures are needed; biometrics is a candidate.
- Better statistical data is needed to track the EPATS evolution and consequences for airports.

3.5 What are the EPATS environmental and safety aspects?

The most important environmental effects of EPATS were studied within the budgetary limits of the project. It gives also an indication of important subjects for further research. The discussion about the environment was divided into two subjects: noise and emissions.

Estimations were made on basis of the expected change in transport from car to Personal Aircraft: about 100 000 additional EPATS aircraft till 2020, resulting in about 93 extra movements per regional airport per working day and 24 000 extra flights on average per European regional airfield per year.

Noise estimation

Comparing different aircraft types is difficult because a lot of factors contribute to the noise production. For a good comparison all aircraft should have comparable weight (except for VLJ since these aircraft are designed to be lighter compared to other small jet aircraft), year of design (engines became quieter during the years), maximum range (the longer the range, the more fuel will be needed, which means that the weight of the aircraft increases) and number of passengers (to find the noise production per passenger).

The decision was made to base our estimations on public data for existing small aircraft close to what is expected to become EPATS aircraft.

Table 3-2: Comparison of noise production of different aircraft types. Source [13]

Aircraft + type	year	MTOW	pas	range	LA TO	LA APP	LA TO corr	LA APP corr
Cessna Citation Encore (J)	1998	7634	11	7634	58.3	83	54.9	79.6
Mitsubishi MU300 Diamond I (J)	1996	7394	7	2744	71.9	77.2	70.4	75.7
Cessna Citation 525 CJ (J)	1998	4853	5	2408	60.3	81.7	60.3	81.7
Piper PA-42 Cheyenne (TP)	1977	5125	6-9	3015	70.3	77.1	67.7	74.5
Beech Super King Air B200 (TP)	1981	5670	13	3251	68.8	77.8	64.7	73.7
Cessna 421C (P)	1976	3103	8	2756	61	74	59.0	72.0
Beech Bonanza A36 (P)	1970	1633	3-5	1291	67.8	64	67.8	64.0
Eclipse 500 (VLJ)	2007	2719	5	2408	54.9	72.8	54.9	72.8

Table 3-2 shows these noise data for several aircraft, furthermore the maximum take-off weight (MTOW) in kilograms, year of introduction (year), maximum number of passengers (pas), range in kilometres and aircraft type (P = piston, TP = turboprop, J = jet and VLJ = very light jet) are given. The noise values (LA) are given for take-off (TO) and approach (APP); the noise values are estimations, given in dB(A). The two final columns show the take-off and approach noise levels, corrected for the number of passengers.

New aircraft with considerable weight reduction and new engines result in a reduction of the noise production. As could be expected aircraft with single piston engine have lower approach noise level. It can be concluded that using VLJ instead of regular light jets is desirable in order to reduce the noise impact. Furthermore the use of single and twin piston engines and turboprops gives better or comparable noise characteristics during the approach, while the VLJ produces less noise during the take-off. It should also be noted that use of EPATS aircraft replaces equivalent transport by car and that it reduces as such the noise produced by cars. The design of noise abatement routes and silent take off and approach procedures will reduce the noise impact.

Emissions

In order to make a good comparison between different types of aircraft, information about the type of engines and emission indices (amount of emitted pollutant per kilogram fuel used) for the different pollutants is needed. However, obtaining all emission indices for a set of different aircraft was outside the scope of this study. For this reason only a comparison of the specific fuel consumption (SFC) for existing look alike EPATS aircraft was made. The amount of fuel used is directly linked to the amount of CO2, H2O and SOX emissions.

The SFC in table 3-2 is given in kilograms of fuel used per passenger kilometre (kg/pas.km). Due to a lack of data the SFC values were calculated by dividing the maximum fuel weight (MFW) in kilograms by the maximum range of the aircraft times the number of available passenger seats.

Table 3-3: Comparison SFC of different aircraft types. Source [13]

Aircraft + type	year	MTOW	pas.	range	MFW	SFC
Cessna Citation Encore (J)	1998	7634	11	3313	2449	0.067
Mitsubishi MU300 Diamond I (J)	1996	7394	7	2744	2228	0.116
Cessna Citation 525 CJ (J)	1998	4853	5	2408	1461	0.121
Piper PA-42 Cheyenne (TP)	1977	5125	6-9	3015	1757	0.065
Beech Super King Air B200 (TP)	1981	5670	13	3251	1653	0.037
Cessna 421C (P)	1976	3103	8	2756	647	0.029
Beech Bonanza A36 (P)	1970	1633	3-5	1291	225	0.035
Eclipse 500 (VLJ)	2007	2719	5	2408	765	0.064
Piper PA-46 Mirage (TP)	2006	1967	6	2491	364.8	0.024
Beech Bonanza G36 (P)	2007	1656	4-5	1391	201	0.029

The table shows that modern turboprop aircraft are much more fuel efficient than VLJs. Since turboprop aircraft have a much lower cruise speed than VLJs, they are best suited for travelling over relatively short distances. Due to higher cruising speed VLJs are better suited for transport over longer distances than aircraft with piston engines.

EPATS was also compared with the fuel consumption of cars supposed to be replaced by EPATS. It showed that the car is most fuel efficient but only if all cars are fully loaded. The load factor has a large impact on the amount of fuel used per passenger kilometre.

For this reason it is of great importance that the load factor of the aircraft in the EPATS concept is as high as possible.

Both the noise and the emission aspects of EPATS can be predicted better if more detailed and mature data become available for the EPATS aircraft of the future.

Safety and EPATS

An overview was made of safety aspects of EPATS in the areas of: aircraft manufacturing and certification, flight operations, training and qualification, airport and air traffic control, safety programs and safety oversight. The assumption was made that JAR-23 Airworthiness will be enhanced to obtain the same safety level as JAR-25.

3.6 How to define Missions Requirement for EPATS Aircraft?

The missions requirement for EPATS aircraft was conducted by Gnarowski W., Pokorski M., Zdrojewski W. from Institute of Aviation [14].
The characteristics of EPATS airplanes taking into account the forecast results CESAR and SESAR programs and American forecast.

In order to define mission requirements for further EPATS family aircrafts, wide variety of activities were performed. They could be divided into 4 steps.

1. Creation of aircraft data base. It includes over 120 constructions of normal and commuter categories (up to 19 passengers and up to 19 000 lb=8550 kg maximum take-off weight). Three types of propulsion systems are represented: pistons, turbo-props and jets. Nearly 50 parameters per aircraft have been collected.

2. The EPATS Aircraft Reference List has been created. It includes 15 constructions. The following criterion (with a few exceptions) have been taken under account for airplanes evaluation:

- Fulfilling forecasted mission for EPATS fleet
- Fulfilling requirements CS-23 with supplementary requirements
- Designed or modernized after year 2000
- Credible and confirmed specifications and performance
- Traditional Value index including airplane Price (TVI-P)

The preliminary calculation for one selected distance 926 km (500 nm) and one utilization level (600 block hours) have been performed. Mission data based on publications.

3. Detailed analyses for 8 most promising airplane. These are:

- Cirrus SR-22
- Piper Seneca V
- Epic Dynasty
- Pilatus PC-12
- Piaggio Avanti II
- BAE Jetstream 32
- Eclipse 500
- Grob SPn.

In this step for particular airplanes either aerodynamics and propulsion characteristics have been reconstructed. Also flight mechanics model was created. Such a way is flexible and full of potential, however it is also more time consuming. 4 distances, 3 flight levels per distance and annual utilization levels from 200 to 2000 block hours have been analyzed.

4. EPATS aircraft requirements. Using data obtained during previous steps and taking under account outer sources such as CESAR, SESAR, American forecasts, a requirements proposal has been created. In fact it is not a full conceptual design. That is because EPATS program is too small to manage such an effort.

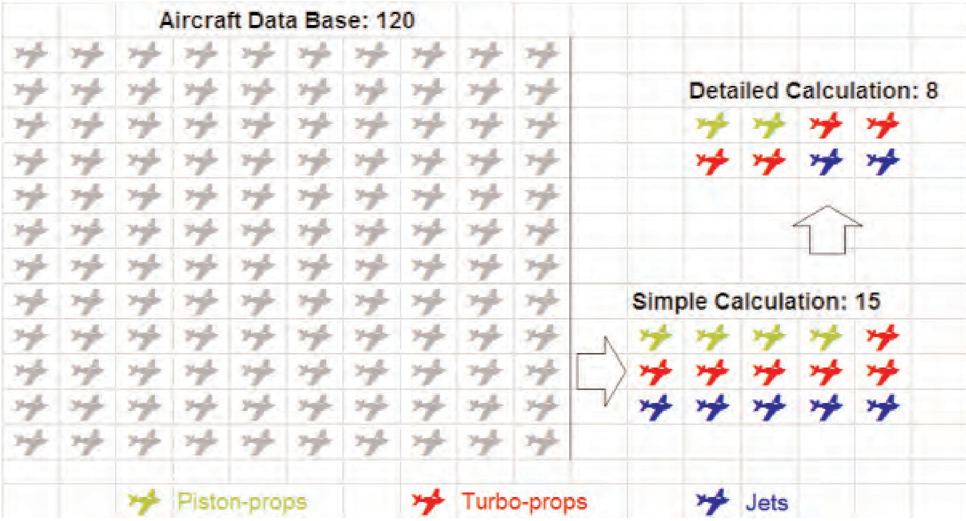


Fig. 3.8 Reference aircraft selection and analyses. Source [14]

Results of comparison of future EPATS aircraft and reference 8 constructions shows in sequence: The Block Speed – Fig. 3.9 and Fig. 3.10, The Direct Operating Costs – Fig. 3.11 and Fig. 3.12, The Specific Fuel Consumptions – Fig. 3.13 and Fig. 3.14.

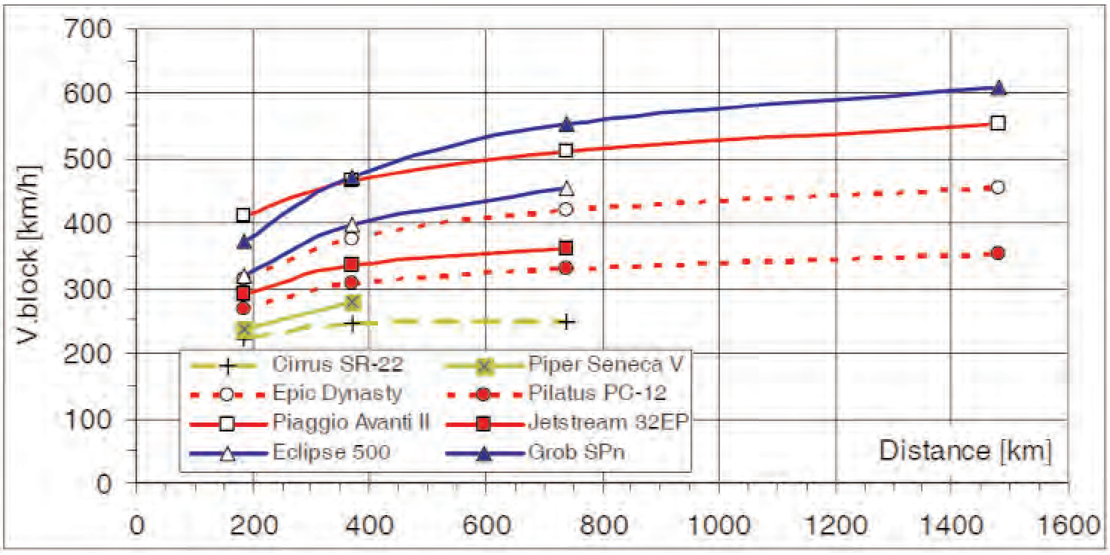


Fig. 3.9 Block speed – reference aircraft. Source [14]

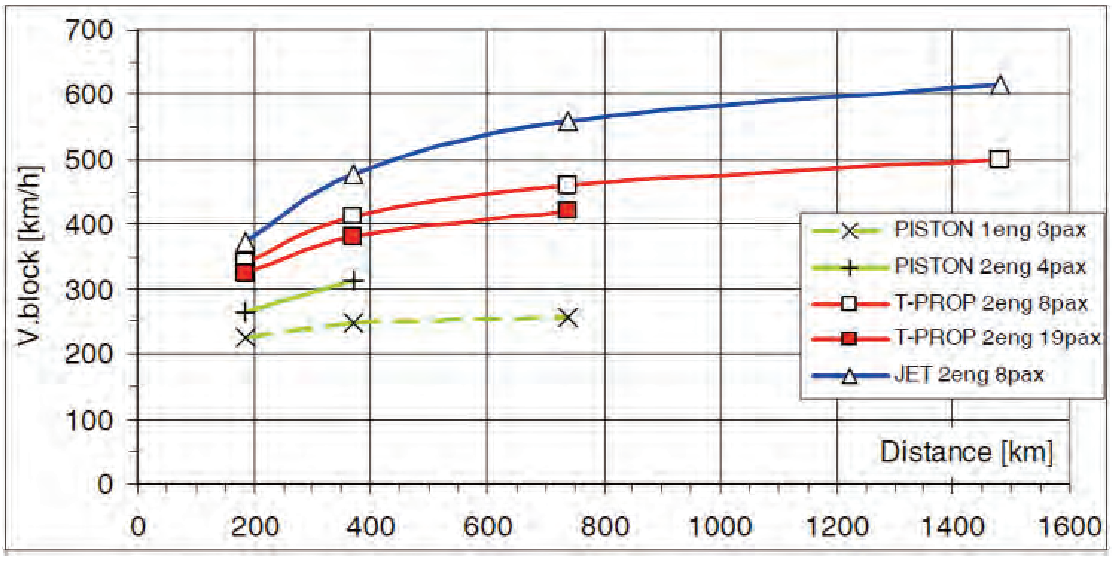


Fig. 3.10 Block speed – future aircraft. Source [14]

The speed of future jet and normally aspirated single-piston are the same as references. New large t-prop is a little quicker while turbocharged pressurized piston is significantly quicker which places it between pistons and turbo-props.

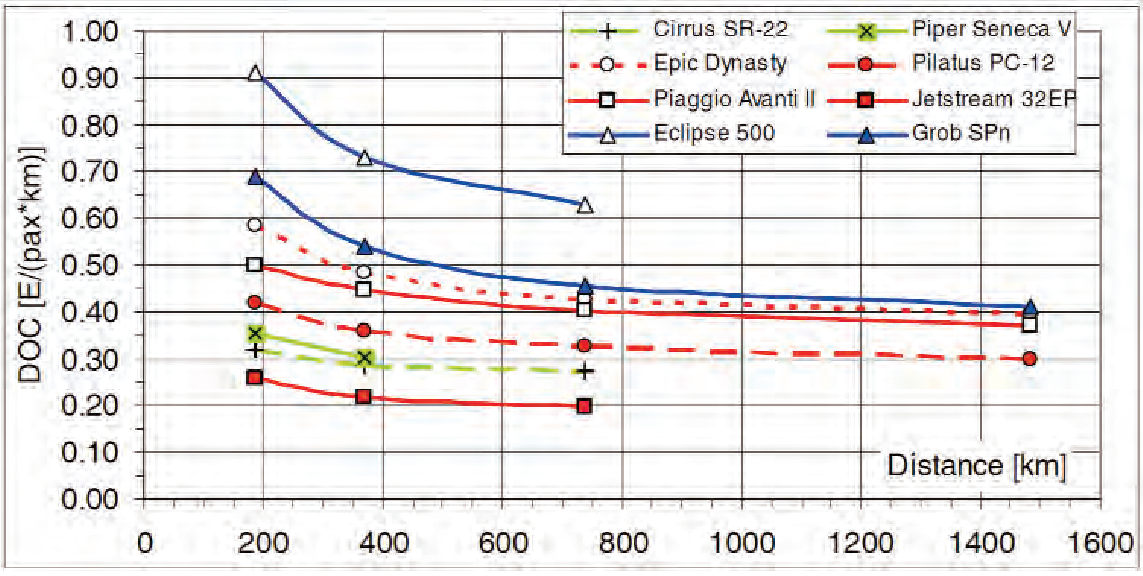


Fig. 3.11 Direct Operating Cost – reference aircraft. Source [14]

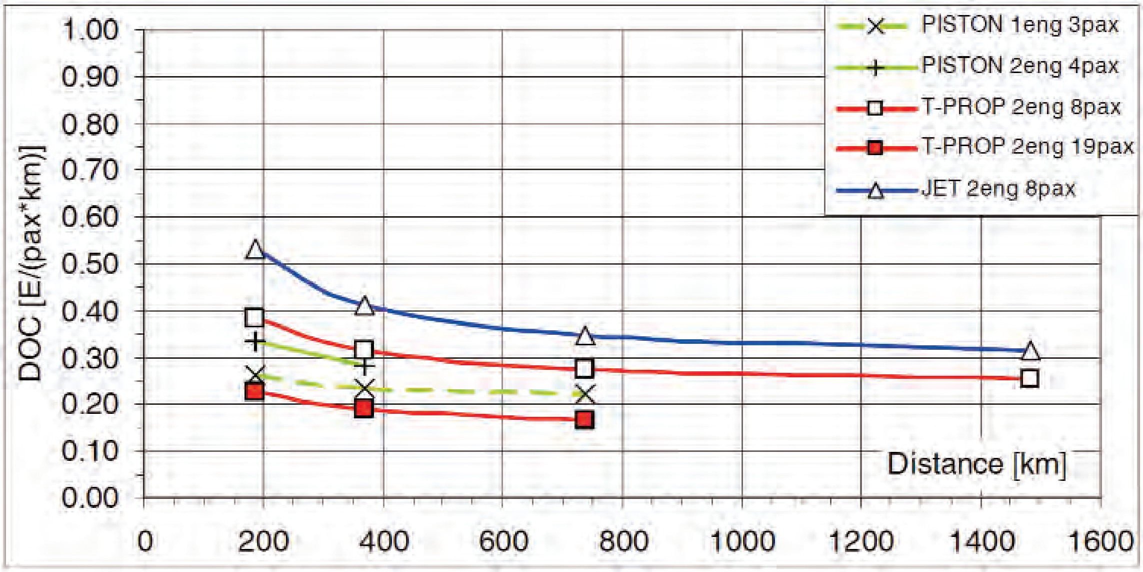


Fig. 3.12 Direct Operating Cost – future aircraft. Source [14]

The Direct Operating Costs of new airplanes are significantly lower than reference's. Jets are the most expensive of all. The cheapest is large (19 pax.) turbo-prop.

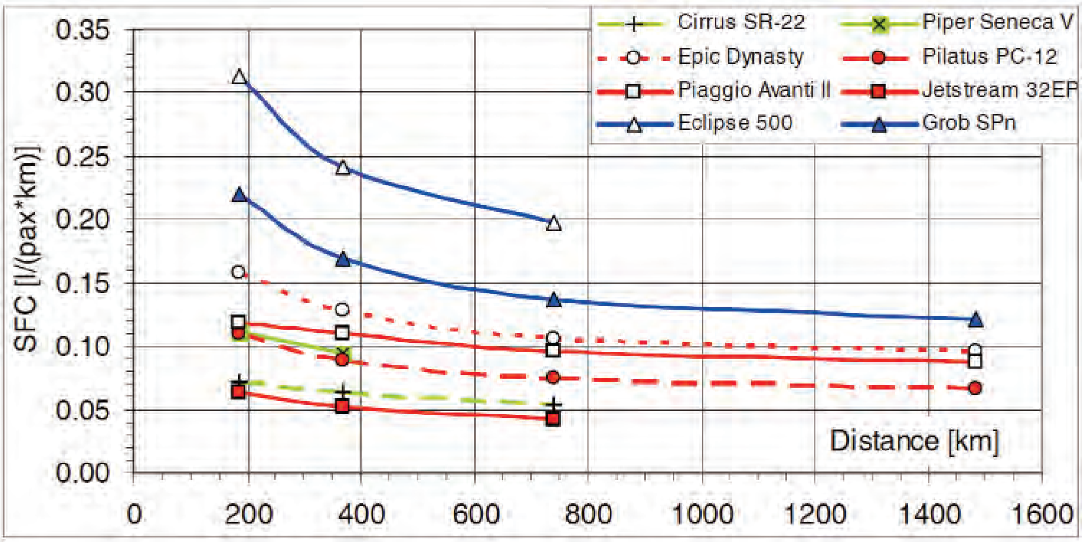


Fig. 3.13 Specific Fuel Consumption – reference aircraft. Source [14]

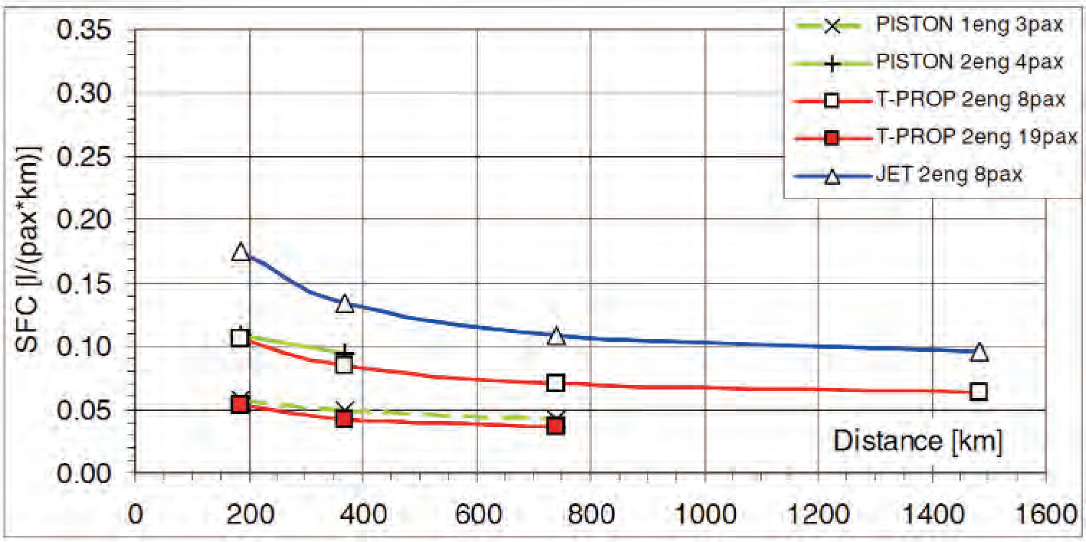


Fig. 3.14 Specific Fuel Consumption – future aircraft. Source [14]

The Specific Fuel Consumptions of new airplanes are significantly lower than reference's. New aircraft are of course better – cheaper and more fuel efficient. The brief summary of comparison is shown in Table 3-4.

Table 3-4: EPATS aircraft comparison: reference vs. future. Source [14]

2020	PISTONS		TURBO-PROPS		JETS
	1eng 4seat	2eng 6seat	2eng 8pax	2eng 19pax	2eng 8pax
Range full seats	1000 km	500 km	2000 km	1000 km	2000 km
Speed (bl.) km/h	Similar	+11(+13)%	-17 (-10)%	+10(+17)%	Similar
DOC €/(pax*km)	-18%	-37%	-23 (-32)%	-12 (-15)%	-24%
SFC l/(pax*km)	-20%	-26%	-11 (-28)%	-16%	-21%

short (long) distance

The analyses show that affordable personal transport is real. However several actions must be taken to reach this goal:
1. Airplanes must be fitted to needs in terms of their
   - Size (range, comfort, speed)
   - Performance (airport accessibility, operating cost, fuel consumption)
   - Available airspace (flight performance)
2. Operating must be optimised (to reduce DOC):
   - High utilization intensity
   - Low Indirect Cost fraction
3. Technical and production improvements are needed
   - Lower design, production and operating costs (e.g. excepted CESAR results)
   - Avionics needed to fly into future airspace (SESAR requirements)

3.7 What should be Roadmap and recommended R&D for next Frame Programs and Strategic Research Agendas?

The EPATS Recommendations for Framework Program and Roadmap was elaborated by the all participants of the project in charge of Piwek. K. and Baron A. from Institute of Aviation [22].

The EPATS Study project can be the beginning of long term, wide and multidisciplinary international transport program for Europe, which is only possible to accomplish with the support of the EU Commission, Member States and local authorities and, also, by cooperating with business and research entities among which, especially, aviation industry and its research and development branches.

It is crucial to solve the transport problems followed by the need of action and research in various sectors, particularly:

A. Space and population mobility management. It is especially important to possess deeper knowledge about unused transport infrastructure, namely airports and airfields, and about population mobility entailing flow intensity and structure among regions and cities (outlaying the main transport networks) national as well as European.

B. Environmental protection. Despite much of research in this area, still, there is a shortage of credible and detailed results of comparison analysis between cars and aircraft concerning the scale of negative impact on the environment and natural resources.

C. Air traffic control and management systems. New, appearing technologies need to be applied and adjusted to future needs of air traffic enlarged by the EPATS introduction. In particular, SESAR program realization is important.

D. Airport infrastructure. It is important to prepare a coherent classification and database of all European airports and airfields, which will be used for airspace management. Furthermore, a European strategic small and medium airports development and modernization program has to be formulated adapting airports to new ATM-ATC and CNS technologies and to the needs of regions.

E. Research and development of the EPATS aircraft. Main objectives will focus on further improvement of small aircraft characteristics simultaneously lowering costs of production and operating. All aviation domains require a wide research: from modelling and aerodynamics through production technologies and pilot training including. Efficient use of the results of the research is conditioned by their integration and application in particular aircraft design project, which then have to be tested in flight. Consequently, research programs should strictly pertain to aircraft development plans.

F. General aviation propulsion. Shortage in production and development of small aircraft engine for propeller driven as well as jet aircraft is a significant problem for the development of general aviation in Europe. The main questions regarding general aviation development in the EU, including the EPATS, is: should European aviation industry rely on its own production, followed by initiatives in the sector, or accept import strategy from the USA? The European Commission should answer to this question of strategic nature (basing on analysis of engine industry), because it is corresponding to one of the most crucial challenges given to the European aviation: to become competitive at the World market, especially towards North America.

G. General aviation equipment. In the area of electronic equipment, the problem is similar to propulsion. Although the European market exists, most of the equipment is imported from the USA due to lower prices. Therefore cockpit production is very expensive in relation to other parts. Unification of equipment and cooperation with car industry could be a possible solution.

H. Aircraft production. One of the main objectives is to lower the costs of production (2-3 times in 20 year). It is only possible in the large serial production system extended by a deeper cooperation among aviation industry companies. It is assumed that the consolidation of European general aviation industry will advance, basing on the European Technology Platform, for which European Commission projects a new instrument entitled Joint Technology Initiative.

I. Transport services. For cities and region functioning the EAPTS serves a social role (i.e. high speed transport, when other modes are unavailable) as well as behavioural control role in the direction to reduce interregional and international car travel. The state should be interested in high speed, efficient, operating mode of transport reflecting the national needs. As a public good, air transport should be clearly legislated in the frame of regulations of the system. The most important elements of the system are regulations concerning the EPATS organizers, rules of operators access and rules of public financing. A base for organization of the EPATS in a region should be an adequate, local, long-term transport plan relying on previous mobility and travellers flow research and supported by cost-benefit analysis.

J. Regulation

Major investigation elements of the EPATS R&D vision

The small aircraft technology R&D which address the EPATS aircraft should explore all areas in which advanced technology application could provide improved passenger acceptance, increased safety, decreased operating costs and better environment. Although some improvements in future EPATS aircraft can be achieved merely by utilizing available technology it is clear, that to meet the EPATS objective news advances in technology have to be achieved. Some topics listed here underneath are realized as part of SESAR and CESAR Program.

Infrastructure

„Smart" airports with higher utility and safety in more weather conditions, along with free flight procedures for expanded AS capacity, and airport utility, including:

- Satellite navigation approaches to all landing areas, without requirements for control towers and radar, and fully digital flight, traffic, and destination information systems.
- Free Flight in the European Airspace System architecture for EPATS airports.
- Flight Information Services (FIS), broadcast by terrestrial or satellite systems.
- Traffic Information Services (TIS), including Automatic Dependent Surveillance, broadcast by aircraft, terrestrial, or satellite systems.
- Destination Information Services (DIS) for intermodal connectivity, and vehicle and operator/passenger services, via terrestrial or satellite systems.
- Near-all-weather operations at non-towered airports without radar coverage.
- 3,500 to 5,000 foot runways, with marking and lighting.
- Airports within a 15 minute drive of communities served.
- Safety services.

Aircraft

Aircraft technology objectives are planned to achieve advancements in affordability, safety, ease-of-use, airport utility, and includes the following:

- Simplified and intuitive flight controls, including decoupling.
- Envelope limiting (Active load control) and ride smoothing concepts.
- Active flow control for improved cruise & low speed performance. The objective is to use control surfaces of an a/c wing to adapt its configuration to the various phases of the flight mission for increased efficiency and to gust and manoeuvres for reduced loads.
- Aircraft fineness ratio and lifting enhancement (higher cruising speed – lower stalling speed).
- Useful weight to takeoff weight enhancement. Multi layer/multi-function architectures should be used to decrease the negative impact on weight deriving from ancillary functions requested to the structure (lightning protection, electrical grounding, thermal insulation). The following sensors technologies are envisaged for consideration: Fibre Bragg-grating (FBG), sensitive coatings (SCS), environmental degradation monitoring sensors (EDMS), micro-wave sensors, acoustic-ultrasonic (AU), acoustic emission (AE), imaging ultrasonic (IU).
- Airframe modular design, highly integrated processes, one shot process for example, by manufacturing a one-piece fuselage section.
- New concept configuration (plan form) to accommodate other systems integration.
- Crashworthy airframes.
- Comfort improvement (ride quality, noise level, cabin space, convenience).
- Minimum maintenance labour.
- Automotive synergies in manufacturing, including automation in integrated composite structures.
- Per passenger cost operations competitive with automobiles on day trips of 300 miles or more.

Aircraft systems

- Highway in the Sky (HITS) graphical flight path operating systems, including graphical weather, navigation, traffic, terrain, and airspace depictions.
- Hazardous weather and ice-tolerant avoid and exit operating procedures.
- Advanced pilot vehicle interface systems, including artificial/synthetic vision for "electronic" visual meteorological conditions.
- Satellite-based communications, navigation, and surveillance for ubiquitous flight and destination information systems.
- On-board access to travel information for seamless air/ground and mass/personal transportation intermodal connectivity.
- Mission management and trajectory control.
- Improve safety, handling, and ride quality while reducing pilot workload and maintenance costs. Potential advanced-technology applications include fly-by-wire or fibre-optics controls, gust-load alleviation technologies, low-cost icing protection, and improved navigation and guidance equipment.
- One Network of "Sensors & Actuators" to Actively Manage the Airflow and Loads Across the Whole Flight Regime of the Product.
- Embedded health-monitoring systems that will allow the airplane to self-monitor and report maintenance requirements to ground-based computer systems.

Aircraft propulsions

- New engines, burning unleaded fuel, with single-lever power controls, intuitive diagnostics, and longer TBOs.
- Next generation propulsion systems, including non-hydrocarbon and hybrid concepts.
- Quiet non-hydrocarbon propulsion, low emissions combustion system & alternative fuel.
- New small turbine and compression-ignition engines. Acquisition price: Piston < 10 000 €, Turbine < 100 000 €.
- Advanced propellers.

Training

Simplified and affordable pilot training through advanced technologies, including:

- Unified instrument-private pilot training curriculum.
- On-board, embedded training capabilities.
- Training time and cost commensurate with Public School implementation of "Fliers education" along with Drivers education.
- Internet-based, and simulation-enhanced training systems.
- Pilots are able to maintain all necessary competencies and proficiencies for EPATS Highway in the Sky system flight operations, within constraints imposed by typical professional and personal time schedules.

The EPATS development phases

The EPATS development consists of 4 phases:
Phase I - Studies and analyses involve

Table 3-5: EPATS phases development timetable. Source [22]

	Phases	2010	2015	2020	2025
1	Studies and analyses				
	EPATS Technology Platform creation				
2	Research and Development				
3	Experimental implementation				
4	EPATS technology development and deployment – aircraft investments				
	SESAR technology development and deployment				
	EPATS airports investments				
	Regulation adaptation				

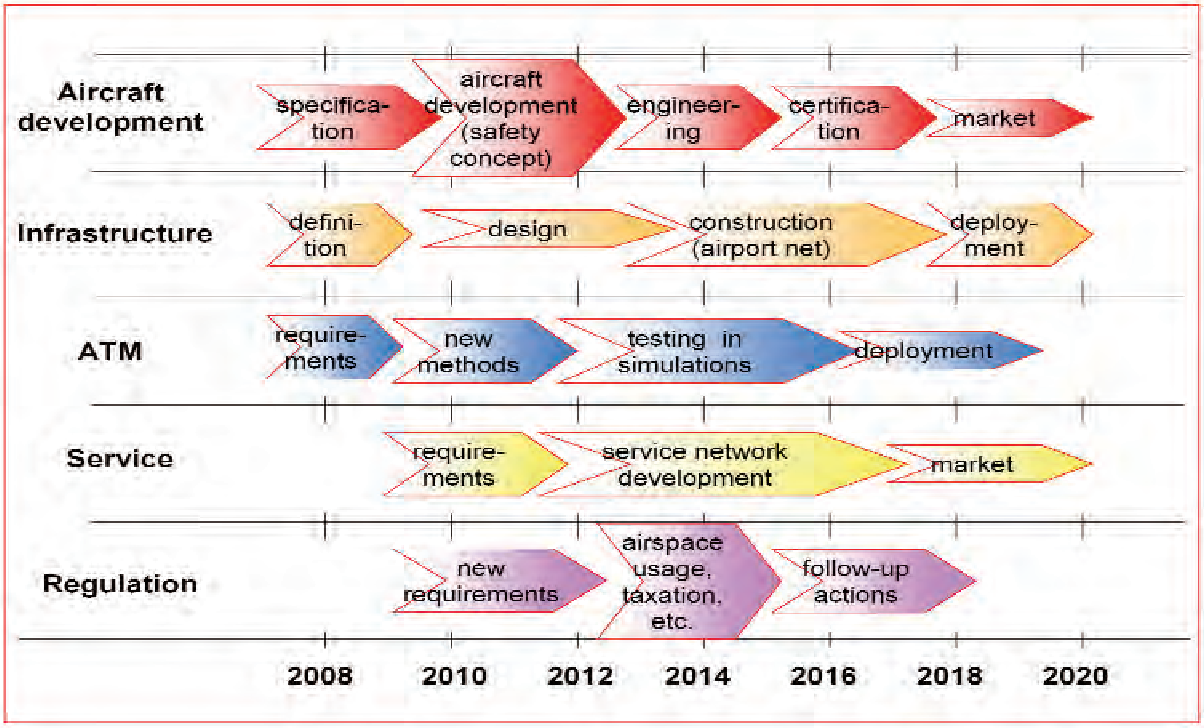


Fig. 3.15 EPATS timetable by areas activities. Source [22]

4. CONCLUSIONS

To summarise this short description of the EPATS STUDY project we conclude:
1. Results of the EPATS STUDY project shows that it is possible to replace car trips on a distance longer than 300 km by personal air transport based on small aircraft and small local airports in Europe.
This statement is confirmed by the following arguments:
- High density Airport Network (about 1,270 airports and 1,300 landing fields).
- New ATM Technology based on SESAR Programme.
- Technically Advanced Aircraft as the result of realized (CESAR) and future European Programme.
- European Synergy Possibility in European Union.
- Increasing Mobility and Social Needs based on the forecast demand.

2. In order to provide competitiveness and meet the customer needs of the EPATS it is necessary to activate the international transport program for Europe. The program should ensure the European GA and ATM manufacturers world leadership in this line of products.

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