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D4.1 EPATS aircraft missions specification

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Dissemination		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	**X**
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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LIST of ABBREVIATIONS

A	Wing aspect ratio
AMP	Airplane Market Price (cena samolotu)
ATC	Air Traffic Control
Block Distance	Great Circle travel distance
Block Speed (V_{block})	Block Distance/Block Time ; the real travel speed (from the gate to the gate at the airports)
Block Time	Travel time which includes: taxi, takeoff, climb and acceleration, cruise, descent and deceleration with ATC maneuvers, landing and taxi-back. It also includes the fact that we fly 110% of great circle distance.
CCI	Customer Choice Index
CS-23	Certification Specifications part 23
DOC	Direct Operating Cost (maintenance, fuel, crew, navigation and landing fees, hull insurance, depreciation). Expresses in €/km or €/h, usually per passenger.
Flight Distance	The real travel distance. It include the fact that usually airplanes do not flight straight lines between points but more
IFR	Instrument Flight Rules
IOC	Indirect Operating Cost
IOC	Indirect Operating Cost
MTOW	Maximum Takeoff Weight
SFC	Specific Fuel Consumption, expresses in kg or litres of fuel per km
SFC	Specific Fuel Consumption
T/W (P/W)	Thrust to Weight (Power to Weight) ratio
TBO	Time Between Overhauls (for engines and propellers)
TOC	Total Operating Cost, the sum of Direct (DOC) and Indirect (IOC) costs
TVI-P	Traditional Value Index including airplane Price
TVI-P	Traditional Value Index
W/S	Wing loading [kg/m^2]

1. INTRODUCTION

With the expanding European Union and ever greater mobility in and between its member States, alternatives to long distance car trips and scheduled air transport need to be considered. Even with the emergence of high speed railways, these benefit only the large cities. With this in mind, general aviation can provide an alternative. Small aircraft providing affordable, personal air transport services will greatly improve accessibility and economical potential between central and remote areas. This will also alleviate ground traffic and relieve the already congested air traffic at large commercial hub airports by allowing operations from smaller non hub airports. People will be able to travel to and from destinations closer to their home and work in a more efficient way.

The report is the attempt to define the requirements for airplanes which can meet such challenges.

In study were used results of work which was led in WP1 and WP4 EPATS program:

- Task 1.1: “Aircraft Data Base”
- Task 1.2: “Airports and Facilities Data Base”
- Task 4.2: “Operating Cost Analysis”
- Task 4.2.1: “EPATS Aircraft Production Costs”
- Task 4.3: “Fuel consumption and transportation energy effectiveness analysis”
- Task 4.4: “Aircraft cockpit systems & human machine interface requirements”.

The characteristics of EPATS airplanes taking into account the forecast results CESAR and SESAR programs and American forecast are showed in chapter 4.3.

2. METHODOLOGY

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. The calculation algorithm is presented on figure 2.1.

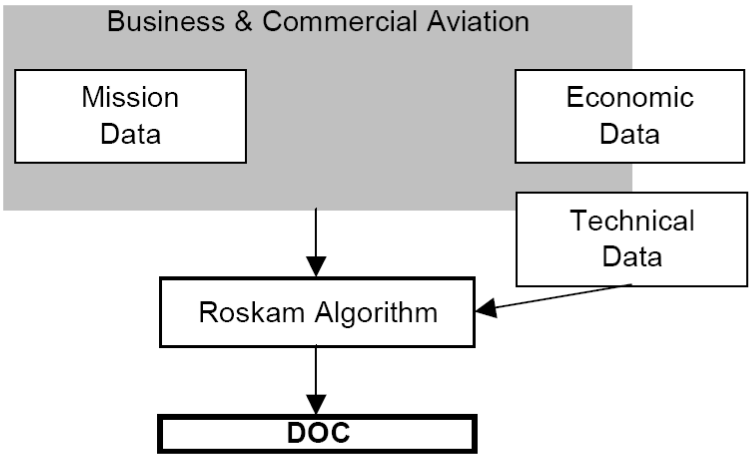


Fig. 2.1 DOC calculation based on Publisher data.

The following figures have been a result:

- V_{block} - Block speed
- DOC - Direct Operating Cost
- SFC - Specific Fuel Consumption
- V_{block}/DOC
- TVI and TVI-P – Traditional Value Index (including airplane Price)
- CCI – Customer Choice Index (Neutral, Business and Low Cost)
- Pax.km potential
- Profit Potential

- Energy Efficiency

Results of this step was presented in “Aircraft Data Base” Report, page 16 – 27.

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. The calculation algorithm is presented on figure 2.2.

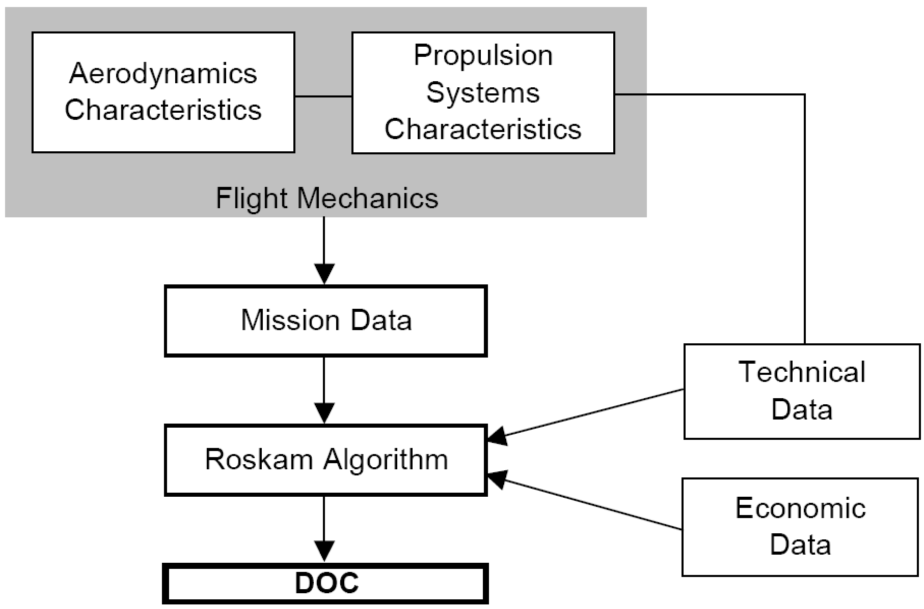


Fig. 2.2 DOC calculation based on algorithm data.

   The set of result figures is the same like in the 3. step.

4. EPATS aircraft requirements. Using data obtained during previous steps and taking under account outer sources such as CESAR, SESAR (presented in NLR - Memorandum ASAS – 2007 – 066, Ref. [16]), 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.

An overview of mentioned activities is presented on figures 2.1 and 2.2. Details of the design process is shown on Fig.2.3.

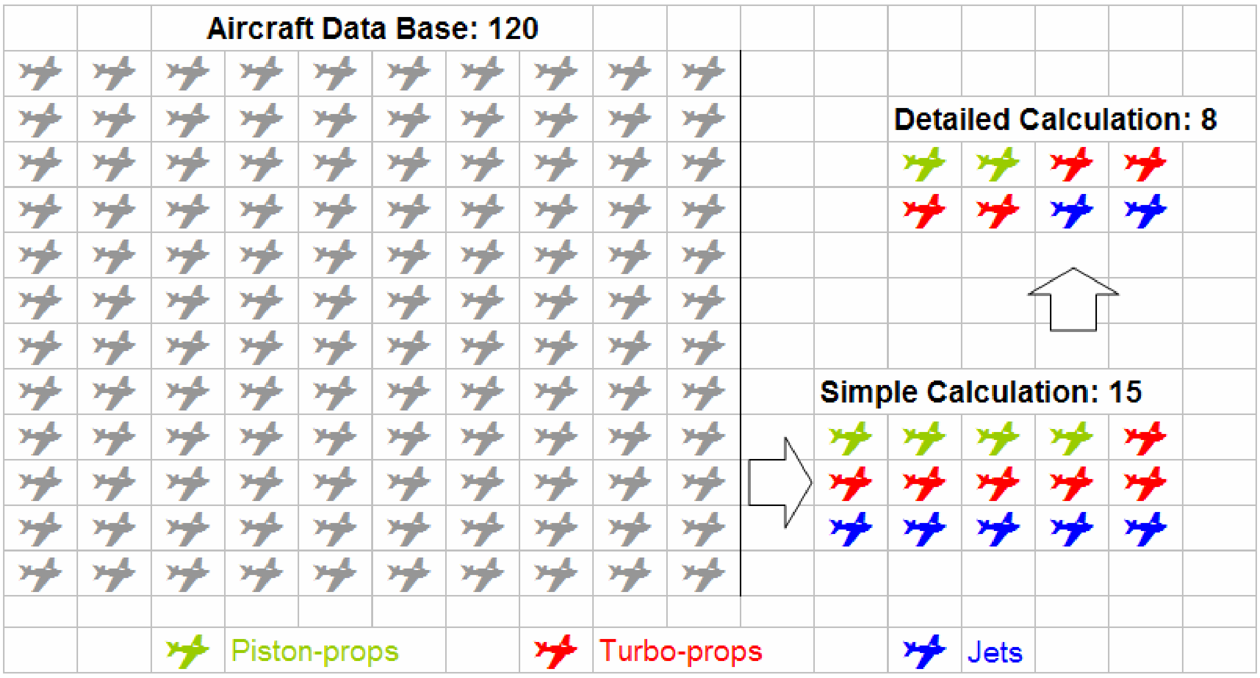


Fig.2. 1 Reference aircraft selection and analyses.

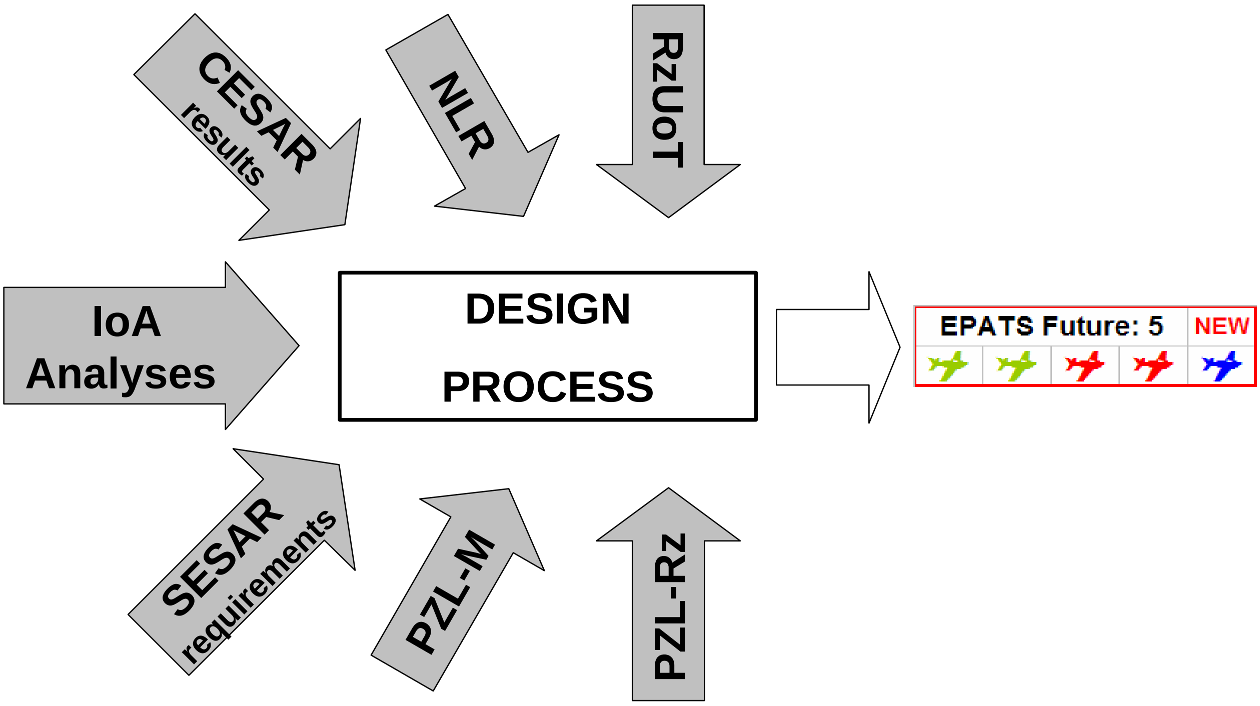


Fig.2. 2 Design process overview – a common effort.

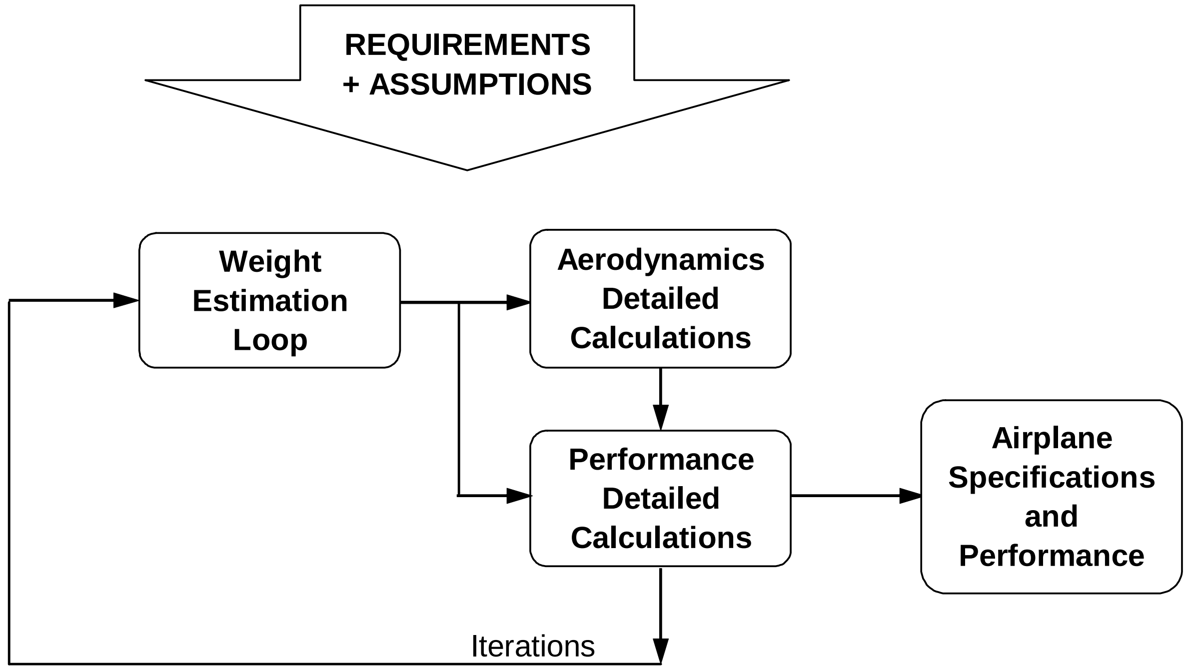


Fig.2. 3 Design process scheme – a partial conceptual design.

3. AIRCRAFT REVIEW

3.1 AIRCRAFT DEFINITIONS

According EPATS WP1.1: there are 3 broad categories defined for EPATS aircraft based on their engines: pistons, turboprops and jets. Each category does include single- and multi-engine powered aircraft. All EPATS aircraft will comply with CS-23 requirements in the normal and commuter category with new amendments regarding extra safety and environmental issues.

These are basic definitions and they are subject to change. The market model should answer the question were people may fly and by what airplanes (we should not limit the range arbitrary).

- **Piston-props aircraft**

Single-engine aircraft (cost comparable to an upper class automobile) will partially replace cars for traveling a distance of 300-700 km as a private aircraft. These aircraft will be flown visual flight rules (VFR), often with pilot (owners) only having a private pilot license. It can accommodate up to 3 passengers and a single pilot. Twin-engine aircraft will operate as an air-taxi with comparable costs to a ground taxi. These be used for one day business trips on routes connecting remote, peripheral regions with distances around 300-700 km. The aircraft will be piloted in VFR/IFR conditions by a single commercial licensed pilot carrying up to 5 passengers. Their customers will be mainly small enterprise managers.

- **Turbo-prop aircraft**

9 to19-seaters, operated by small carrier companies will serve direct , regular air connection, characterized by low intensity of traffic (5000-10000 passengers yearly), between peripheral regions on distances 300-1500 km, to hubs. These aircraft will also provide charter service on routes with low , irregular flow of passengers (tourism, seasonal travel to work abroad, sport, cultural events, etc.).Cost of travel using these aircraft should be comparable with costs of traveling by low-cost carriers and should be available to most of the citizens.

- **Jet aircraft**

Two main categories for utilization are planned: Small 3-5-seaters, Very Light Jets with maximum take-off weight below 5000 kg will be used as air-taxi providing regional and executive transport (the aircraft should be viewed as a productivity asset). Cost efficiency could be reached by high value managers. 7-9-seaters will operate in the area of whole Europe as a corporate and business airline charter-regularly scheduled flights between cities deemed profitable.

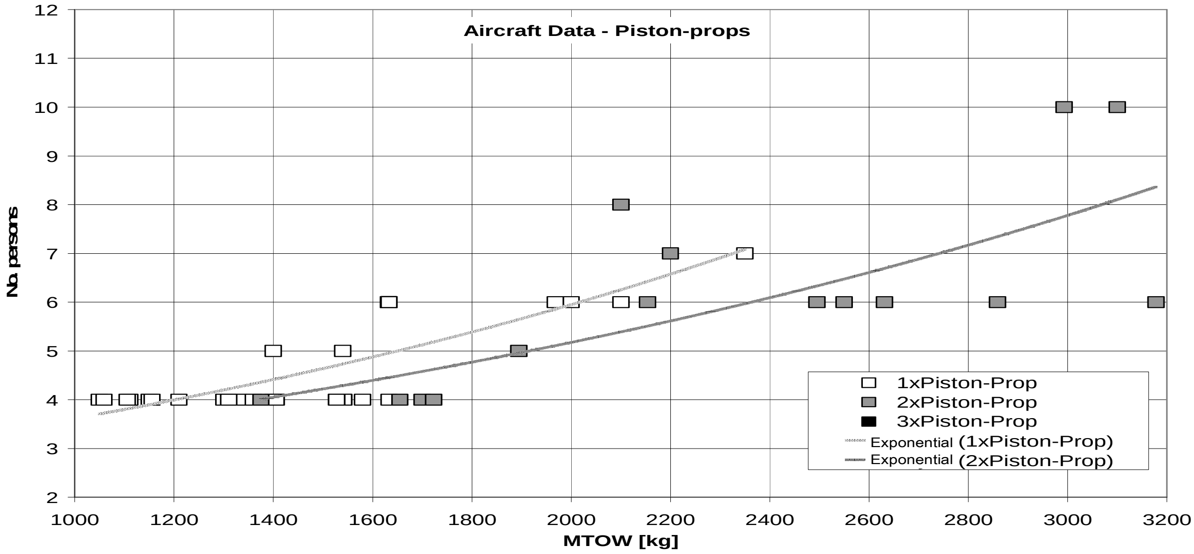
3.2 OVERVIEW OF CURRENT NORMAL AND COMMUTER CATEGORY AIRCRAFT

For the purpose of design process knowledge of many aircraft's parameters are important. The selected of them for about 120 constructions are presented on the figures below.

Figures 3.1 to 3.3 show review of particular classes: pistons, turbo-prop and jets. They plot number of persons on board (both pilots and passengers) versus maximum takeoff weight. Fig 3.4 includes all categories. Point are approximated by exponential curves.

Figure 3.5 presents empty weight fraction (W_e/W). The scatter of this parameter is very high. Values d.

Figures 3.6 shows power to weight while 3.7 thrust to weight ratios.



3.1 Total number of seats vs. MTOW – pistons. All the world.

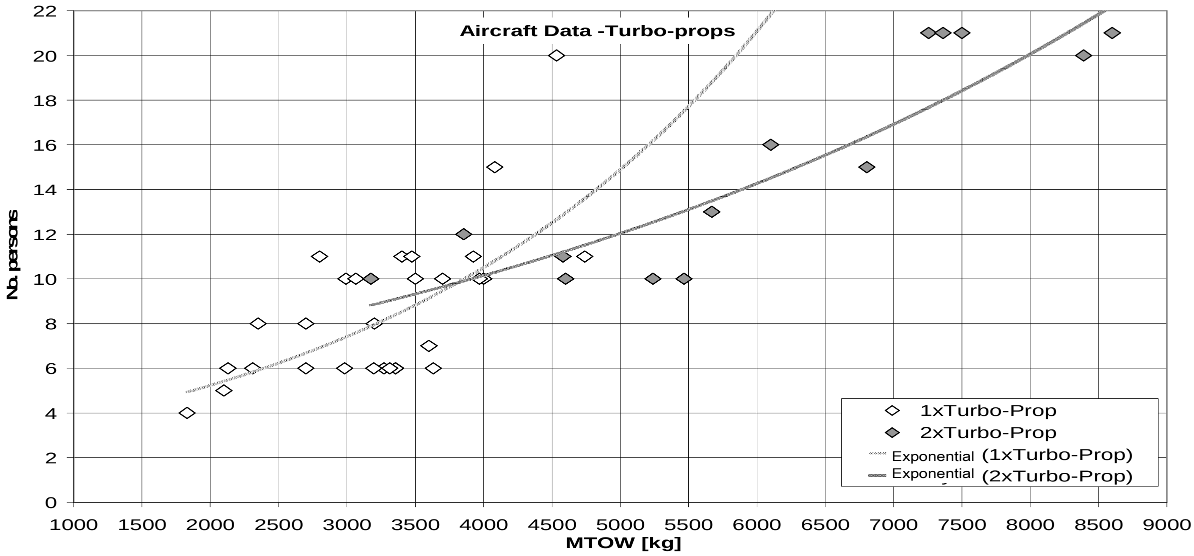


Fig. 3.2 Total number of seats vs. MTOW – turbo-props. All the world.

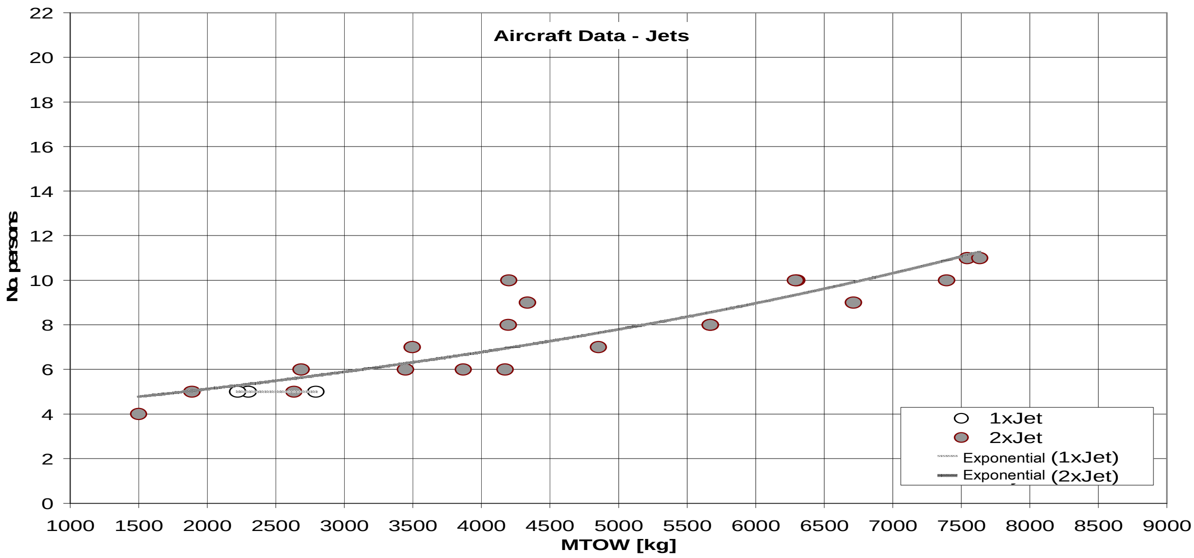


Fig. 3.3 Total number of seats vs. MTOW – jets. All the world.

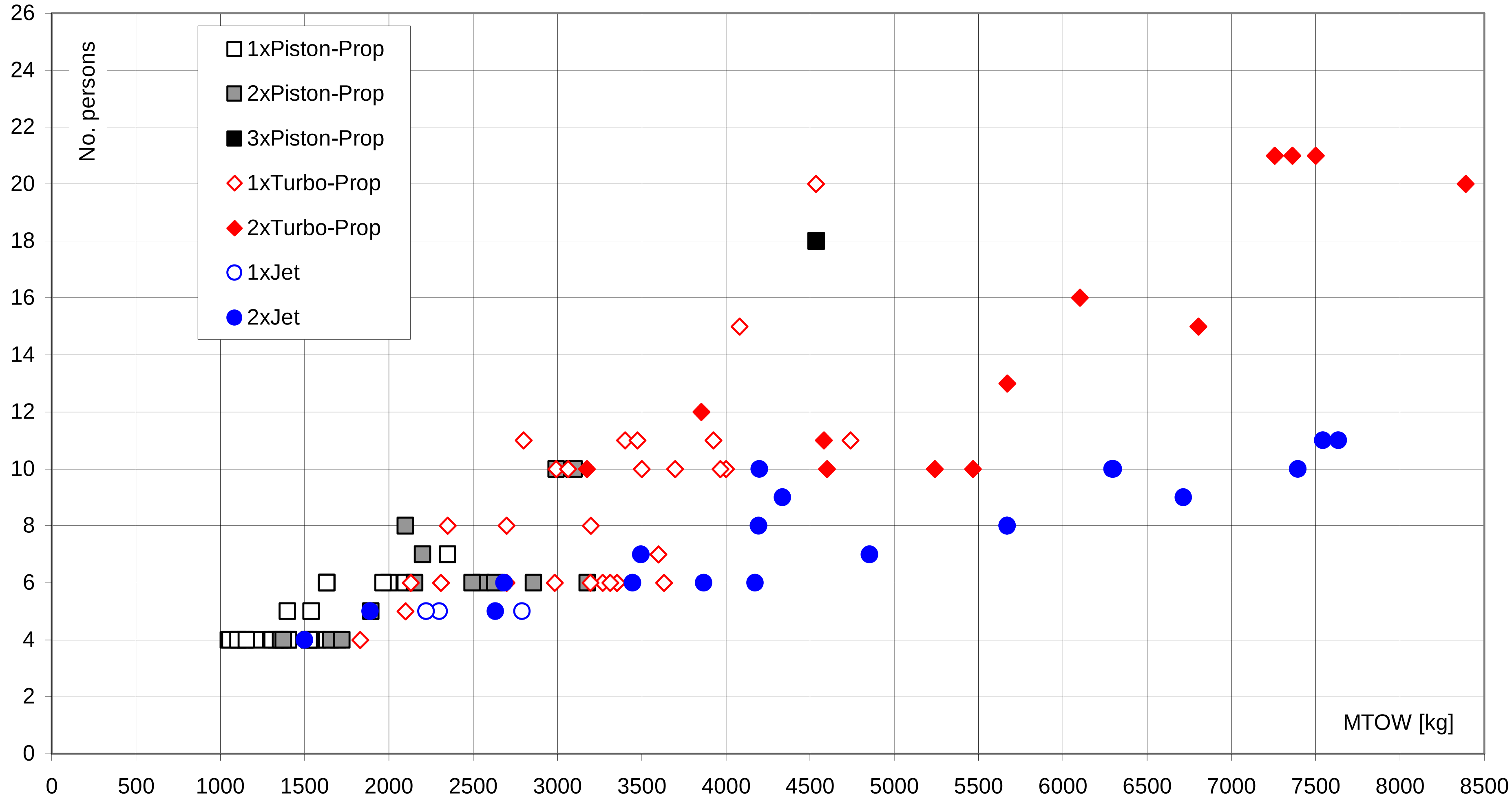


Fig. 3.4 Total number of seats vs. MTOW – all type of propulsion. All the world

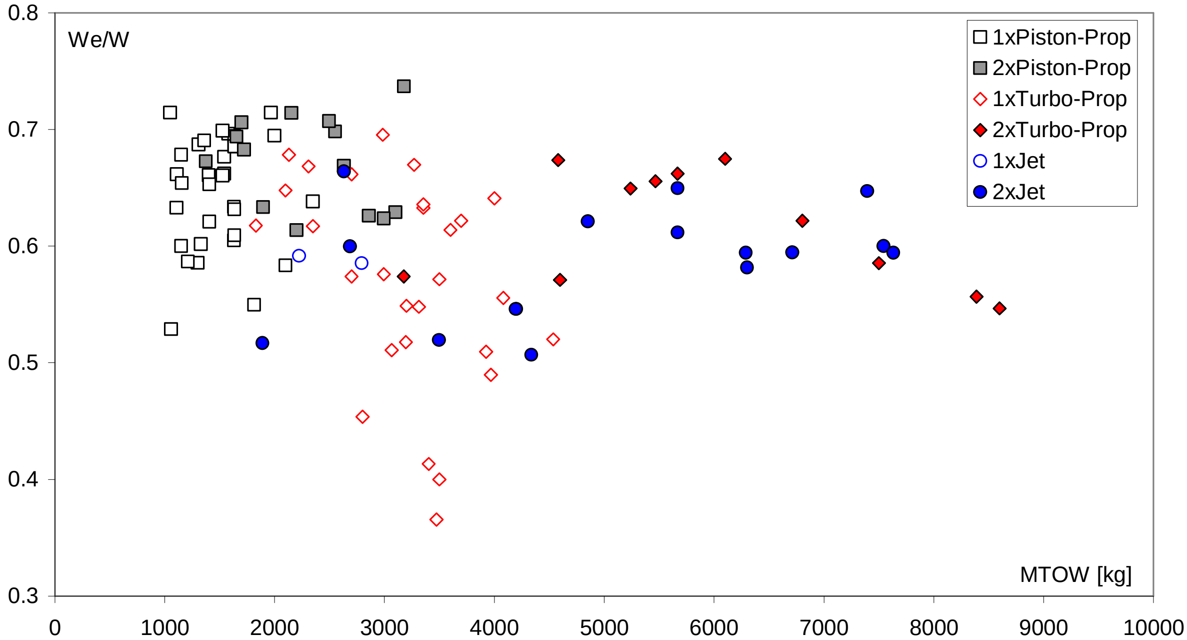


Fig. 3.5 Empty Weight fraction vs MTOW. All airplanes.

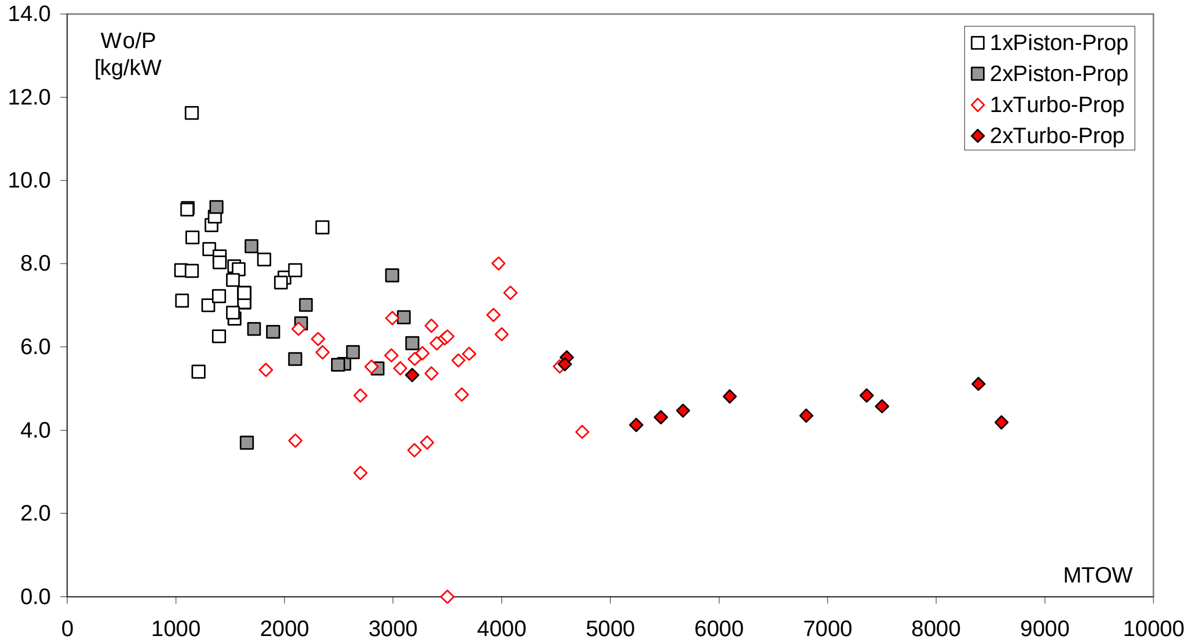


Fig. 3.6 Power loading for pistons and turbo-props vs MTOW.

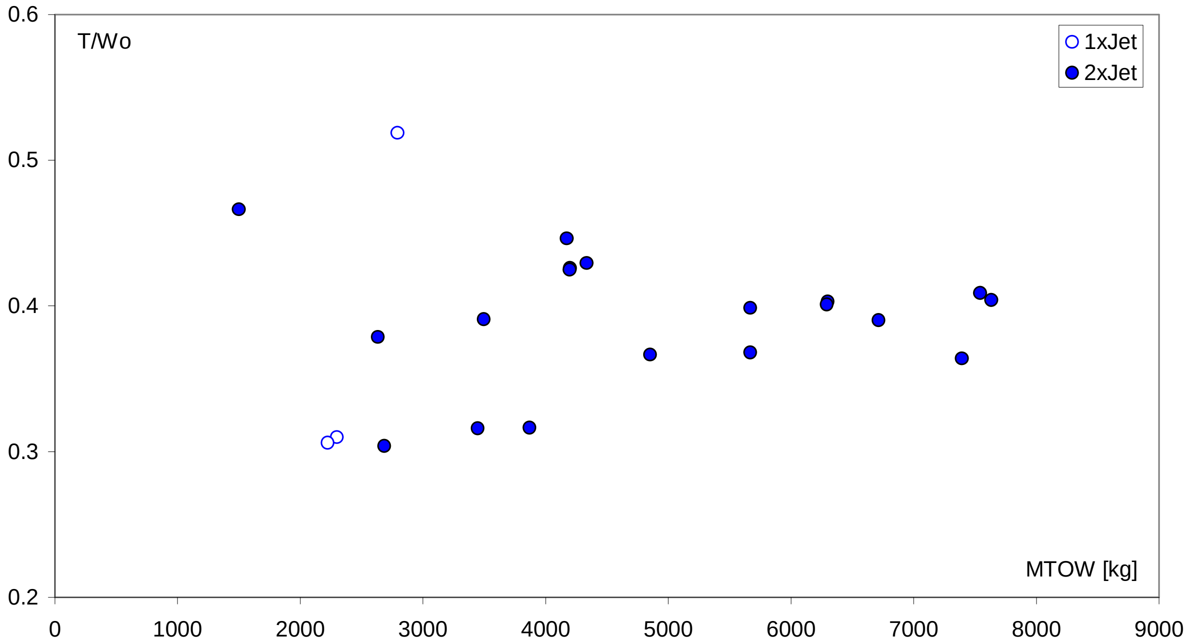


Fig. 3.7 Thrust to Wright ratio for jest vs MTOW

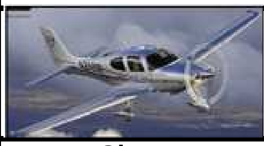
3.3 EPATS AIRCRAFT REFERENCE LIST

The final EPATS Aircraft Reference List includes the 8 most promising constructions. They are presented in tables 3.1 to 3.4 Details of selections stages are described in points in paragraph 2 – methodology.

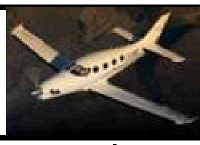
The data have been updated. Moreover they are more detailed than in "Aircraft Data Base" report by IoA, Ref.[14] :

1. Number of seats presents many configurations. For each, seat pitch[1] and cabin volume per seat have been calculated. The unified numbers of seats used in calculations are bolded.
2. Internal dimension include estimated lavatory impact on space. Cabin volume calculations take under account cross section shape (not a square=width*hight).
3. Weight are more detailed. Now payload means both pilots and passenger weights. Such a way is more flexible. It allows buildup weights easer when number of pilots changes.
4. Performances are presented with conditions at those they are reached. For example range is presented for different payloads and/or speeds (if available).
5. Estimated value are typed using thin italic type.

[1] Seat pitch is a distance between seats rows.

EPATS AIRCRAFT REFERENCE LIST	SINGLE-ENGINE PISTONS	MULTI-ENGINE PISTONS
		
Manufacturer	**Cirrus**	**Piper**
Model	**SR-22**	**Seneca V**
Price (avr.)	€ 296 296	€ 592 593
Certification Year	2000?	1996
Characteristic		
Seating	1+**3**	1+5
Dimensions Internal [m]		
Lenght	3.3	3.15
Width	1.24	1.24
Height	1.27	1.07
Cabin Volume [m^3]	*4.081*	*3.282*
Cab. Vol.per Pax. Seat	*1.020*	*0.547*
Seat Pitch [m]		
Power		
Engine	Teledyne Continental IO-550-N	Teledyne Continental TSIO-360-RB
Price [€]		
Output [kW]	231	164
Weight	187	149
SFC		
TBO [h]	2000	1800
Weights [kg]		
Max. TO	1542	2156
Empty Weight Equipped		1540
Max. Payload		428
Useful Load	531	562
Max. Fuel	301 (251 usable)	332
Performance		
Max. Cruise/Altitude [km/h /]	300 (75% P)	378 (75% P)
Service Ceiling [m]	5334	4575
Rate of Climb [m/min]	426	65
TO Distance to 15 m [m]	486	671
DOC/(pax*km)		
litre/(pax*km) - Cruise		
Range		
Cruise Speed [km/h] / Altitude Range [km]/Payload	75% P/2438 1502/- 2167 (55% P) / -	1533
Reserves		

Tab. 3.1 EPATS reference single-engine piston-prop.

EPATS AIRCRAFT REFERENCE LIST	SINGLE ENGINE TURBOPORPS	
		
Manufacturer **Model**	**Epic** **Dynasty**	**Pilatus** **PC-12**
Price [Milions]	$ 1.950	€ 2.24
Certification Year	2008	1994
Characteristic		
Seating	1+ **5**	2 + 6 / (**8**) 9
Dimensions Internal [m]		
Lenght	4.57	5.16
- Lavatory	1.00	0.6
- Seating Area	3.57	4.56
Width	1.4	1.53
Hight	1.49	1.47
Cabin Volume [m^3]	7.487	10.358
Cab. Vol.per Pax. Seat	**1.248**	1.726 / (**1.295**) 1.151
Seat Pitch [m]	**1.19**	1.52 / (**1.14**) 0.91
Power		
Engine	P&WC PT6-67A	P&WC PT6A-67B
Price [€]		
Output [kW]	895	895
Weight [kg]	230	234
SFC [kg/(kW*h)]	0.335	0.336
TBO [h]	3000	3500
Weights [kg]		
Max.Ramp	3347.1	4760.0
Max TO	3314.0	4740.0
Empty Weight Equiped[kg]	1816.0	2887.0 / 2661.0
Max. Zero Fuel		4100
Max. Payload [kg]	613	1123 / 1349
Max. (Usable) Fuel [kg]	856-1070	(1227)
Useful Load [kg]	1531.1	1873 / 2099
Performance		
Max. Cruise [kmh]	630	500
Altitude-Max. Cruise		FL250
Service Ceiling	FL310	FL300
Rate of Climb [m/min]		480
TO Distance 15 m (BFL) [m]	488	(917)
DOC/(pax*km)		
litre/(pax*km) - Block		
Range		
Cruise Speed/Altitude [m]	533 / -	- / FL242
Range [km]/Payload	2870 / 1+5	2583 /1+9 Hi Speed 2904 /1+9 Long R
Reserves	IFR	NBAA IFR

Tab. 3.2 EPATS reference single-engine turbo-props.

EPATS AIRCRAFT REFERENCE LIST	**MULTI-ENGINE TURBOPROPS**	
		
Manufacturer **Model**	**Piaggio** **Avanti II**	**BAE** **Jetstream 32EP**
Price	€ 5 850 000	€ 4 900 000 ?
Certification Year	2006	1997
Characteristic		
Seating	2 + 6 / **8** / 9	2 + **19**
Dimensions Internal [m]		
Lenght	4.55	7.39
- Lavatory	*0.6*	*0.6*
- Seating Area	*3.95*	*6.79*
Width	1.85	1.85
Height	1.75	1.80
Cabin Volume [m^3]	*11.569*	*19.327*
Cab. Vol.per Pax. Seat	*1.928 / **1.446** / 1.285*	***1.017***
Seat Pitch [m]	*1.32 / **0.99** / 0.79*	***0.68***
Power		
Engine	P&WC PT6A-66B	Garett TPE331-12
Price [€]		
Output [kW]	2 x 634	2 x 761
Weight [kg]	213 (v. 66)	182
SFC [kg/(kW*h)]	0.378 (v. 66)	0.333
TBO [h]	3000 (v. 66/A)	3600-**5000**-5400
Weights [kg]		
Max.Ramp	5511	*7433.6*
Max TO	5489	7360
Empty Weight Equipped	*3470.2*	*4512.4*
Max. Zero Fuel	4445	6736
Max. Payload (pilots+pax)	907	2223.6
Max. (Usable) Fuel	*1271.2*	1489
Useful Load	*2040.8*	*2921.2*
Performance		
Max. Cruise [kmh]	737	491
Altitude-Max. Cruise	FL280	
Service Ceiling	FL410	FL250
Rate of Climb [m/min]	899	
TO Distance 15 m (BFL) [m]	(1295)	1432
DOC/(pax*km)		
litre/(pax*km) - Block		
Range		
Cruise Speed [km/h] / Altitude	-/-	463 / -
Range [km]/Payload	1815 / 908 v.l 2791 / ?	915 / full pax. Load 1978 / 60% pax. load
Reserves	IFR	

Tab. 3.3 EPATS reference multi-engine turbo-props.

EPATS AIRCRAFT REFERENCE LIST	**MULTI-ENGINE JETS**	
		
Manufacturer	**Eclipse**	**Grob**
Model	**500**	**SPn**
Price [Milons]	$ 1.520 (€ 1.126)	€ 5.80
Certification Year	2007	2008 ?
Characteristic		
Seating	1+ **4** / 5	1+9 / 2**+8**
Dimensions Internal [m]		
Lenght	3.76	5.10
- Lavatory		1.04
-Seating Area		4.06
Width	1.42	1.52
Hight	1.27	1.64
Cabin Volume [m^3]	*5.325*	*11.347*
Cab. Vol.per Pax. Seat	*1.065 / 0.888*	*1.418*
Seat Pitch [m]	*0.85 / 0.85*	*1.015*
Power		
Engine	P&WC PW610F	Williams FJ44-3A
Price [€]		
Output [kN]	2 x 4.0	2 x 12.5
Weight [kg]		
SFC [kg/(kW*h)]		0.456
TBO [h]	3500	4000
Weights [kg]		
Max.Ramp	2737.2	*6363*
Max TO	2721.7	6300
Empty Weight Equiped	1648.0	*3727.4*
Max. Zero Fuel	2213.7	
Max. Payload [kg]		1130.0
Max. (Usable) Fuel [kg]	765	2000
2 Useful Load [kg]	1089.1	*2635.6*
Performance		
Max. Cruise [kmh]	685	754
Altitude-Max. Cruise		FL330
Service Ceiling	FL410	FL410
Rate of Climb [m/min]	1044	1320
TO Distance to 15 m (BFL) [m]	714	(914)
DOC/(pax*km)		
litre/(pax*km) - Cruise		
Range		
Cruise Speed/Altitude [m]		
Range [km]/Payload	1019 / 1+5x90.8 1426 / 1+4x90.8 1815 / 1+3x90.8	3334 / 1+6x90.8 3093 / 1+8x90.8
Reserves	NBAA IFR	IFR

Tab. 3.4 EPATS reference multi-engine jets.

3.4 EPATS REFERENCE AIRCRAFT PERFORMANCES

This chapter based on the report: "Operating Cost Analysis" [2], Ref.[19]. The resented results regard current utilization level of 600 block hours and flight conditions that maximize V.block to DOC ratio.

Block speed (V.block) increases with distance; Fig.3.8 . Jets are the fastest, however a new generation of turbo-props is just a steep behind, offering benefits in operating cost and fuel consumption. Older turbo-props offer medium speeds. Piston is the slowest, however it gains advantage at short distances. This is due to the fact that it flies at low altitudes and spend less time climbing.

Fig.3.9 show that DOC decreases with distance. Jets are the most expensive of all. Medium size turboprops (up to 9 pax.) offer costs at medium level. Piston is the cheapest, except large turbo-prop (19 pax.) which is beyond the competition.

SFC decreases with distance; Fig.3.10 . Jets have the highest fuel consumption. Normal category (up tp 9 pax.) turbo-props have medium, while piston the lowest (fuel consumption). Commuter category turbo-prop – Jetstream (19 pax.) is beyond the competition again.

The cheaper and faster airplane is better of course. Why cheaper. That is obvious. Why faster? The benefit of high speed is saved time (which has its value) and therefore money. Usually faster means more expensive. To take under account both mentioned parameters we use: Block speed to DOC ratio. This is the reason this is the significant parameter used for airplane demand calculation. Fig.3.10 shows that V.block to DOC ratio increases with distance. In general, jets are the worst, but when distance increases they become more competitive, winning with piston and slow medium size (9 pax.) turbo-prop (t-prop). Fast medium size (9 pax.) t-props are good at all distances except short, where small piston dominates. Jetstream, 19 pax. t-prop is the best of all at any distance.

[2] The following errors were found in this report
- SFC of Grob should be lower by about 15%
- Navigation fees were calculated for constant distance instead of many.
- Power of Jetstream 32 was underrated (should be higher by 34%) what impacted its performance.

These errors were fixed and results are presented in chapter 5.
- The price of Jetstream was probably estimated as too low.

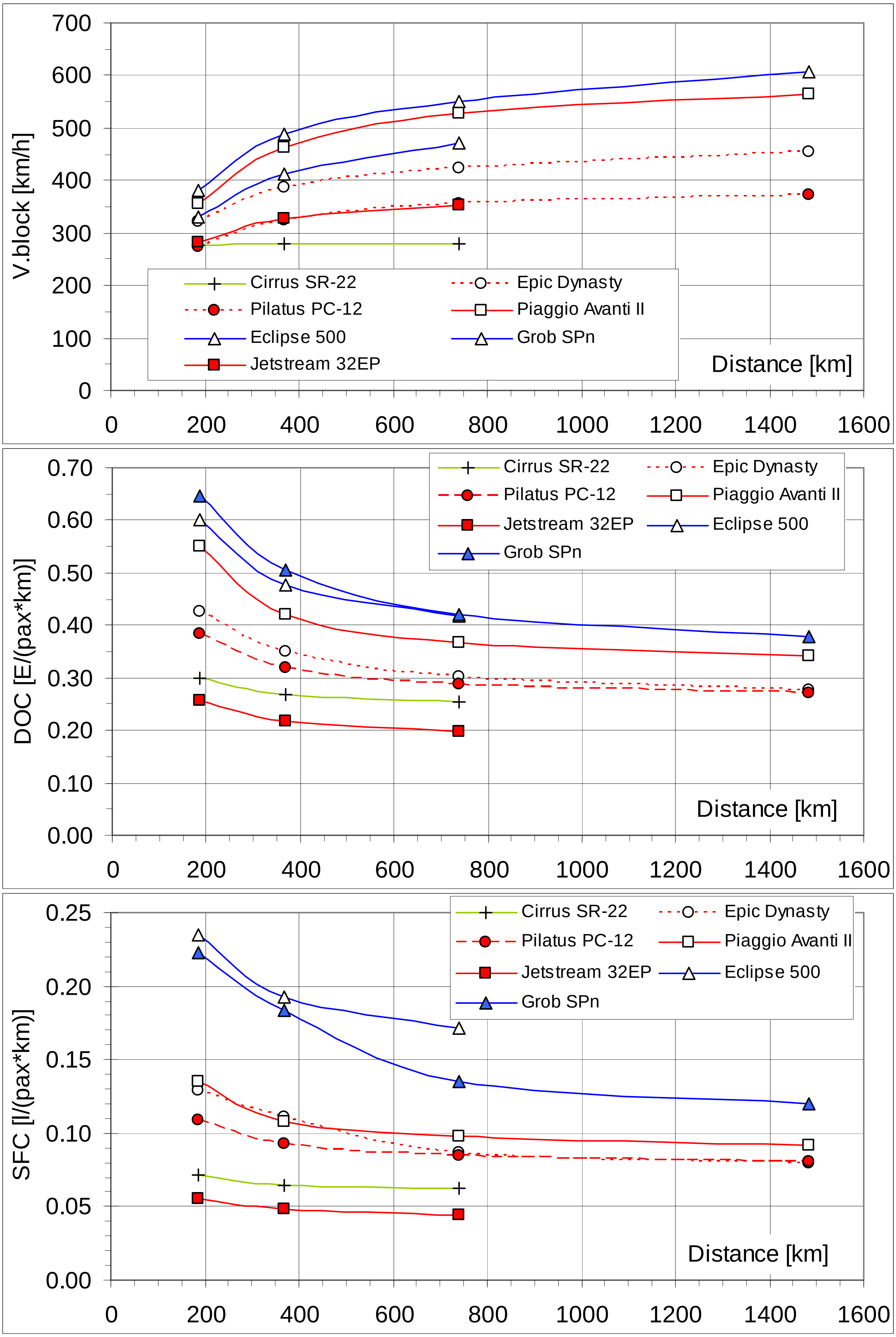


Fig. 3.8, Fig. 3.9, Fig .3.10 V_{block}, DOC and SFC as a function of distance for reference aircraft (for 600 block hour per year).

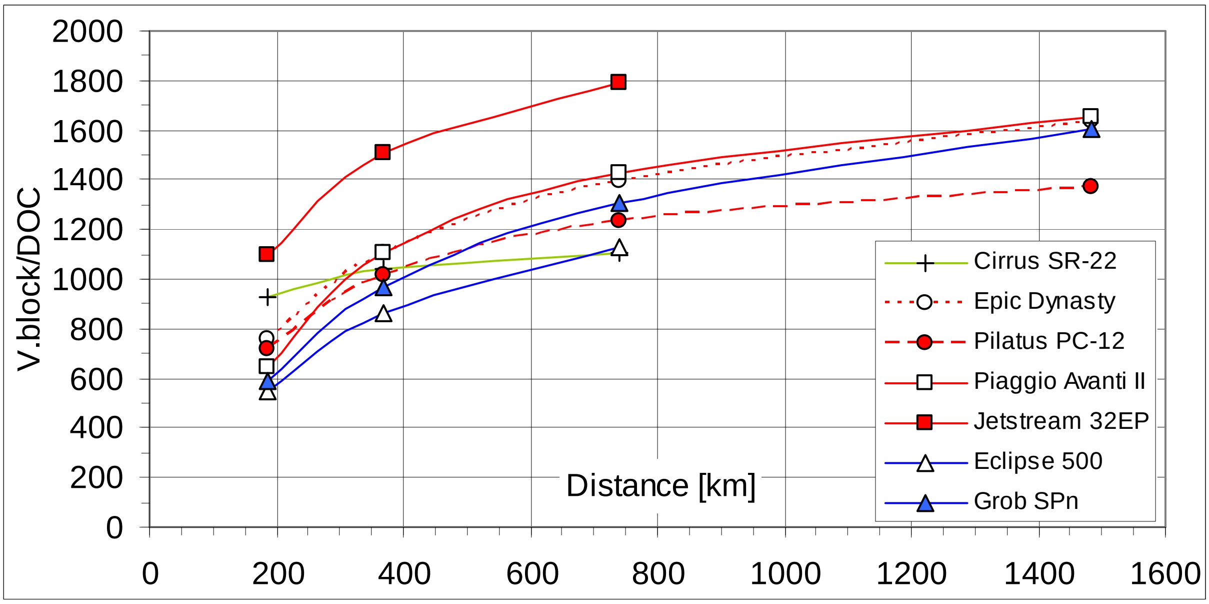


Fig. 3.11 V_{block}/DOC as a function of distance for reference aircraft (for 600 block hour per year).

3.5 EPATS AIRCRAFT AVIONICS REFERENCE LIST

Specification of the avionics actually used in the aircrafts from the Reference List is show below in tables 3.5 to 3.8 (according to NLR- Memorandum ASAS-2007-066, Ref.[16]).

EPATS AIRCRAFT AVIONICS REFERENCE LIST	SINGLE-ENGINE PISTONS	MULTI-ENGINE PISTONS
		
Manufacturer Model	Cirrus SR22-G3	Piper Seneca V
Configuration	standard Avidyne Entegra	standard Avidyne Entegra
Nav Comms		
unit	Garmin GNS 430 & 420	dual Garmin GNS 430
navigation	VOR / ILS / 2x GPS ADF / DME opt.	2x VOR / ILS / GPS ADF / DME opt.
FMS	GPS navmap	GPS navmap
compliance	B-RNAV	B-RNAV
communications	2x VHF 25 / 8.33 kHz	2x VHF 25 / 8.33 kHz
satellite	opt. sat radio	opt. sat radio
audio	Garmin GMA 340	Garmin GMA 340
Surveillance		
transponder	Garmin GTX 327 mode C	Garmin GTX 330 mode S
traffic	opt. TIS/TAS	opt. TIS/TAS
weather	opt. sferics / satlink	opt. sferics / radar
terrain	opt. TAWS-B	opt. TAWS-B
ELT	yes	yes
Instrumentation		
PFD	Avidyne EX5000C	Avidyne EXP5000
MFD	Avidyne EX5000C	Avidyne EX5000
size	10.4" SVGA	10.4" SVGA
EFB	opt. EICAS / charts	opt. charts
backup mech.	ATT / SPD / ALT	ATT / SPD / ALT / HSI
Flight		
interface	sidestick	center yoke
autopilot	S-Tec 55SR	S-Tec 55X
AP type	dual axis	dual axis
AP modes	HDG ps/hold ; ALT hold CRS int ; VOR/LOC trk GPS trk	HDG ps/hold ; ALT ps/hold CRS int ; VOR/ILS trk REV crs ; GPS trk
Extra	SP ops / ac parachute	SP ops
Ref.	[41][42]	[41][45]

Tab. 3.5 Single-engine piston-prop avionics list, Ref.[16].

EPATS AIRCRAFT AVIONICS REFERENCE LIST	SINGLE-ENGINE TURBOPROPS	
		
Manufacturer Model	Epic Dynasty	Pilatus PC-12
Configuration	standard Garmin G1000	next gen Honeywell Primus Apex
Nav Comms		
unit	dual Garmin GIA 63	dual
navigation	2x VOR / ILS / GPS ADF / DME opt.	2x VOR / ILS / GPS ADF / DME / rALT
FMS	GPS navmap	yes
compliance	B-RNAV	B-RNAV
communications	2x VHF 25 / 8.33 kHz	2x VHF 25 / 8.33 kHz
satellite	opt. sat radio	no
audio	Garmin GMA 1347	KMA-24H
Surveillance		
transponder	2x Garmin GTX 33 mode S	2x KT-70 mode S
traffic	opt. TIS/TAS	opt. TCAS I
weather	opt. sferics / satlink	radar / opt. VHFlink
terrain	opt. TAWS-B	opt. TAWS-A
ELT	yes	yes
Instrumentation		
PFD	Garmin GDU 1040A	dual Honeywell
MFD	Garminm GDU 1040A	dual Honeywell
size	10" XGA	12"
EFB	opt. charts	yes
backup mech.	ATT / SPD / ALT / compass	ESIS
Flight		
interface	center yoke	center yoke
autopilot	TruTrak Sorcerer?	KFC 325
AP type	triple axis	triple axis
AP modes	HDG ps/hold ; ALT ps/hold CRS int ; VOR/LOC trk REV crs ; GPS trk	HDG ps/hold ; ALT ps/hold CRS int ; VOR/ILS trk REV crs ; GPS trk ; YD ; PT
Extra	SP ops / FADEC	SP ops
Ref.	[46]	[48]

Tab. 3.6 Single-engine turbo-props avionics list, Ref.[16].

EPATS AIRCRAFT AVIONICS REFERENCE LIST	MULTI-ENGINE TURBOPROPS	
		
Manufacturer Model	Piaggio P.180 Avanti II	BAE Jetstream 32EP
Configuration	standard Rockwell Collins Pro Line 21	standard airliner Rockwell Collins Pro Line II
Nav Comms		
unit	NAV-4000/4500 GPS-4000A	2x VIR-32/VHF 22A / HF-9031
navigation	2x VOR / ILS / 1x GPS ADF / DME / rALT	2x VOR / ILS ADF / DME / rALT
FMS	FMS 3000	no
compliance	B-RNAV/RVSM/Cat.II steep	B-RNAV / Cat.II
communications	2x VHF 25 / 8.33 kHz	2x VHF 25 kHz 1x HF
satellite	no	no
audio	dual Baker M-1035	dual Racal B692
Surveillance		
transponder	2x Collins TDR-94D mode S	2x Collins TDR-94D mode S
traffic	TCAS I	TCAS II
weather	radar	radar
terrain	TAWS-B	TAWS-A
ELT	yes	yes
Instrumentation		
PFD	dual	dual Collins EFD-85
MFD	single	Collins MFD-85B
size	12"	5" CRTs
EFB	yes	no
backup mech.	ESIS	full legacy
Flight		
interface	center yoke	center yoke
autopilot	dual FGC-3003	Collins APS-85
AP type	triple axis	triple axis
AP modes	HDG ps/hold ; ALT ps/hold CRS int ; VOR/ILS trk REV crs ; GPS trk ; YD ; PT	full airliner modes
Extra	SP ops / FDR	FDR / CVR
Ref.	[41][49]	[41][51]

Tab. 3.7 Multi-engine turbo-prop avionics list, Ref.[16].

EPATS AIRCRAFT AVIONICS REFERENCE LIST	MULTI-ENGINE JETS	
		
Manufacturer **Model**	Eclipse 500	Grob SPn
Configuration	standard Avio NG	standard Honeywell Primus Apex
Nav Comms		
unit	dual Honeywell KTR 2280	dual Honeywell
navigation	2x VOR / ILS / GPS ADF / DME / rALT opt.	2x VOR / ILS / GPS ADF / DME / rALT
FMS	yes	dual
compliance	B-RNAV / RVSM	P-RNAV / RVSM
communications	2x VHF 25 / 8.33 kHz	2x VHF 25 / 8.33 kHz
satellite	opt. satcom	opt. satcom
audio	PS Engineering PMA500	KMA-24H
Surveillance		
transponder	2x Garmin GTX 33 mode S	mode S
traffic	opt. TIS / TCAS I / ADS-B	TCAS II
weather	radar / opt. sferics	opt. radar / sferics / satlink
terrain	opt. TAWS-B	TAWS-A
ELT	yes	yes
Instrumentation		
PFD	IS&S	dual Honeywell
MFD	IS&S	dual Honeywell
size	XGA PFD & WXGA+ MFD	15" PFD & 10"MFD
EFB	opt.	opt.
backup mech.	no	3" ESIS
Flight		
interface	sidestick	center yoke
autopilot	dual	?
AP type	triple axis	triple axis
AP modes	HDG ps/hold ; ALT ps/hold CRS int ; VOR/ILS trk REV crs ; GPS trk ; YD ; AT	?
Extra	SP ops / AT / FADEC	SP ops / FADEC / EVS
Ref.	[41][53][54]	[41][55]

Tab. 3.8 Multi-engine jets avionics list, Ref.[16].

4. REQUIREMENTS CREATION

The creations of future EPATS aircraft requirements is final stage of the Work Package 4 (WP4). It is also a serious effort. This phase utilises participants contributions:

- PZL-Reszów
- PZL-Mielec
- Rzeszów Uniwersity of Technology
- NLR
- M3 Systems
- ILot
- Eurocontrol

The requirements can be divided in several parts:

- Airport performances
- Mission requirements
  - Distances
  - Flight levels
  - Cruise speed
- Utilization
  - Utilization intensity
  - Indirect cost level
- Regulations

Another subject concerns earlier stages such as research and development and production. In this case CESAR achievements will be utilize. Also SESAR impact of air traffic management will be concern.

4.1 AIRPORT PERFORMANCES

This chapter based on the report ,,Airports and Facilities Data Base”,Ref.[15], prepared by Rzeszów Uniwersity of Technology (RzUoT). It includes a review of European airports and landing fields - all together 2567.

We assume that future EPATS aircraft will be operated using existing airport and landing fields infrastructure and defined percentage of them should be available:

- 80% for commuters and normal category turbo-props and jets
- 90% for normal category twin-engine piston-props
- 95% for normal category single-engine piston-props

What means - according to Fig.4.1- that take off field length should not exceed respectively: 1000, 750 and 500 meters (elevation and ambient temperature must be defined). Moreover additional figures like runway width (Fig.4.2) and elevation (Fig.4.3) must be consider to answer which combinations of these 3 parameters will be crucial.

Simultaneously all requirements according to regulations (CS-23) must be fulfilled (met).

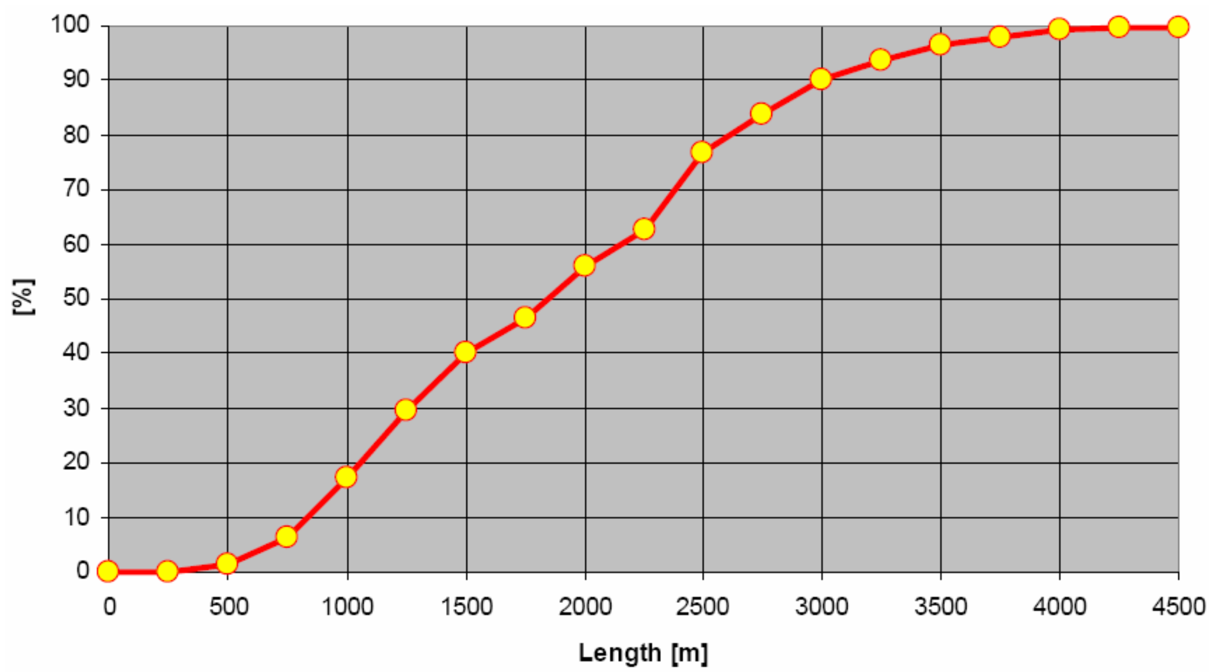


Fig. 4.1 Cumulative distribution function of all European airports runways length. Ref.[15]

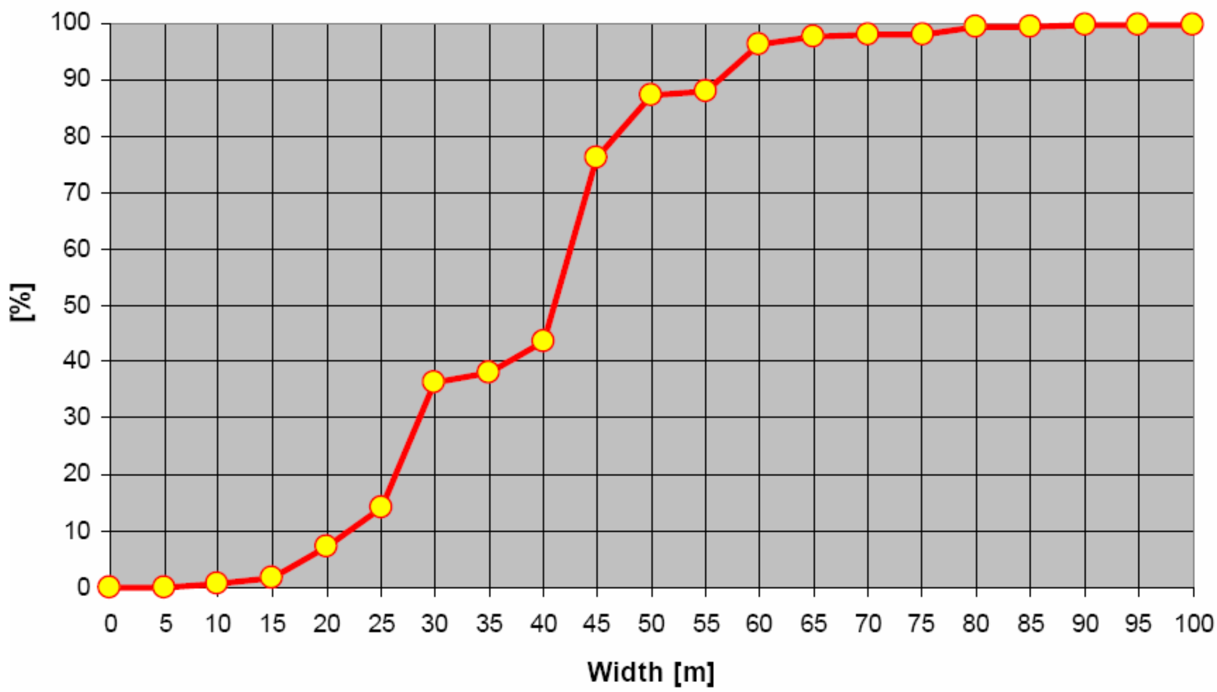


Fig. 4.2 Cumulative distribution function of all European airports runways width. Ref.[15]

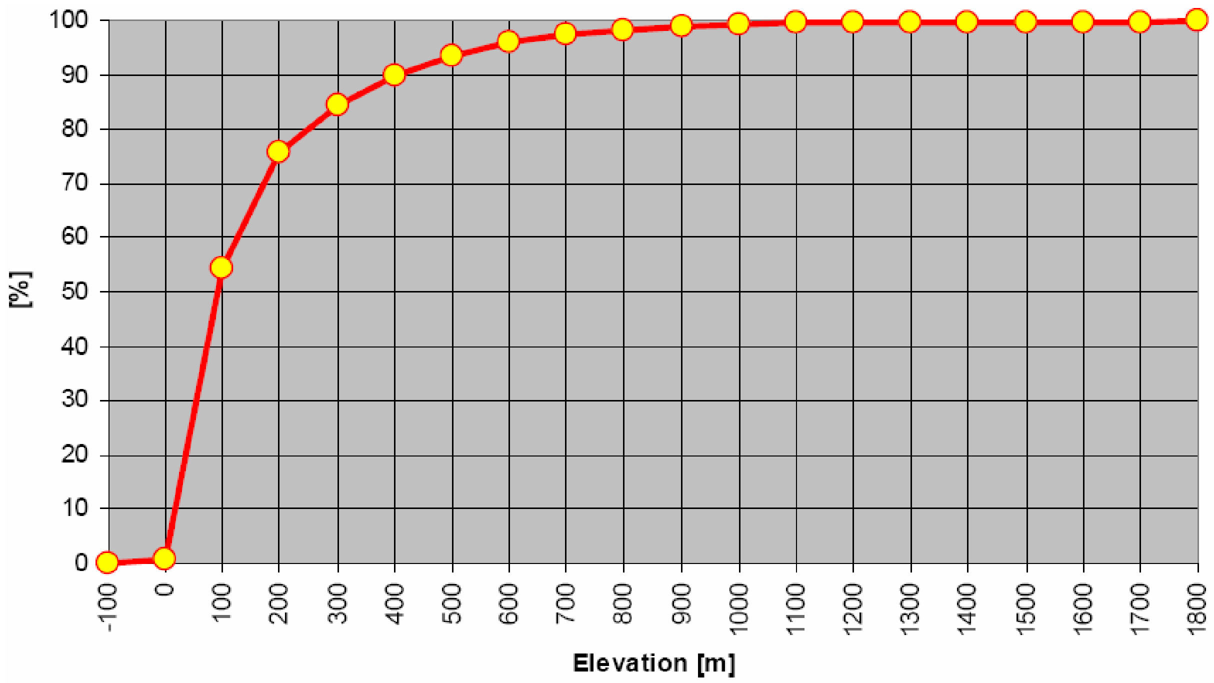


Fig. 4.3 Cumulative distribution function of all European airports runways elevations. Ref.[15]

4.2 DISTANCES

Range requirements based on the report: "Airports and Facilities Data Base" prepared by Rzeszów University of Technology", Ref.[15] and "EUROCONTROL Trends in Air Traffic, volume 1: Getting to the Point Business Aviation in Europe" by Eurocontrol, Ref.[21], and Institute of Aviation's analyses.

1. Analysis of data on Fig.4.4 and Fig.4.6 shows that airplanes having range about 3000 km could serve nearly all European air connections.
2. Only a part of them is used in reality. Fig.4.5 shows a histogram of business IFR operations per day in Europe. According to it, 1500 km of range is enough to serve majority of using connections (EPATS may extend this).
3. Range strongly influences take of weight and therefore several important airplane's parameters too, e.g: price, operating cost and fuel consumption. Further chapters present flight levels limitations those also have a negative impact on. These are the reasons that maximum range should not be to long.
4. Reference aircraft ranges have impact on also.

We propose to limit turbo-props and jets ranges to about 1500 to 2000 km. Also we suggest to limit range of piston-props to about 1000 km with availability to flight per 1.5 block hour there and back (approximately 2x450 km) without refueling (in this case lack of comfort and lavatory are the strongest restrictions). Such a range should be enough to fulfill a predicted role of pistons: private owner and/or "car replacement". For twin-engine pistons we propose to limit range to 500 km which is about 1.5 block hour.

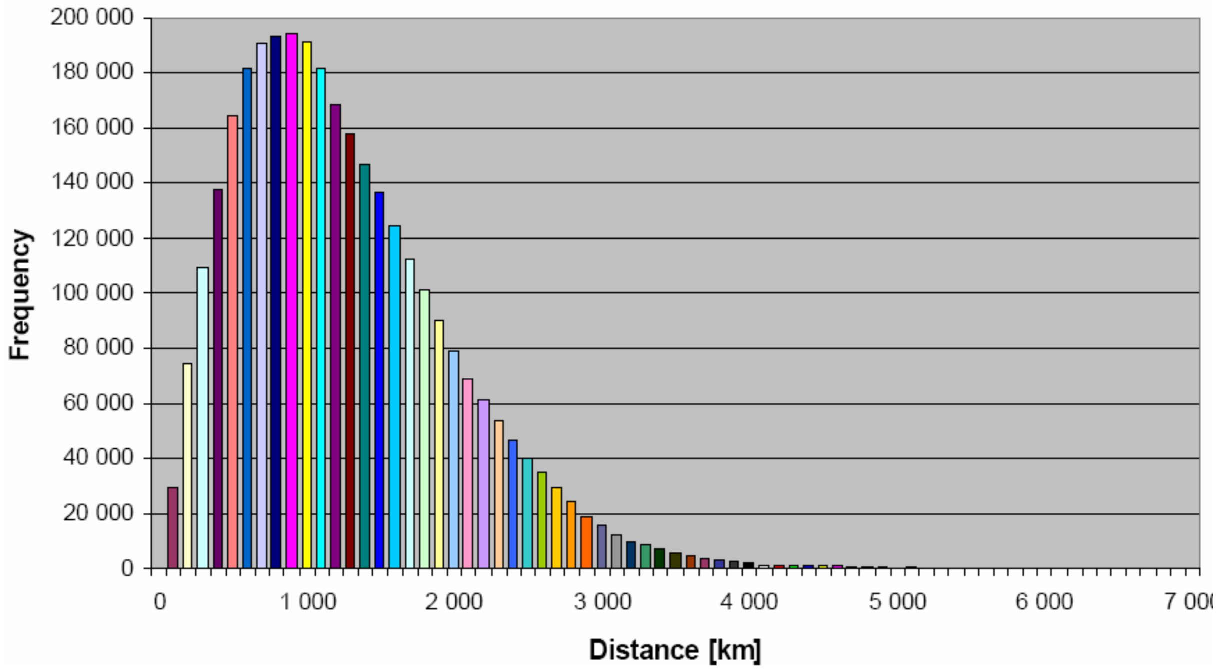


Fig. 4.4 All European air connections lengths histogram: landing fields and airports. Ref.[15]

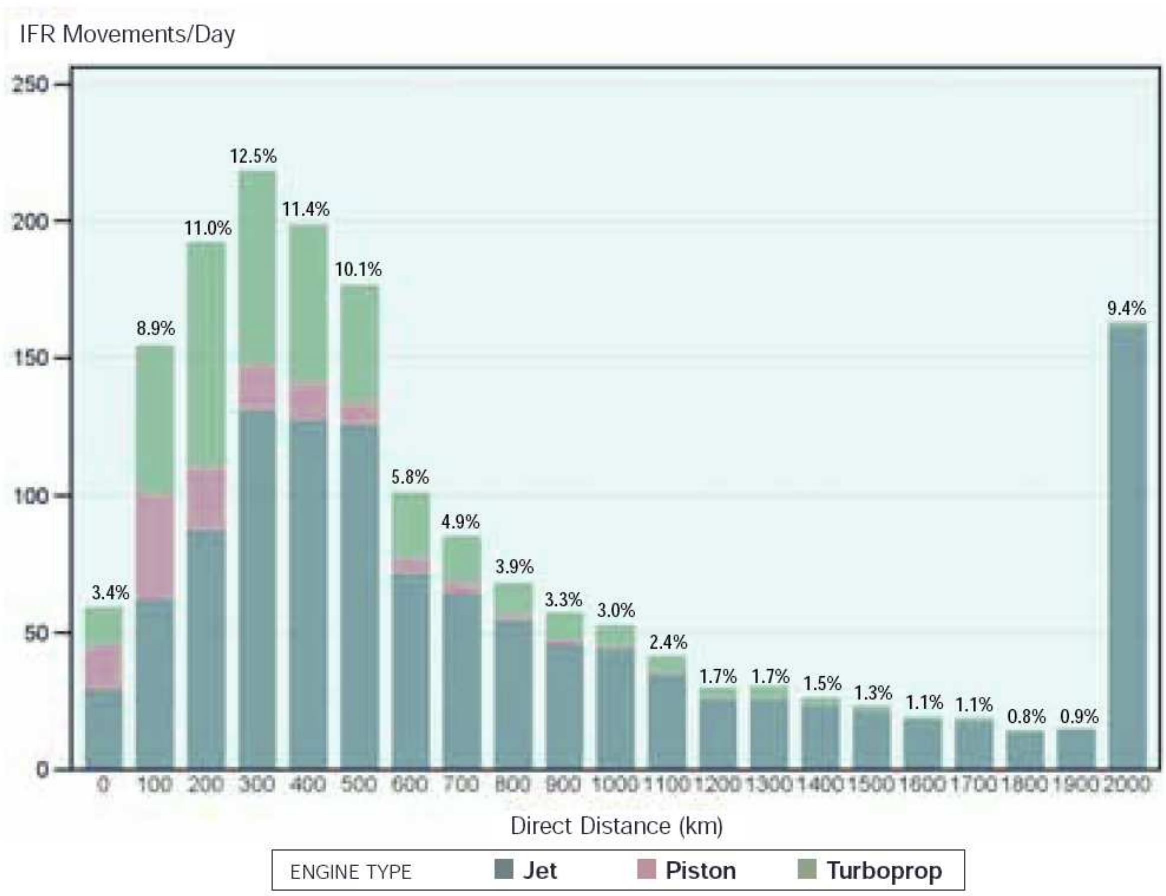


Fig. 4.5 Number of business IFR operations per day in Europe. Ref.[21]

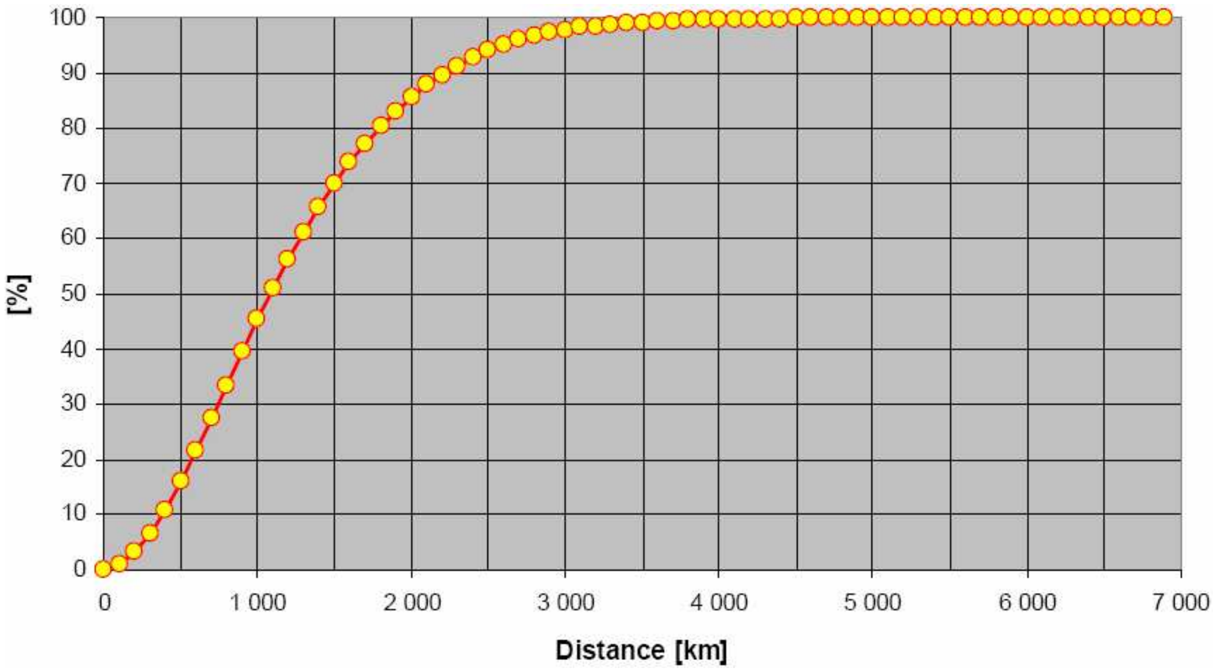


Fig. 4.6 Cumulative distribution function of all European air connections lengths: landing fields and airports. Ref.[15]

4.3 FLIGHT LEVELS

EPATS system is going to put a large number of new aircraft into, already congested airspace. So the important task concerns planning the airspace structure.

EPATS considers different types of airplanes powered by three types of propulsion: pistons, turbo-props and jets. Each of them has different features. So another range of' altitude and speed will be available, and what could be more important, favourable for them.

We have to take under consideration current airspace load. Figures 4.8 to 4.11 (according to Ref.[20]) present the highest cruising altitude for 4 kinds of jets: narrow body, wide body, regional and business (light and heavy). Due to slower speed of light jets there is a conflict between them and airliners. If we add a relatively short distances that EPATS would utilize the solution is a limitation of maximum flight level.

Considering results obtained in the previous stage: "Operating Cost Analysis" several important remarks can be made. Fig.4.15 to shows (for jets) an important economic parameter: V.block to DOC ratio, for many altitudes and distances. It seems clear that even at the longest distance of 1482 km there is no need to fly higher than about 30 000 ft (9144 m). The situation is different if we take under consideration fuel consumption. Then despite short range the higher altitude is the better.

For turbo-props there are no such negative interactions between regional and small constructions. For example maximum speed of ATR 42-500 equals 550 km/h, for Jetstream 32EP - 491 km/h. Epic Dynasty and Pilatus PC-12 can fly respectively 630 and 500 km/h (all, manufacturers data). The exception is Piaggio Avanti – 737 km/h. Also in this category analyses show that V.block to DOC ratio even at the longest

route reaches its maximum at about FL200 for normal category turbo-props and at about FL 50 for commuter. Also fuel consumption is not affected negatively by low altitude as for jets. For short distances it is even better to fly lower.

For un-pressurized, normally aspirated piston it is better to fly low in regard of speed and high in regard of fuel consumption at any distance. For pressurized, turbocharged pistons the situation is different. It is better to fly low at short distance in regard of either speed and fuel consumption and high at longer trip.

Considering our analyses and according to Ref.[20] we decided preliminary to limit EPATS airspace to FL290 (8839 m) and divide it as follows:

- FL30 to FL100: Un-pressurized, normally aspirated Pistons
- FL100 to FL180: Pressurized, turbocharged Pistons
- FL120 to FL220: Turbo-Props
- FL230 to FL290: Jets

Details are presented on Fig.4.7.

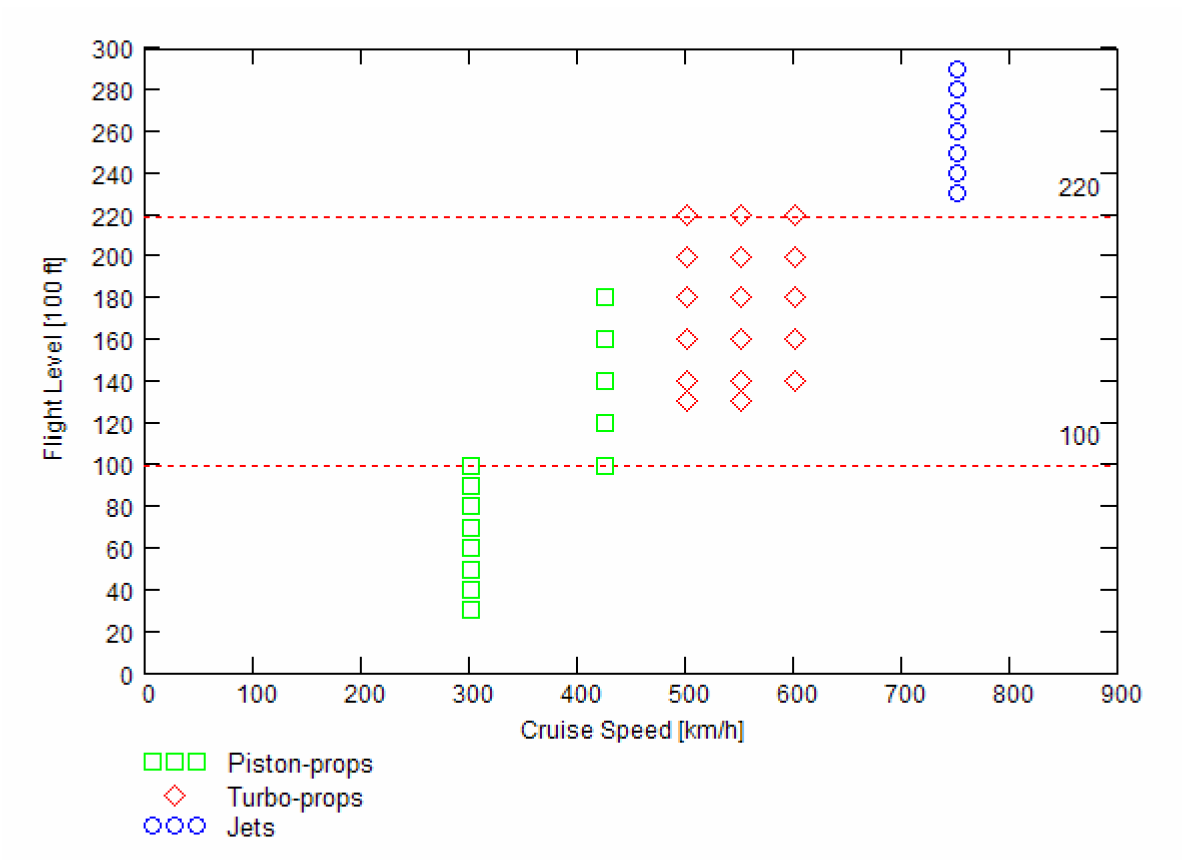


Fig. 4.7 Proposed EPATS airspace structure.

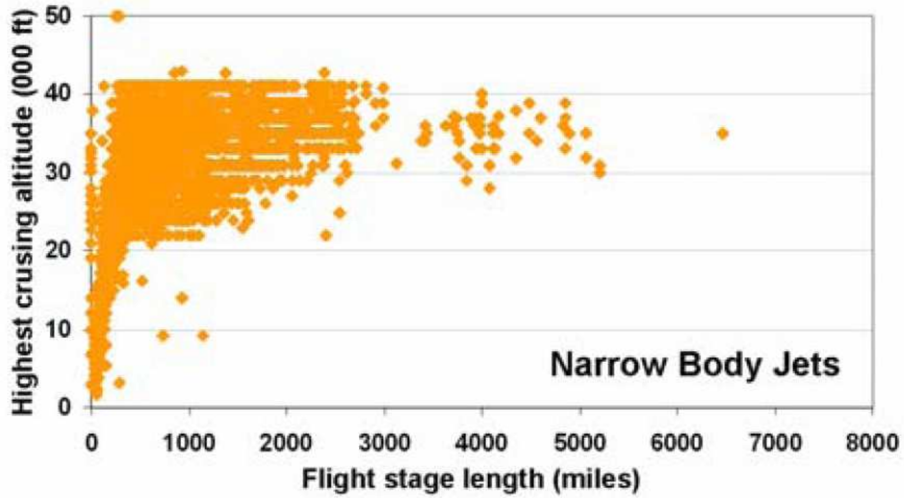


Fig. 4.8 Narrow Body Jets – the highest cruising altitude, Ref.[20].

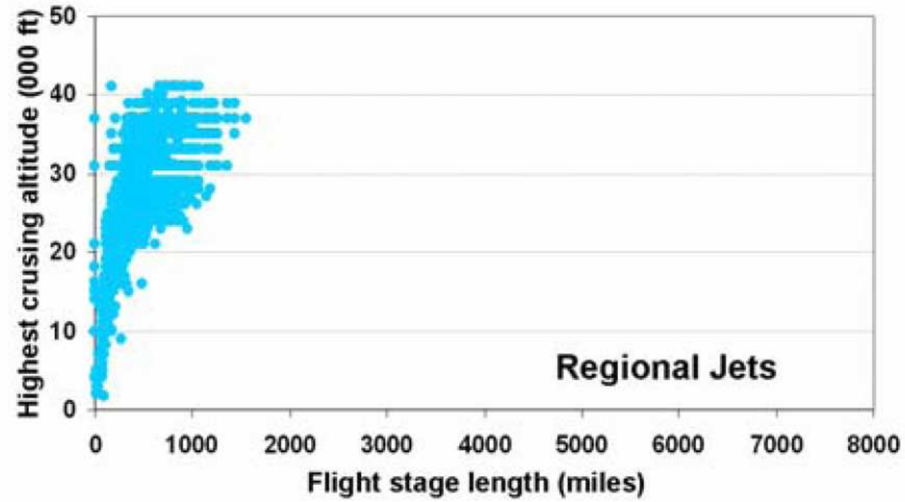


Fig. 4.10 Regional jets – the highest cruising altitude, Ref.[20].

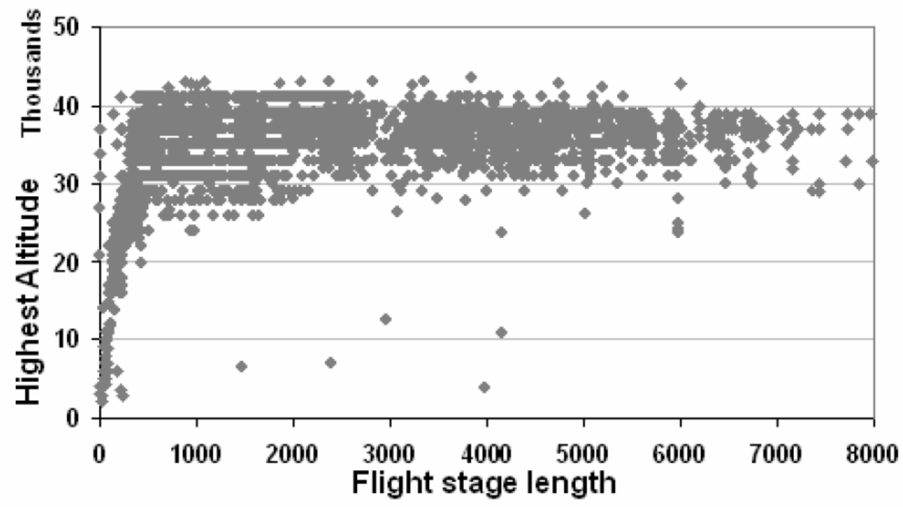


Fig. 4.9 Wide Body Jets – the highest cruising altitude, Ref.[20].

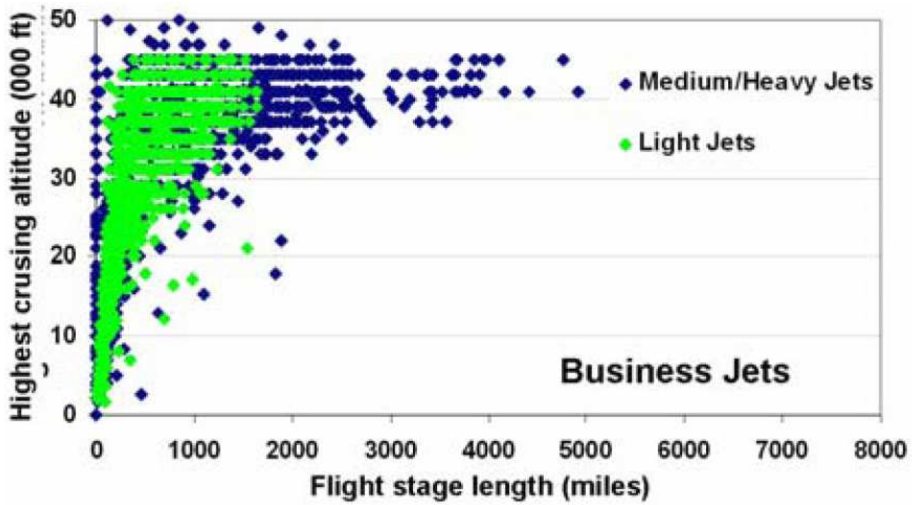


Fig .4.11 Business Jets – the highest cruising altitude, Ref.[20].

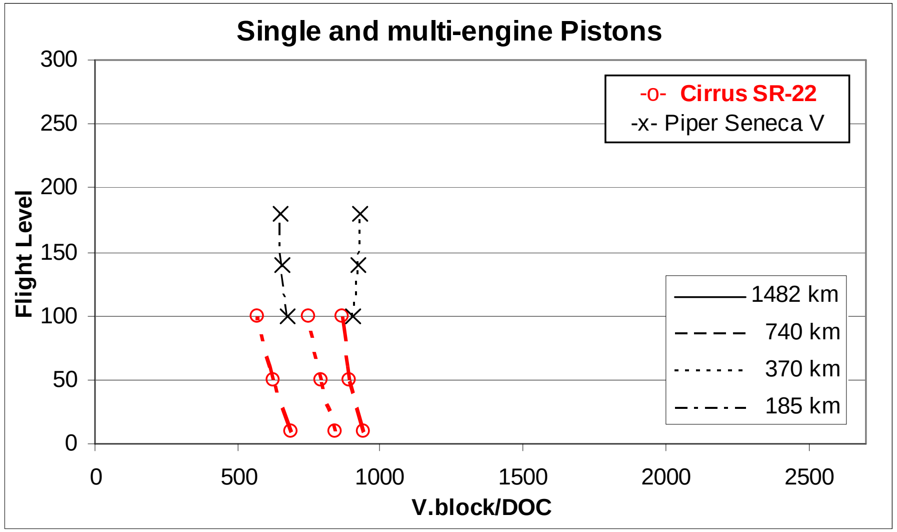


Fig. 4.12 V.block/DOC for single-engine piston, Ref [19].

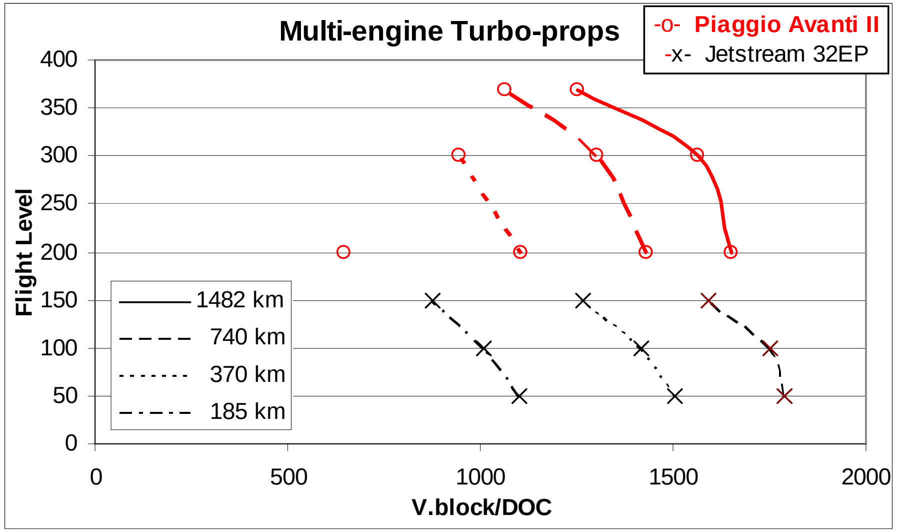


Fig. 4.14 V.block/DOC for multi-engine turbo-props. *see footnote, page 17, Ref [19].

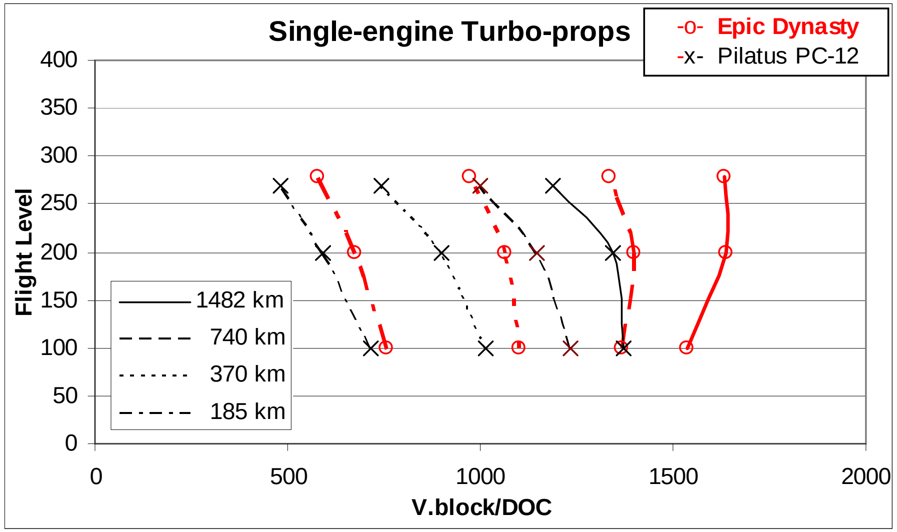


Fig. 4.13 V.block/DOC for single-engine turbo-props, Ref [19].

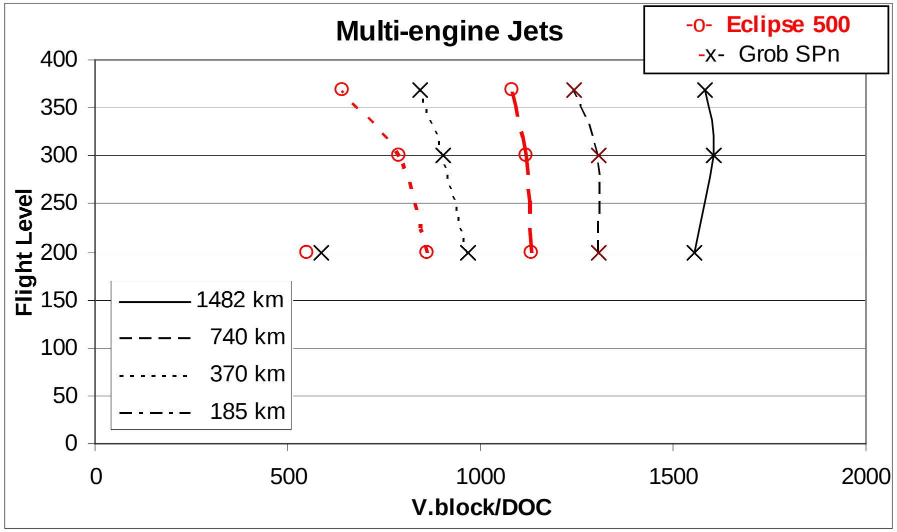


Fig. 4.15 V.block/DOC for multi-engine jets, Ref [19].

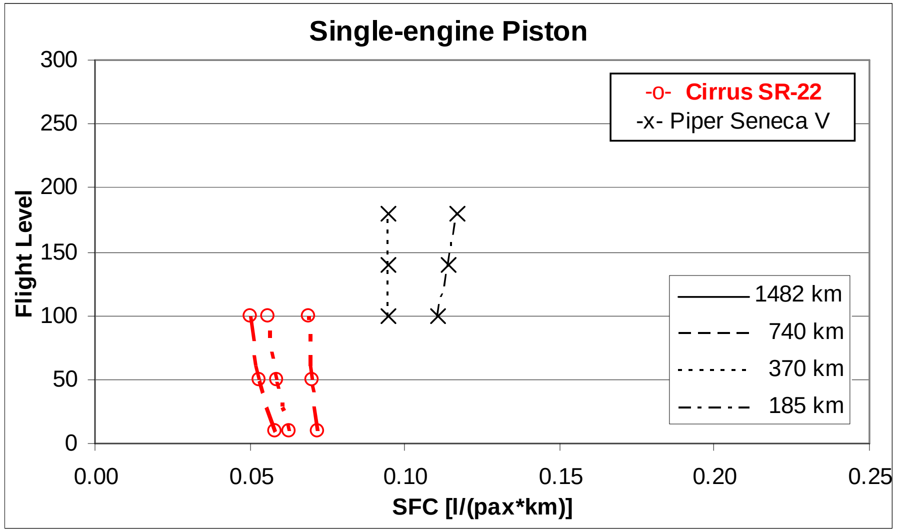


Fig. 4.16 SFC for single-engine piston, Ref [19].

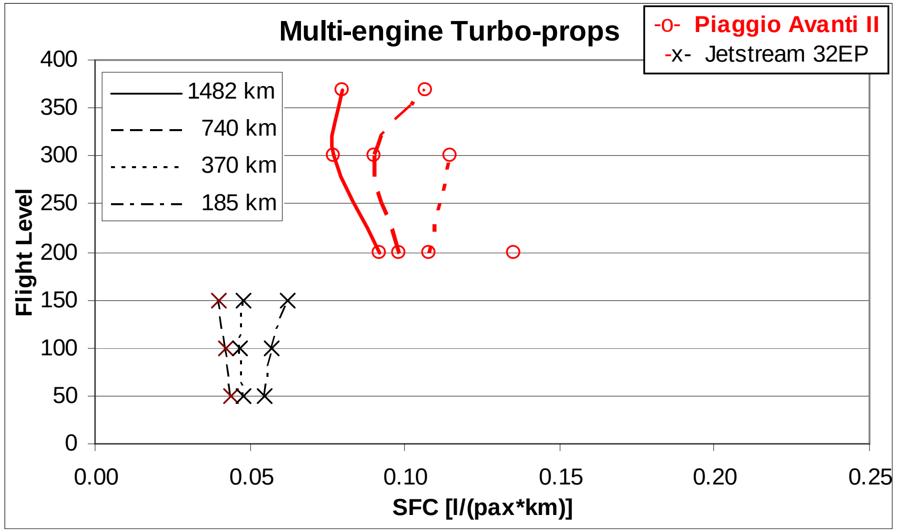


Fig. 4.18 SFC for multi-engine turbo-props. *see footnote, page 17, Ref [19].

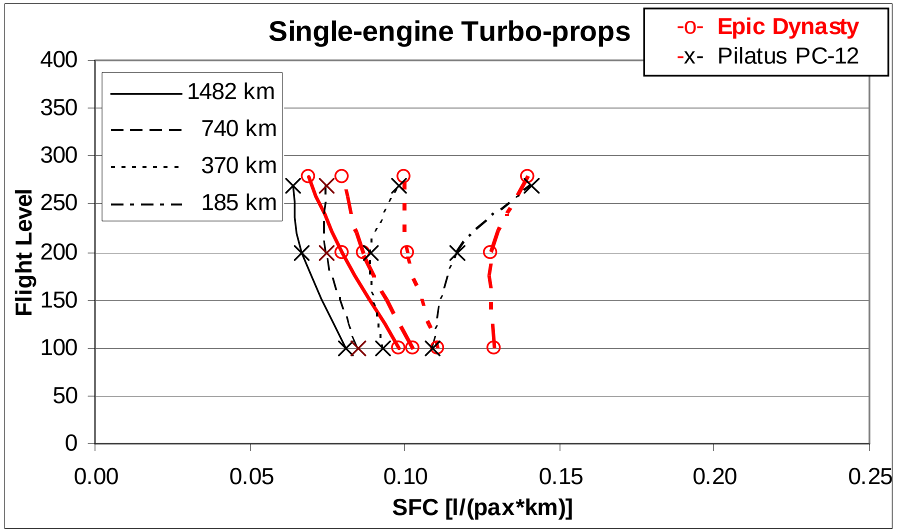


Fig. 4.17 SFC for single-engine turbo-props, Ref [19].

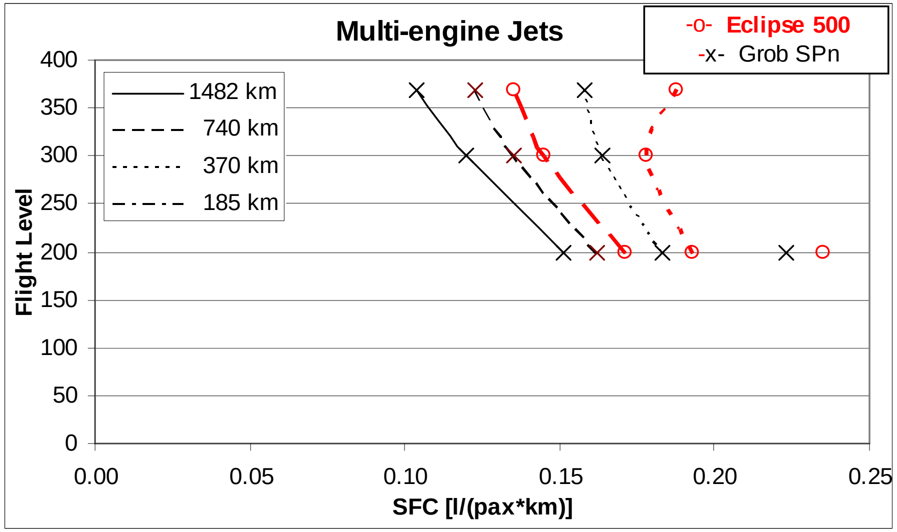


Fig. 4.19 SFC for multi-engine jets, Ref [19].

4.4 UTILIZATION: INTENSITY and INDIRECT COST FRACTION

Increasing air transport affordability requires cost reduction. As it has been shown in aircraft demand analyses the cost is a crucial parameter not only in Poland but in France and the whole EU too.

The total operating cost includes two components: direct (DOC) and indirect cost (IOC). Figure.4.20 (according to "Operating Cost Analysis", Ref.[19]) shows that DOC is very sensitive to utilization level especially for low number of block hours. Therefore it is recommended to intensify it strongly. If so, airframe life time limits should be extended up to 30 000 hours for all airplanes oriented for commercial services. For private owner 20 000 should be enough.

The next important goal should be to cut Indirect Cost. We assume that the scale of the business may help an IOC level can look like Fig.4.21 presents.

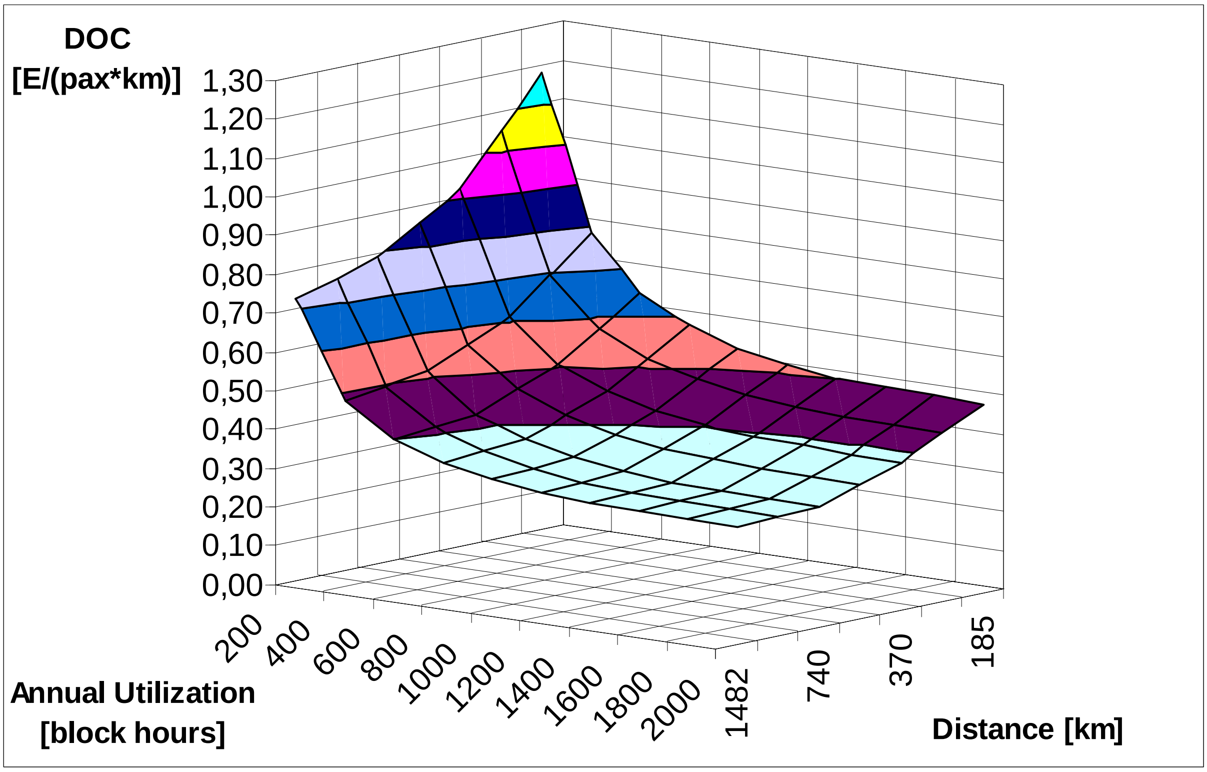


Fig. 4.20 Direct Operating Cost as a function of annual utilization level and distance (Grob SPn, 8 pax. 2 pilots)

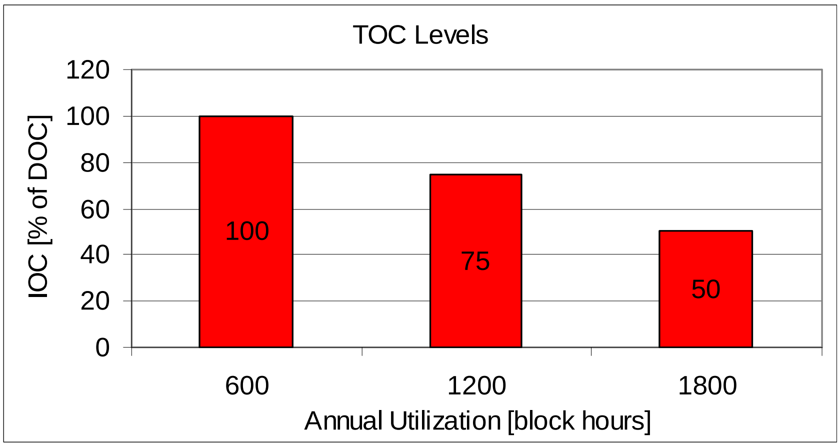


Fig. 4.21 Indirect Cost decline with utilization level - assumption.

4.5 EXPECTED CESAR RESULTS IMPLEMENTATION

This chapter were prepared on the basis of ,,EPATS Aircraft Production Cost”- T4.2-AcftProdCosts-V0 and ,,Airplane Shipments by Manufacturer 1996-2006”).

The EPATS program assumes, that expansion of air transportation by personal aircraft in Europe till 2020 will approach the U.S level of today. Fulfilling this assumption requires to put a strong effort on development and consolidation of European manufactures. Nowadays there are 16 airplanes manufactures with EASA certificate those could undertake such a task. Increasing of production capacity would decrease unit prices significantly and finally decrease operating cost (by reducing cost of depreciation, parts, hull insurance, etc.). This will help to increase affordability of air transport.

Production cost analyses carried out within WP4 exploiting DAPCA IV method demonstrate that double the production capacity (from about 150 to 300) could reduce unit price up to 15% for pistons and 20% for normal category turbo-props and jets. And this values were assumed for DOC calculation as realistic. If we wanted to reach current American production level we would increase production in Europe 20 times for pistons, 3.5 times for turbo-props and 10 times for jets. This would result in prices reduction respectively by 50%, 30% and 54%. Details of these analyses are shown below on figures 4.22 to 4.25.

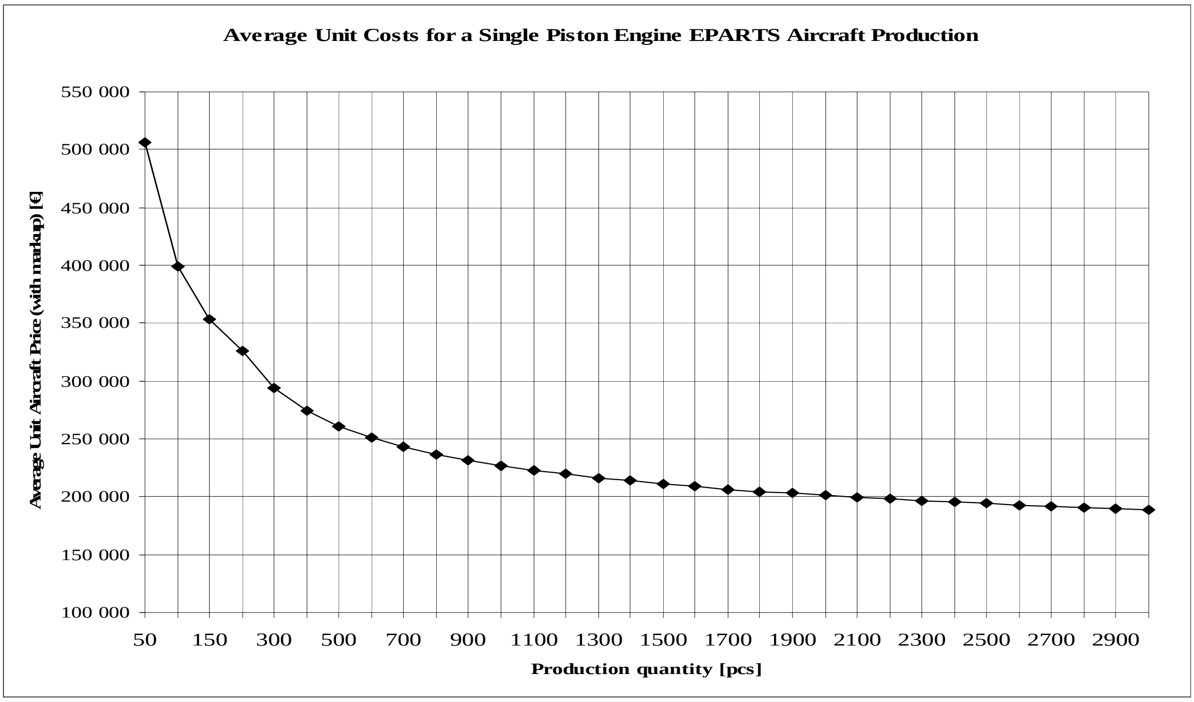


Fig. 4.22 Unit price as a function of production capacity for single-engine piston.

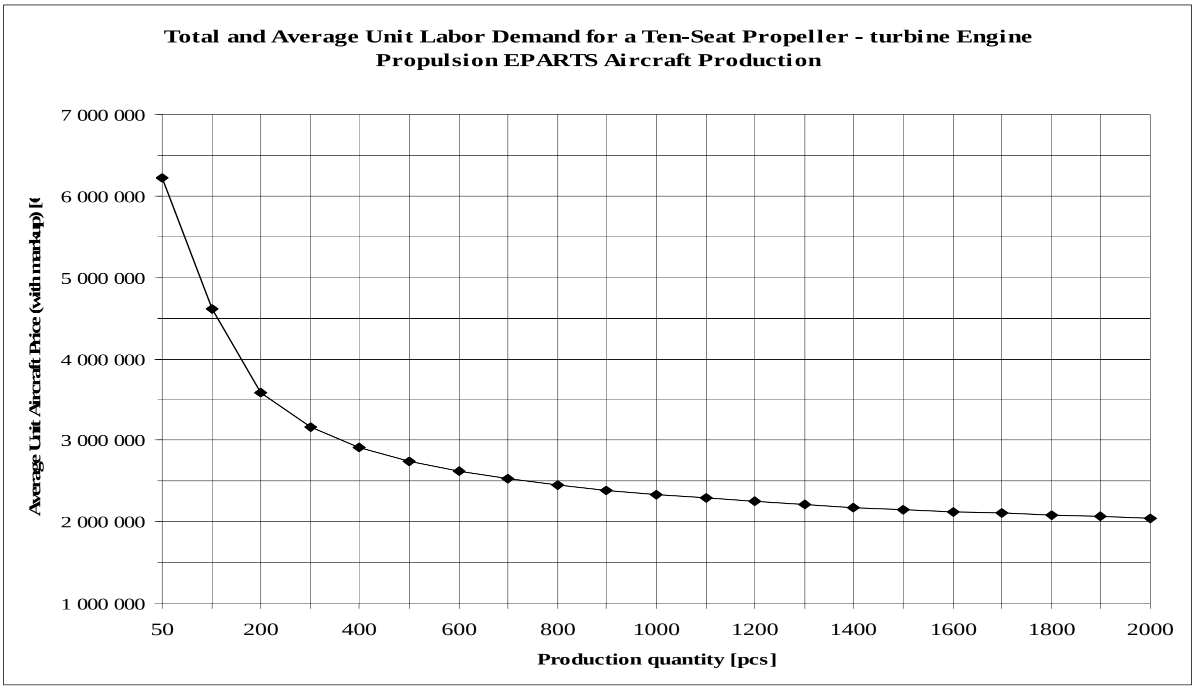


Fig. 4.23 Unit price as a function of production capacity for ten seat (2+8) turbo-prop.

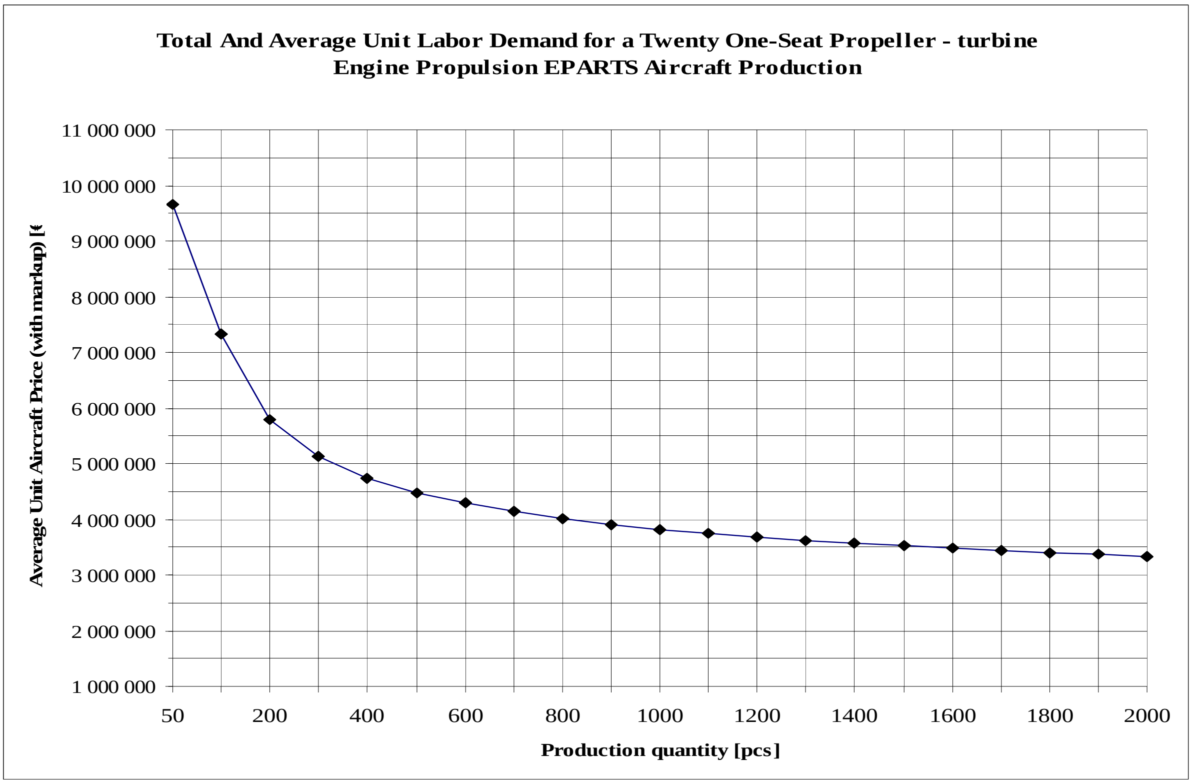


Fig. 4.24 Unit price as a function of production capacity for commuter for 21 seat (2+19) turbo-prop.

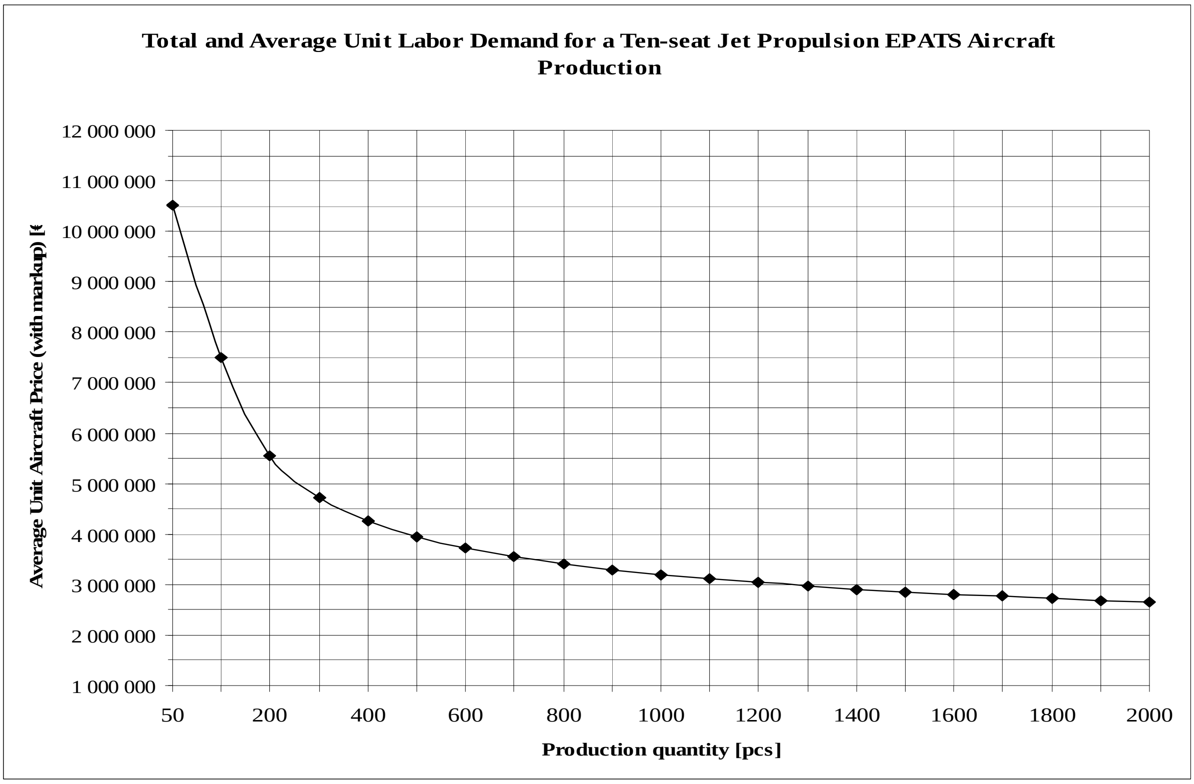


Fig. 4.25 Unit price as a function of production capacity for ten seat jet (2+8 seats).

CESAR program aims to the following goals (according to 1st Activity Report - October 2007 page8):

1. Time to market reduction by 2 years
2. Development cost reduction by 20%
3. Reduction of manufacturing and assembly cost by 16%
4. Reduction fuel consumption by 5-15% (average 10%)
5. Reduce overall engine, equipment and structure weight 7-9% (avreage 8%)
6. Reduce maintenance cost by 30% and improve serviceability

Impact of assumed reduction of costs, connected with time needed to design, manufacture and examine new construction, on unit price was estimated with use of the method presented by J. Roskam ,, Airplane Design Part VIII: Airplane cost estimation : design, development, manufacturing and operating" chapters 3 and 4, showing reduction of unit price of an aircraft 10 to 15% depends aircraft type.
Impact of the other changes was taken into account in analysis of operating costs and achievements of the EPATS 2020 aircrafts.

4.6 EXPECTED SESAR REQUIREMENTS IMPLEMENTATION

Detailed proposal of requirements for avionics for further EPATS aircrafts (with its reasons) is presented by NLR in WP4 Task 4.4, Memorandum ASAS-2007-066, Ref.[16]: "EPATS Study Cockpit Avionics & Human Machine Interface Requirements", chapter 6. Extract from this report, concerning proposed avionics suits, foreseen price and percentage share of avionics price of EPATS 2020 aircraft is presented below.

EPATS avionics cost according to Ref.[16] were used for calculations, except the small single-engine piston. In this case avionics cost fraction was to high and we decided to decrease its price to $40 000 (according to PZL-M). Calculated avionics cost fractions for future EPATS aircraft were shown on Fig.4.27. Please notice that airplane unit price decrease with production rate as well a its components costs (engines, avionics, etc.). This is the reason that the result is different than a simple division: avionics price from Fig.4.1 by airplane price from Fig.5.3 to 5.5 (assumed exchange rate equals 1.35$ per €.)

The conclusion is that further pistons' avionics prices decline is needed.

Because the scope of this paragraph, especially tables with EPATS avionics may cause several difficulties the chapter 5 from Ref.[16], which wider describes the subject, was added as an Appendix II.

EPATS Aircraft Class	**Single Engine**	**Twin Engine Piston**	**Twin Engine Turboprop**		**Twin Engine Jet**	
Class number	**1**	**2**	**3**	**4**	**5**	**6**
Communications						
dual 8.33 kHz VHF radio	√	√	√	√	√	√
SWIM dual data link	√	√	√	√	√	√
WiMax			√	√	√	√
broadband services					O	O
Navigation						
dual GNSS /w SBAS	√	√	√	√	√	√
dual DME	√	√	√	√	√	√
RVSM					√	√
P-RNAV FMS	√	√				
4D RNAV FMS			√	√	√	√
ILS receiver(s)	√	√	√	√	√	√
Surveillance						
ADS-B In/Out 1090ES	√	√				
enhanced ADS-B			√	√	√	√
TAS	√	√	√		√	
TCAS II				√		√
ELT 406 MHz	√	√	√	√	√	√
FDR & CVR				√		√
TAWS-B	√	√	√		√	
TAWS-A				√		√
lightning detection (sferics)	√	√				
weather radar			√	√	√	√
Human machine interface						
IFD (PFD/MFD/audio/AP)	√	√	√	√	√	√
HUD / SVS / EVS					O	O
EFB	√	√	√	√	√	√

Tab.4. 1 EPATS avionics equipment list, Ref.[16].

EPATS Avionics Cost estimate	**Single Engine**	**Twin Engine Piston**	**Twin Engine Turboprop**		**Twin Engine Jet**	
Class number	**1**	**2**	**3**	**4**	**5**	**6**
Communications						
dual 8.33 kHz VHF radio	√	√	√	√	√	√
SWIM dual data link	16	16	25	25	25	25
WiMax			20	20	20	20
broadband services (option)					*25-200*	*25-200*
Navigation						
dual GNSS /w SBAS	√	√	√	√	√	√
dual DME	5	5	5	5	5	5
RVSM					65	65
P-RNAV FMS	√	√				
4D RNAV FMS			50	50	50	50
ILS receiver(s)	√	√	√	√	√	√
Surveillance						
ADS-B In/Out 1090ES	20	20				
enhanced ADS-B link			25	25	25	25
TAS	10	10	15		21	
TCAS II				226		226
ELT 406 MHz	1	1	3	3	1	3
FDR & CVR				30		30
TAWS-B	10	10	10		10	
TAWS-A				30		40
lightning detection (sferics)	10	10				
weather radar			15	15	15	15
Human machine interface						
IFD (PFD/MFD/audio/AP)	75	75	75	75	75	75
HUD (option)					*50*	*50*
SVS (option)					*20*	*20*
EVS (option)					*15*	*15*
EFB	√	√	√	√	√	√
Total cost						
avionics (k$)	147	147	243	504	312	579
fraction of total aircraft value	56.5%	28.3%	11.0%	9.2%	24.0%	14.8%

Tab.4. 2 EPATS avionics cost estimate, Ref.[16].

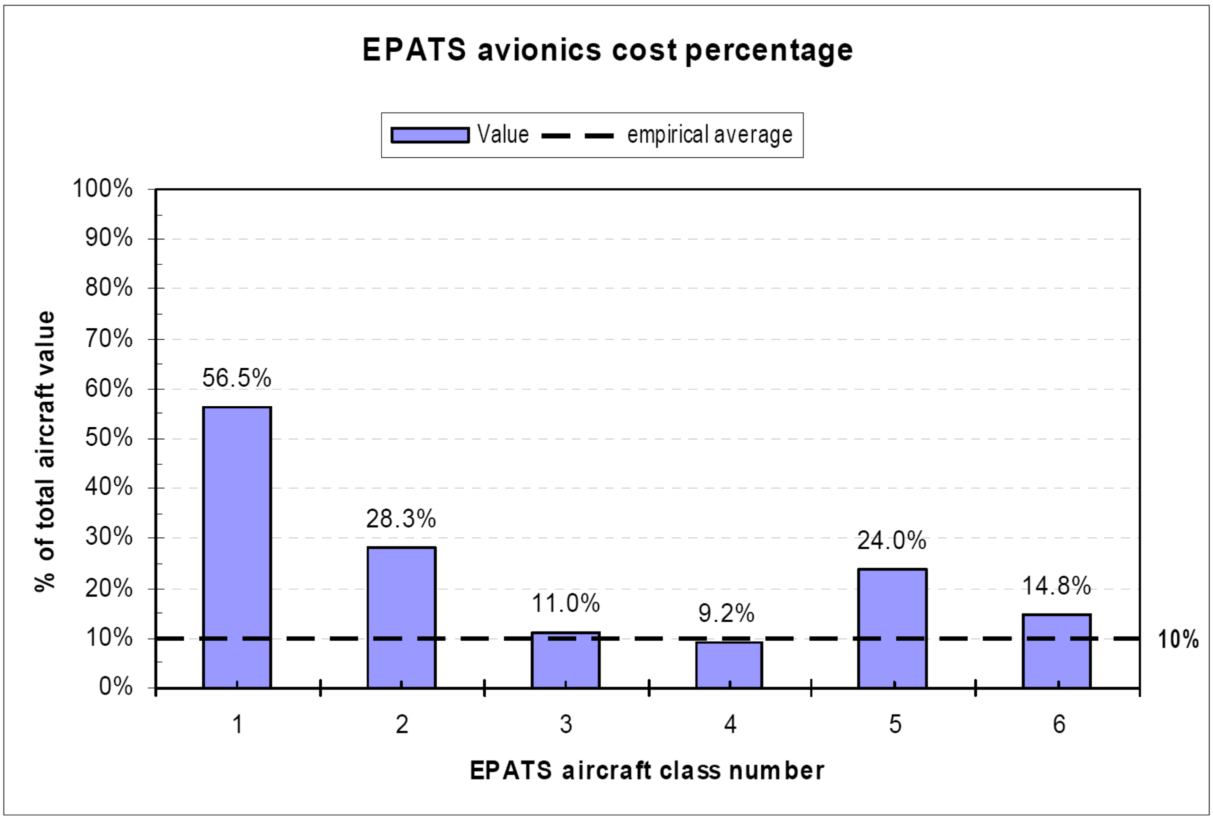


Fig.4. 26 EPATS avionics cost percentage - prediction, Ref.[16].

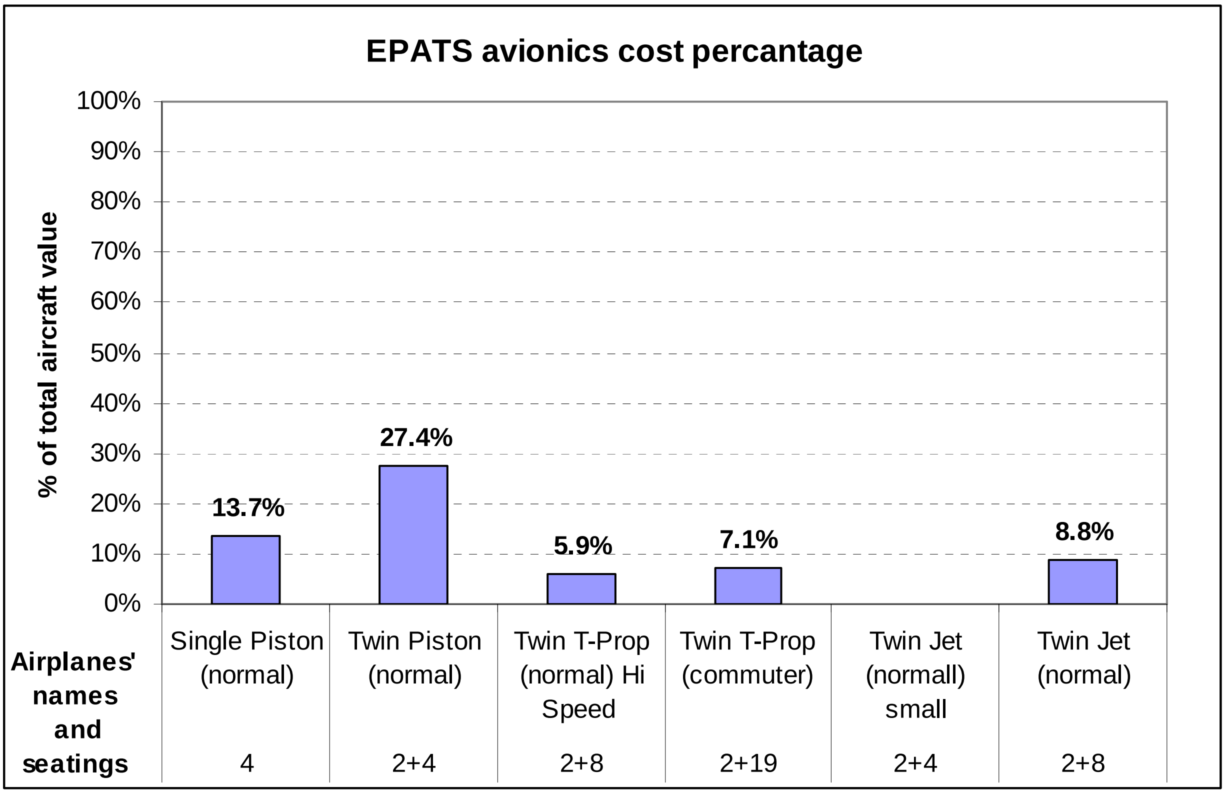


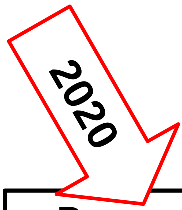
Fig.4. 27 EPATS avionics cost percentage – calculations; IoA.

5. EPATS AIRCRAFT COMPARISON – REFERENCE vs. FUTURE

For the comparison purpose 8 reference constructions were recalculated. Now:

- all airplanes fly into proposed EPATS airspace
- flight conditions are a compromise between economic parameters and ecology (fuel consumption); In general the longer distance the higher altitude
- all airplanes except single piston fly with two pilots
- perceived errors are fixed.

New aircraft are of course better – cheaper and more fuel efficient. The brief comparison is shown on Fig.5.1. Selected technical features presents Fig.5.2.



	PISTONS  1eng 4seat	PISTONS  2eng 6seat	TURBO-PROPS  2eng 8pax	TURBO-PROPS  2eng 19pax	JETS  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

Tab.5. 1 EPATS aircraft comparison: reference vs. future.

	Name / Categoty	Seating	T(P)/W [N/N] ([kW/kg])	WS [kg/m^2]	A	Notes
EPATS Reference	Cirrus SR-22	4	0.150	115	10.2	
	Piper Seneca V	2+4	0.152	111	7.3	
	Epic	6	0.270	175	9.1	
	Pilatus	2+8 (9)	0.189	190	8.9	
	Piaggio	2+8 (9)	0.231	344	12.3	WS main+forwa
	Jetstream	2+19	0.207	292	10.0	
	Eclipse	5 (6)	0.300	210	9.4	
	Grob	2+8	0.405	266	8.1	+winglets
EPATS Future	**Single Piston (normal)**	**4**	**0.150**	**115**	**9.0**	**+winglets**
	Twin Piston (normal)	**2+4**	**0.175**	**175**	**8.5**	**+winglets**
	Twin T-Prop (normal) Hi Speed	**2+8**	**0.300**	**325**	**8.5**	**+winglets**
	Twin T-Prop (commuter)	**2+19**	**0.250**	**280**	**8.5**	**+winglets**
	Twin Jet (normal)	**2+8**	**0.400**	**265**	**8.5**	**+winglets**

Tab.5. 2 EPATS aircraft features comparison: reference vs. future

5.1 FUTURE EPATS AIRCRAFT LIST

This chapter presents tables including detailed data of botch EPATS airplanes: reference and future.

	Current		Future 2020	
EPATS AIRCRAFT REFERENCE LIST	**SINGLE-ENGINE PISTONS**	**MULTI-ENGINE PISTONS**	**SINGLE-ENGINE PISTONS**	**MULTI-ENGINE PISTONS**
				
Manufacturer Model	**Cirrus SR-22**	**Piper Seneca V**	**EPATS 4-seat PISTON**	**EPATS 6-seat PISTON**
Price (avr.)	€ 296 296	€ 592 593	€ 216 815	€ 397 407
Certification Year	2000?	1996	Future	Future
Characteristic				
Seating	1+**3**	1+5	4	6
Dimensions Internal [m]				
Lenght	3.3	3.15	3.3	4
Width	1.24	1.24	1.24	1.40
Height	1.27	1.07	1.27	1.30
Cabin Volume [m^3]	*4.081*	*3.282*	*4.081*	*5.718*
Cab. Vol.per Pax. Seat	*1.020*	*0.547*	*1.020*	*1.429*
Seat Pitch [m]				0.815
Power				
Engine	Teledyne Continental IO-550-N	Teledyne Continental TSIO-360-RB		
Price [€]				
Output [kW]	231	164	200.9	2 x 195.9
Weight	187	149		
SFC				
TBO [h]	2000	1800	2500	2500
Weights [kg]				
Max. TO	1542	2156	1340.0	2239.0
Empty Weight Equipped		1540	867.4	1515.7
Max. Payload		428	363.2	544.8
Useful Load	531	562	472.6	723.3
Max. Fuel	301 (251 usable)	332	109.0	178.4
Performance				
Max. Cruise/Altitude [km/h /]	300 (75% P)	378 (75% P)	305 / FL30 (80% P)	440 / FL180 (80% P)
Service Ceiling [m]	5334	4575		
Rate of Climb [m/min]	426	65	448.4	500.9
TO Distance to 15 m [m]	486	671	< 500	< 750
DOC/(pax*km)				
litre/(pax*km) - Cruise				
Range				
Cruise Speed [km/h] / Altitude Range [km]/Payload	75% P/2438 1502/- 2167 (55% P) / -	1533	290 / FL100 1000 / 4*90.8 Hi Speed Cruise	440 / FL180 500 / 2+4*90.8 Hi Speed Cruise
Reserves			45 min.	45 min.

Tab.5. 3 EPATS aircraft comparison: reference vs. future; piston-props.

	Current		Future 2020	
EPATS AIRCRAFT REFERENCE LIST	**MULTI-ENGINE TURBOPROPS**		**MULTI-ENGINE TURBOPROPS**	
				
Manufacturer	**Piaggio**	**BAE**	**EPATS**	**EPATS**
Model	**Avanti II**	**Jetstream 32EP**	**8-pax T-PROP**	**19-pax T-PROP**
Price	€ 5 850 000	€ 4 900 000 ?	€ 3 054 815	€ 5 260 741
Certification Year	2006	1997	Future	Future
Characteristic				
Seating	2 + 6 / **8** / 9	2 + **19**	2 + 8	2 + **19**
Dimensions Internal [m]				
Lenght	4.55	7.39	4.27	8.75
- Lavatory	*0.6*	*0.6*	*0.60*	0.60
- Seating Area	*3.95*	*6.79*	*3.67*	8.15
Width	1.85	1.85	1.65	1.85
Height	1.75	1.80	1.60	1.80
Cabin Volume [m^3]	*11.569*	*19.327*	*8.847*	22.884
Cab. Vol.per Pax. Seat	*1.928 / **1.446** / 1.285*	*1.017*	*1.106*	1.204
Seat Pitch [m]	*1.32 / **0.99** / 0.79*	*0.68*	*0.815*	0.815
Power				
Engine	P&WC PT6A-66B	Garett TPE331-12		
Price [€]				
Output [kW]	2 x 634	2 x 761	2 x 724	2 x 810
Weight [kg]	213 (v. 66)	182		
SFC [kg/(kW*h)]	0.378 (v. 66)	0.333		
TBO [h]	3000 (v. 66/A)	3600-**5000**-5400	5000	5000
Weights [kg]				
Max.Ramp	5511	*7433.6*		
Max TO	5489	7360	4 823.0	6 481.0
Empty Weight Equipped	*3470.2*	*4512.4*	*2 992.0*	*3 874.0*
Max. Zero Fuel	4445	6736		
Max. Payload (pilots+pax)	907	2223.6	908.0	1 907.0
Max. (Usable) Fuel	*1271.2*	1489	*922.7*	700.0
Useful Load	*2040.8*	*2921.2*		
Performance				
Max. Cruise [kmh]	737	491	600	545
Altitude-Max. Cruise	FL280			
Service Ceiling	FL410	FL250		
Rate of Climb [m/min]	899		931	765
TO Distance 15 m (BFL) [m]	(1295)	1432	< 1000	< 1000
DOC/(pax*km)				
litre/(pax*km) - Block				
Range				
Cruise Speed [km/h] / Altitude	-/-	463 / -	600 / FL200	540 / FL200
Range [km]/Payload	1815 / 908 v.I 2791 / ?	915 / full pax. Load 1978 / 60% pax. load	2000 / 2+8x90.8 Hi Speed Cruise	1000 / 2+19x90.8 Hi Speed Cruise
Reserves	IFR		NBAA IRF 100nm	NBAA IFR 100nm

Tab.5. 4 EPATS aircraft comparison: reference vs. future; turbo-props.

	Current	Future 2020
EPATS AIRCRAFT REFERENCE LIST	**MULTI-ENGINE JETS** 	**MULTI-ENGINE JETS** 
Manufacturer	**Grob**	**EPATS**
Model	**SPn**	**8-pax JET**
Price	€ 5 800 000	€ 4 882 222
Certification Year	2008 ?	Future
Characteristic		
Seating	1+9 / 2**+8**	2 + 8
Dimensions Internal [m]		
Lenght	5.10	4.267
- Lavatory	1.04	0.60
-Seating Area	4.06	3.67
Width	1.52	1.65
Height	1.64	1.60
Cabin Volume [m^3]	*11.347*	*8.847*
Cab. Vol.per Pax. Seat	*1.418*	*1.106*
Seat Pitch [m]	*1.015*	*0.815*
Power		
Engine	Williams FJ44-3A	
Price [€]		
Output [kN]	2 x 12.5	2 x 10.9
Weight [kg]		
SFC [kg/(kW*h)]	0.456	
TBO [h]	4000	5000
Weights [kg]		
Max.Ramp	*6363*	
Max TO	6300	5 570.0
Empty Weight Equipped	*3727.4*	*3 243.0*
Max. Zero Fuel		
Max. Payload (pilots+pax)	1130.0	908.0
Max. (Usable) Fuel [kg]	2000	1 419.0
Useful Load [kg]	*2635.6*	
Performance		
Max. Cruise [kmh]	754	760
Altitude-Max. Cruise	FL330	
Service Ceiling	FL410	
Rate of Climb [m/min]	1320	1442
TO Distance to 15 m (BFL) [m]	(914)	< 1000
DOC/(pax*km)		Figures
litre/(pax*km) - Cruise		Figures
Range		
Cruise Speed [km/h] / Altitude		760 / FL290
Range [km]/Payload	3334 / 1+6x90.8 3093 / 1+8x90.8	2000 / 2+8x90.8 Hi Speed Cruise
Reserves	IFR	NBAA IFR 100nm

Tab.5. 5 EPATS aircraft comparison: reference vs. future; jets.

5.2 AIRCRAFT COMPARISON

In his paragraph detailed comparison is presented. To make this easier scale of graphs presenting features of either reference or future graphs are the same. Now the differences can be noticed even at first glance. Because DOC and SFC of new aircraft are significantly lower than references' the lines are placed close one to another what may make them less readable. Therefore it is worth repeating figures describing future airplanes (section 5.3) with scale fitted to ‘’new’’ value. More over placing 3 of them on a single sheet facilitate comparison.

- Block Speed

The speed of future jet and normally aspirated single-piston are the same as references'. New medium size t-prop (8 pax.) is a little bit slower than reference Piaggio however it is still almost as fast as VLJ Eclipse. New large t-prop is a little quicker while turbocharged pressurized piston is significantly quicker which places it between pistons and turbo-props.

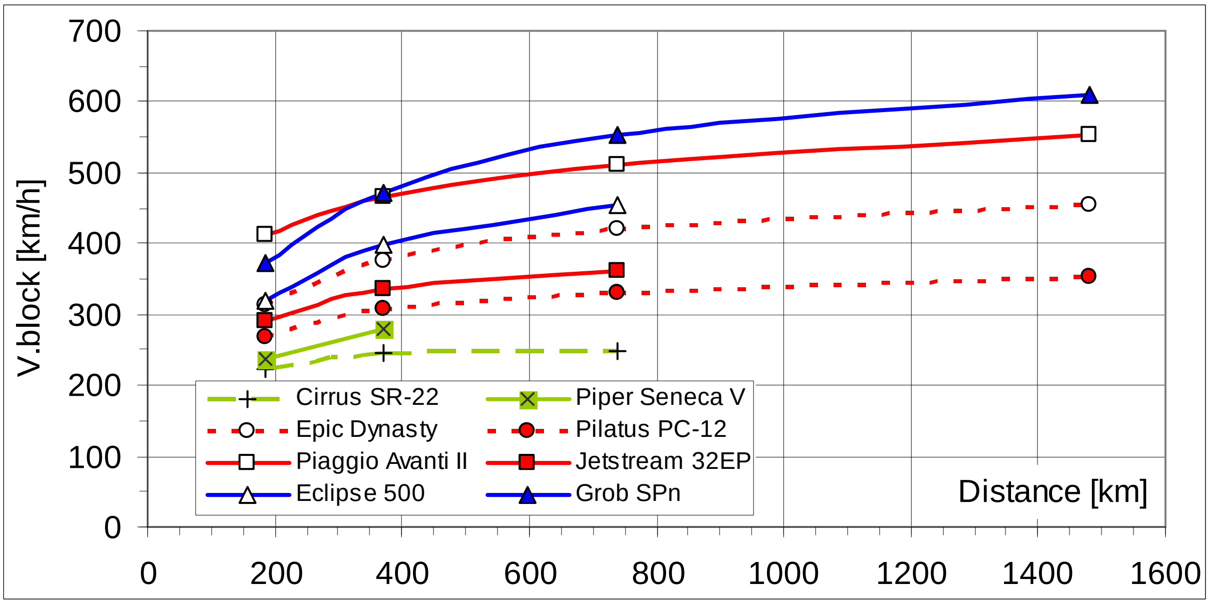


Fig.5. 1 Block speed – reference aircraft.

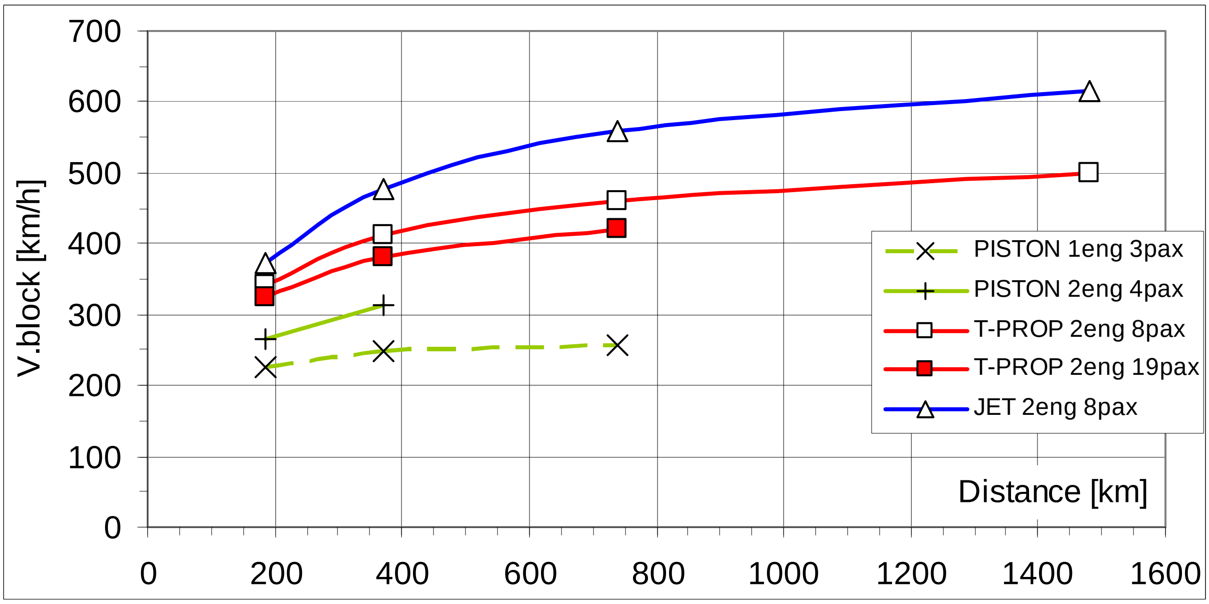


Fig.5. 2 Block speed – future aircraft.

- DOC

The Direct Operating Costs of new airplanes are significantly lower than reference's. Jets are the most expensive of all. Than there is medium t-prop (8 pax.), turbocharged piston (6 seat) and single-engine normally-aspirated piston (4 seat). The cheapest is large (19 pax.) turbo-prop.

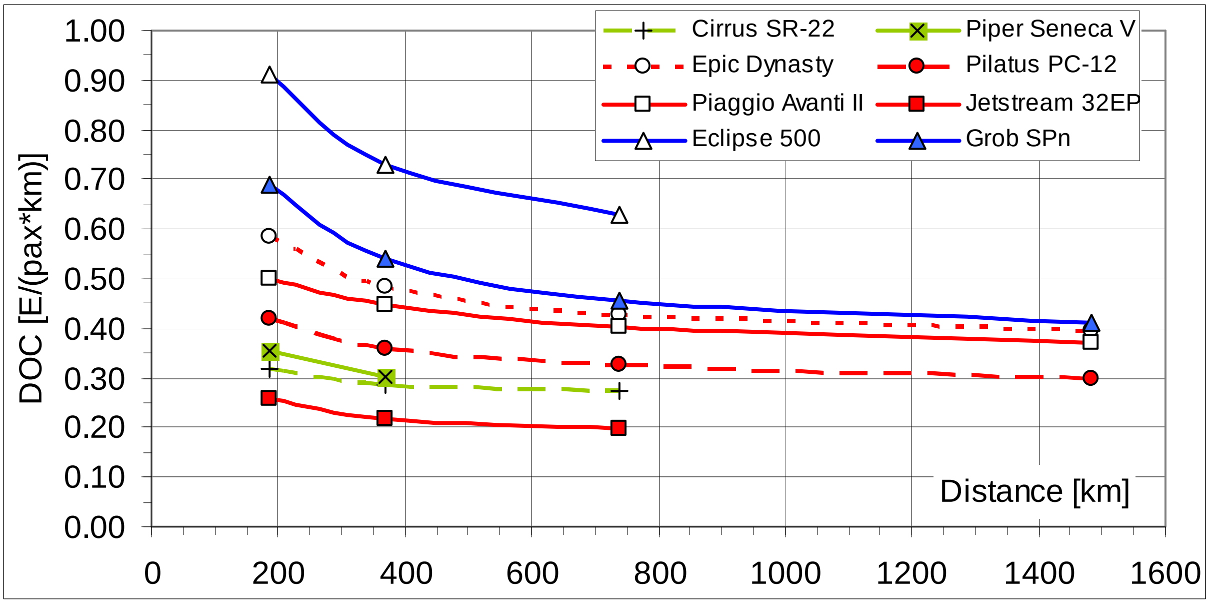


Fig.5. 3 Direct Operating Cost – reference aircraft.

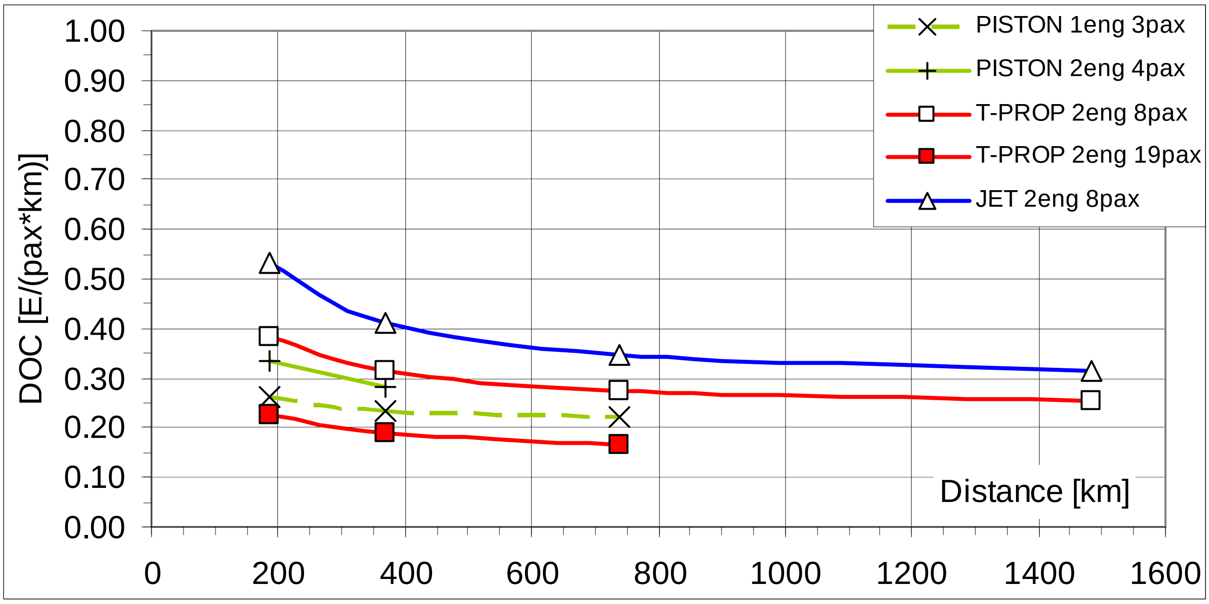


Fig.5. 4 Direct Operating Cost – future aircraft.

- SFC

The Specific Fuel Consumptions of new airplanes are significantly lower than reference's. However order is the same: jets burn the most, than we have medium turbo-prop (8 pax.) and turbocharged pistons and finally normally aspirated piston and large t-prop (19 pax.).

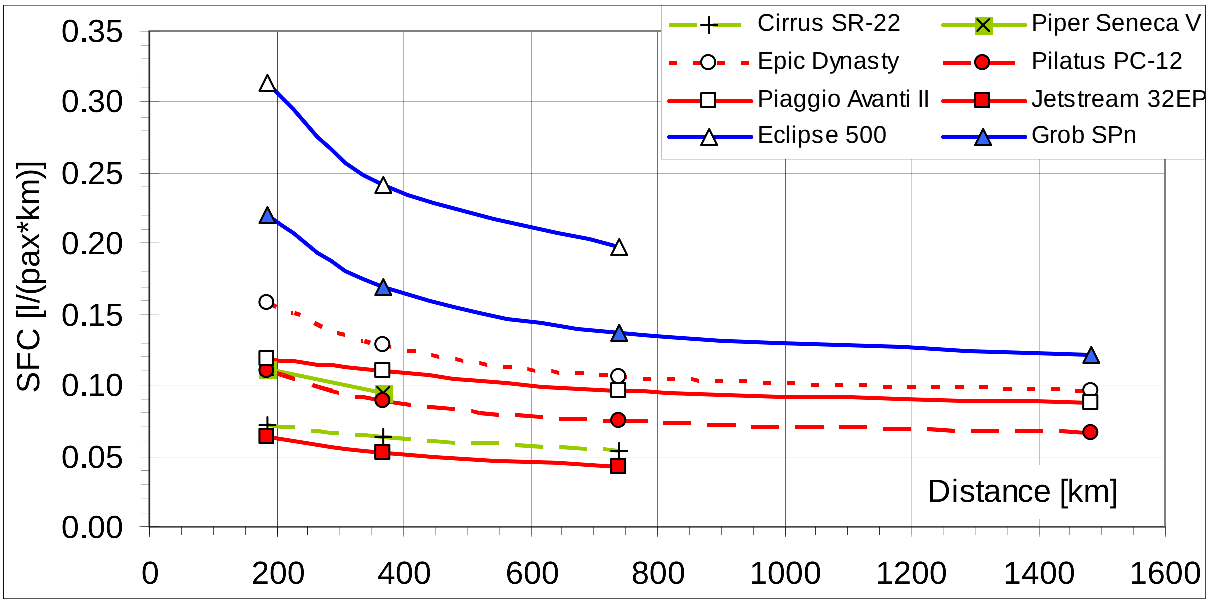


Fig.5. 5 Specific Fuel Consumption – reference aircraft.

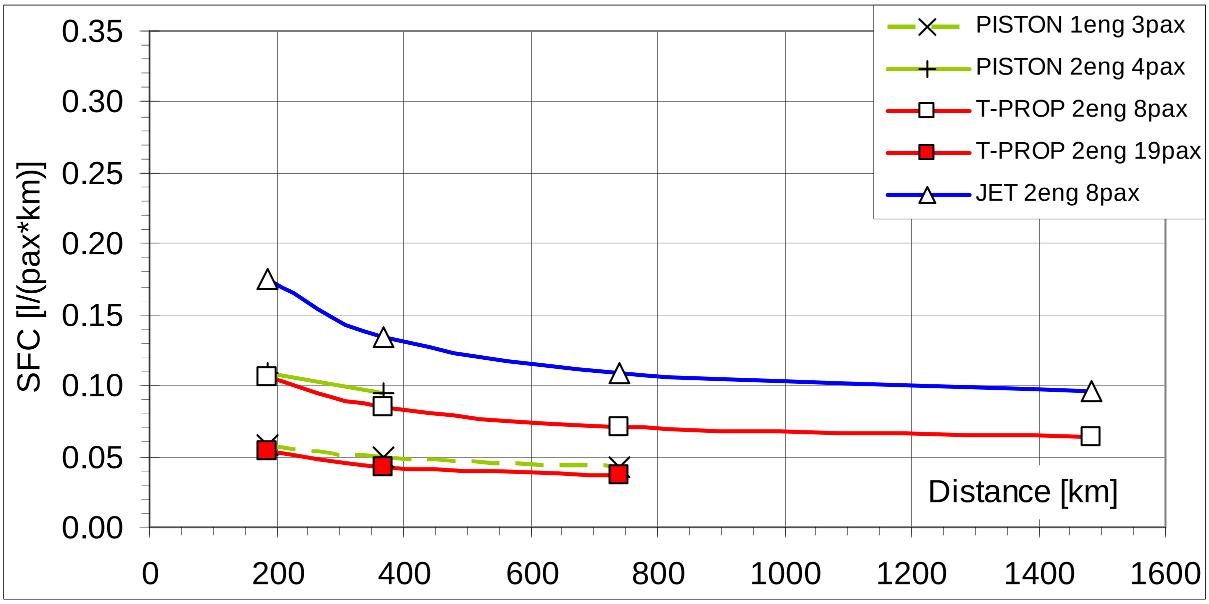


Fig.5. 6 Specific Fuel Consumption – future aircraft.

- V_{block}/DOC

The Block Speed to Direct Operating Costs ratios of new airplanes are substantially higher, however there is no change of order. The best at any distance is large turbo-prop. The medium are 8-passanger t-prop and jet and jet became more competitive at longer distances. Both pistons are also very similar. They are placed between medium jet and t-prop at short distance and move down below jet at medium.

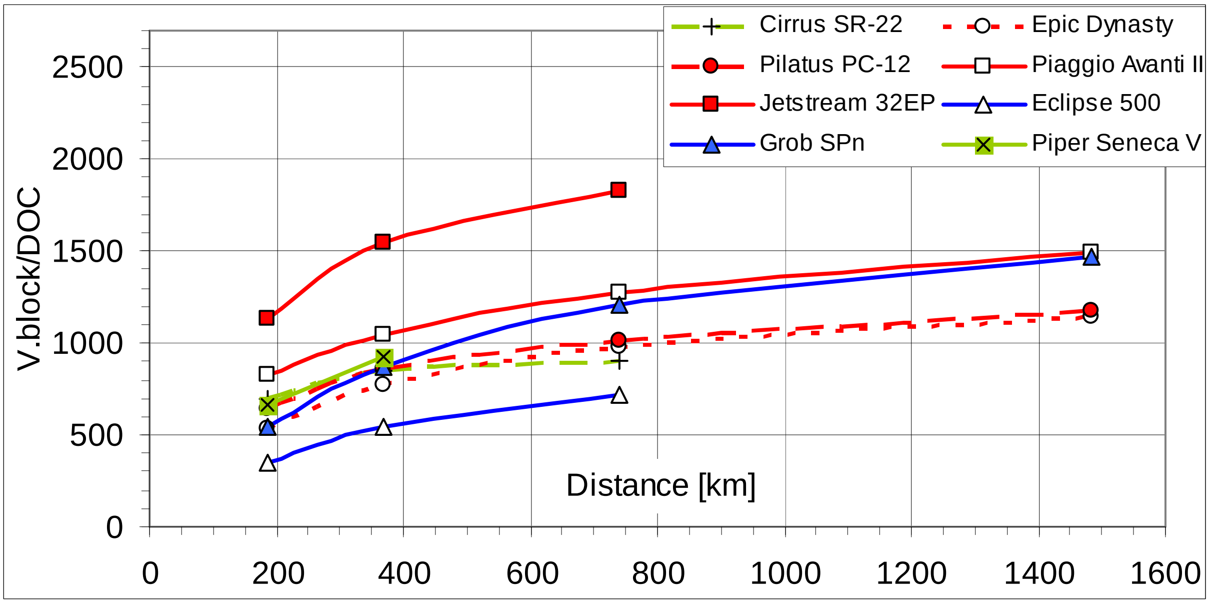


Fig.5. 7 Block speed to DOC ratio – reference aircraft.

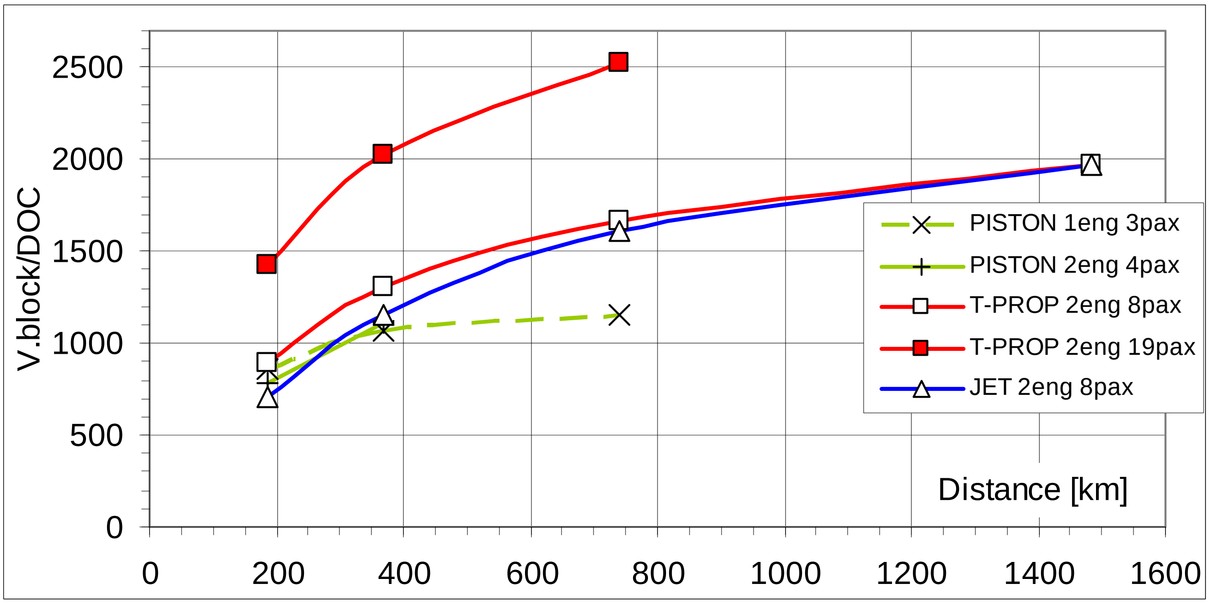


Fig.5. 8 Block speed to DOC ratio – future aircraft.

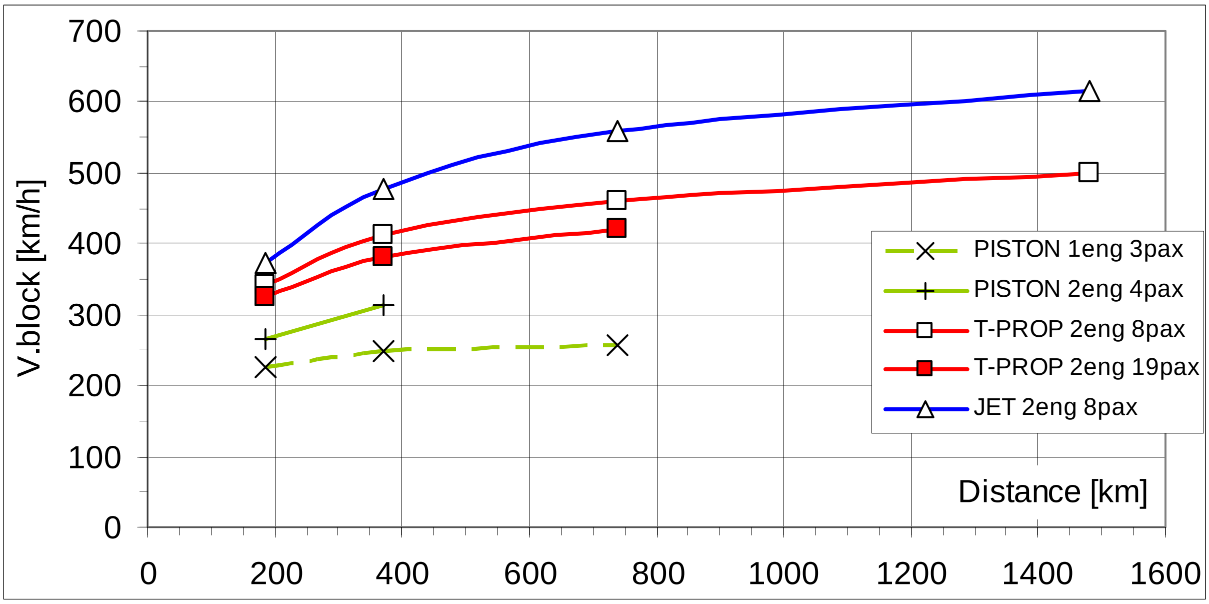
5.3 FUTURE EPATS AIRCRAFT PERFORMANCES

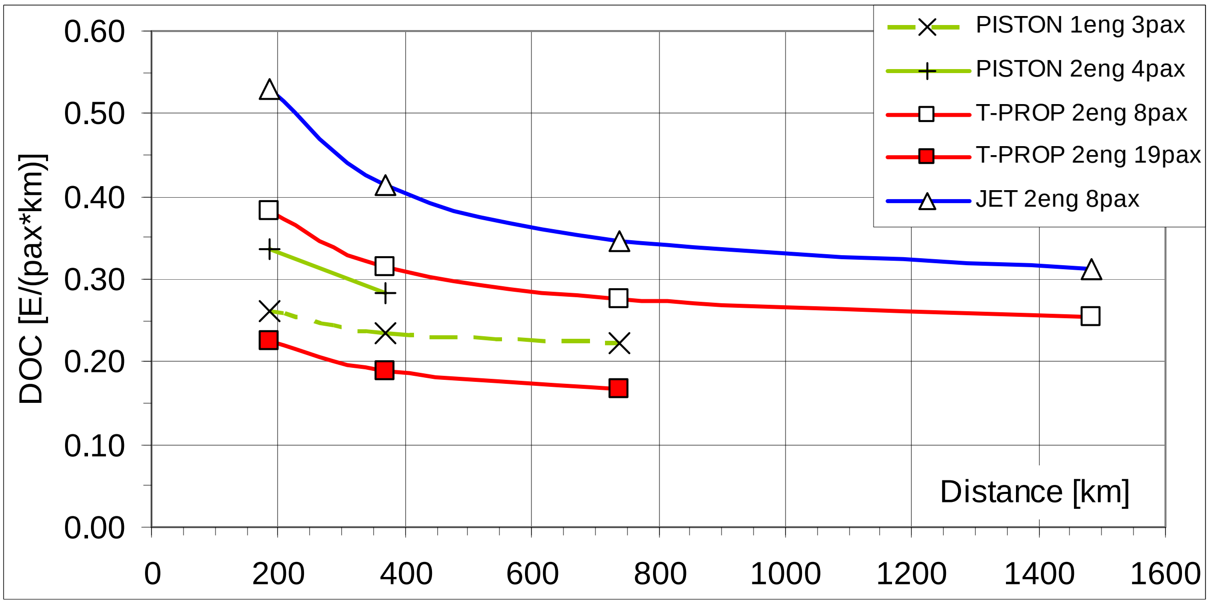
This section contains repeated figures presenting future aircraft feature. Now the scale of the graph is fitted to ‘’new’’ value (in contrast to paragraph 5.2).

Very interesting is the comparison between the same size t-prop and jet. The same size means that they have the same number of passenger seats and cabin volume. The same range and takeoff length. They are as similar as possible. Therefore it can be possible to extract the real difference between theirs propulsion systems. Turbo prop is slower than jet however it has a few strong advantages. DOC is lower by 28/19% (short/long distance) and SFC lower by 39/34%. So the gap is huge.

There are two reason for fuel consumption is a very important parameter: environmental care and fuel prices. Environmental care is a significant factor nowadays and will be even more in the future. Oil prices have soared about 5 times for last 6 years and they are not likely stop rising (this subject will be discussed in a separate point: fuel price impact). Moreover the aircraft demand analyses shown that cost are crucial not only for Poland but either for France and the whole Europe too. The advantage of jet’s speed is offset by these disadvantage what makes jets less suitable for EPATS.

The Block Speed to Direct Operating Costs ratio is a good parameter for initial estimation of aircraft potential, however detailed demand calculations are needed to know which of those people would prefer.





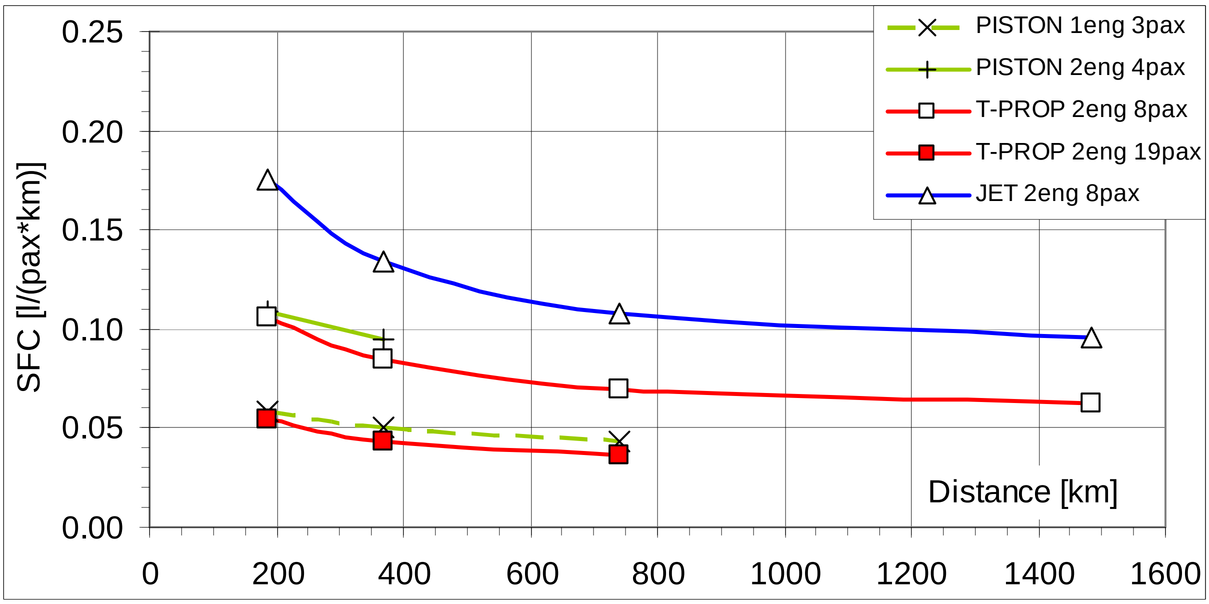


Fig.5. 9 Fig.5. 10 Fig.5. 11 Future aircraft performance comparison.

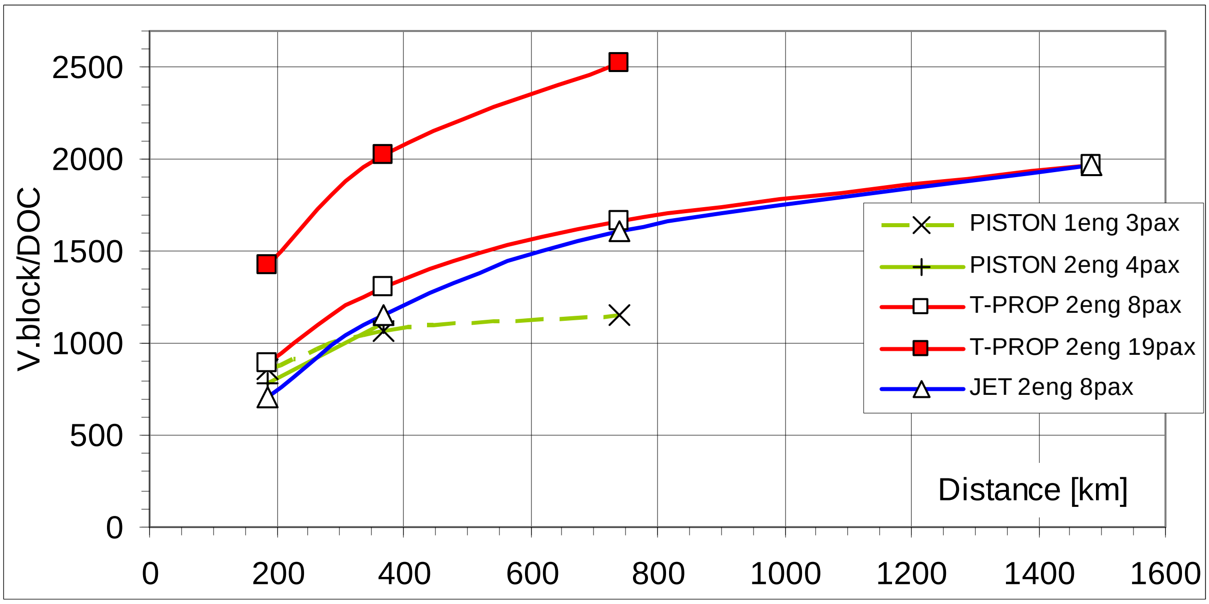


Fig.5. 12 Future aircraft performance comparison – block speed to DOC ratio.

- **Customer Choice Index – initial airplanes evaluation**

Customer Choice Index is an attempt to take under account customers' needs. In our opinion, there are three primary factors that customers take into account while choosing a transport type. How fast? How comfortable? And how much does it cost? Block speed is responsible for travel time, cabin volume per passenger seat shows comfort and Direct Operating Cost per pax.km answers how much does it cost. Different customers groups have different needs shown in table 5.6 below. The results are shown on graphs: Fig.5.13 to 5.15. More information concerning evaluation index can be found in Ref.[19].

$$CCI = \frac{V_{.block}^{\ A} \cdot Vol_{.cab\_pax}^{\ B}}{DOC_{.pax\_km}^{\ C}}$$

CCI TYPE	EXPONENT VALUE		
	A	**B**	**C**
	Block Speed (V_{block}) [km/h]	Cabin Volume per Passenger (Vol_{cab_pax}) [m^3/pax]	Direct Operating Cost per km*pax (DOC_{pax_km}) [€/(km*pax)]
BUSINESS (CCI-BS)	2	1.41	1
NEUTRAL (CCI-N)	1	1	1
LOW COST (CCI-LC)	1	1.41	2

Tab.5. 6 Customer Choice Index exponent values.

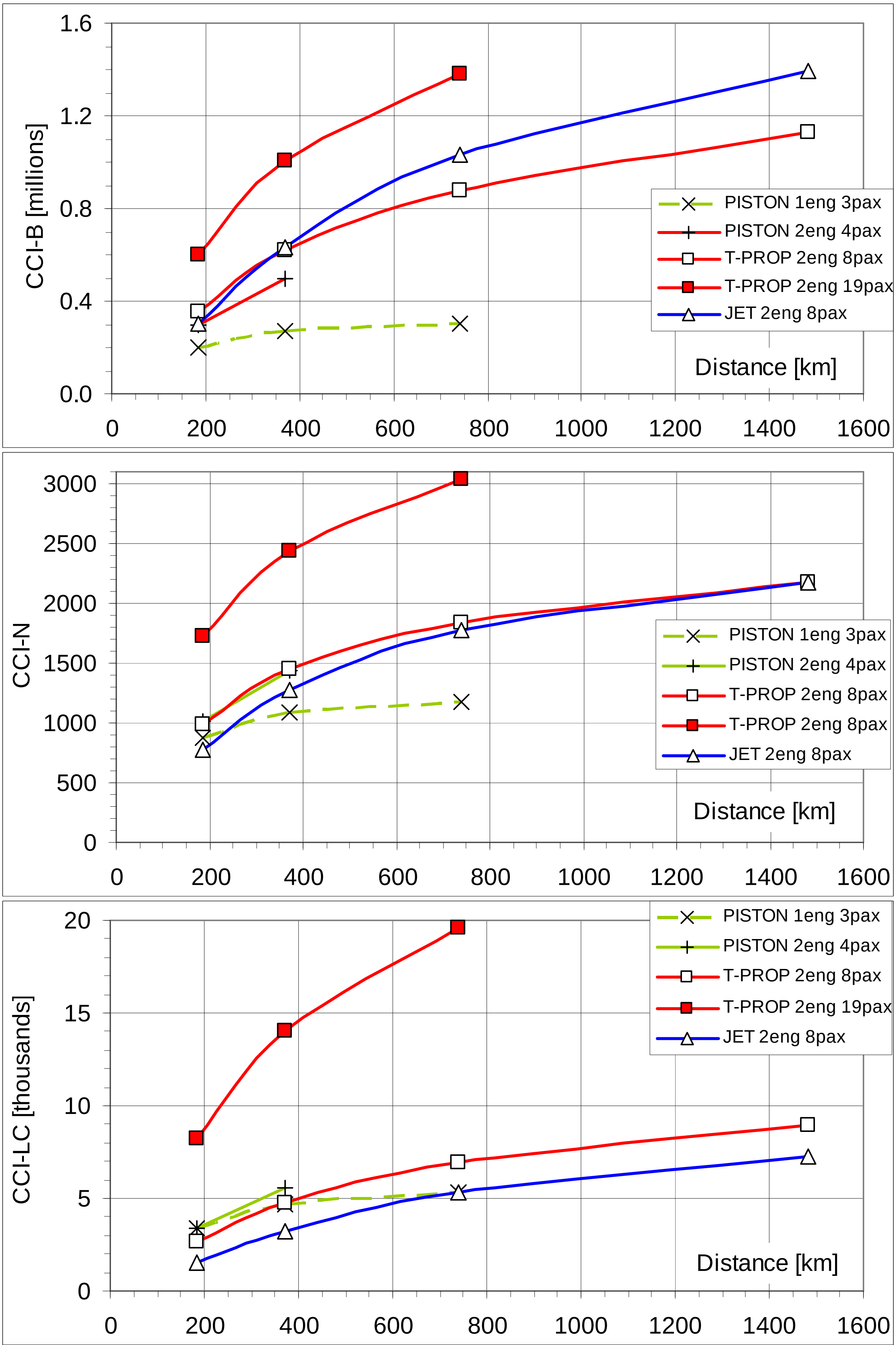


Fig.5. 13 Fig.5. 14 Fig.5. 15 Set of Customer Choice Indexes: Business, Neutral, Low-cost

According to Customer Choice Index attractiveness of particular airplanes changes with distance. Moreover different customers groups prefer different types of aircraft. Of course large turbo-prop wins in all categories due to its low cost, medium speed and high comfort level, but it is not a typical business-plane. More interesting is a comparison between medium and small construction (normal category). As it can be notice the Business and Low-cost travelers preferences are totally different. In the first case jet rules beyond 370 km. Turboprop is behind but wins at shorter trips. Pistons do not count. In contrast, for low-cost passenger pistons are better up to about 370 km distance. Than, over 370 km t-prop dominates.

The CCI may be a useful tool for initial estimation of aircraft potential. However it is not enough. We considered an airplane level. In fact a transport system level must be taken under account. A very important in this case will be detailed passenger flows (vary daily, weekly and seasonally) and indirect cost level (changes from one operator to another and for different European regions-new/old especially). Such data are necessary to fit airplanes size to needs (pax. loading factor will vary therefore). To sum up detailed demand calculations utilizing an advanced model are needed to know which airplanes people would prefer, at which routs.

- **Airspace structure proposal check**

In chapter 4.3 airspace structure proposal was set. Now we check if it is correct. The future EPATS aircraft feature will be consider. The graphs below present Vblock to DOC ratio and Specific Fuel Consumption for 3 flight levels at each of 4 distances.

The flight conditions those are the best compromise between economic parameters and fuel consumption are signed by filing the symbols. The airplanes' features presented above (V_{block}, DOC, SFC) were calculated at these conditions. In general the airspace structure is correct. However a few notes can be made.

1. Normally aspirated pistons must choose (at all distances) what do they want to: minimise fuel consumption or maximise V_{block}/DOC
2. Large turbo-prop may fly lower- approximately up to FL180. This can improve economic parameters and spoil a little fuel efficiency, especially at longer trips.
3. Jets' SFC is negatively affected by flight level limitation. (V_{block}/DOC not)

- **Single and multi-engine pistons.**

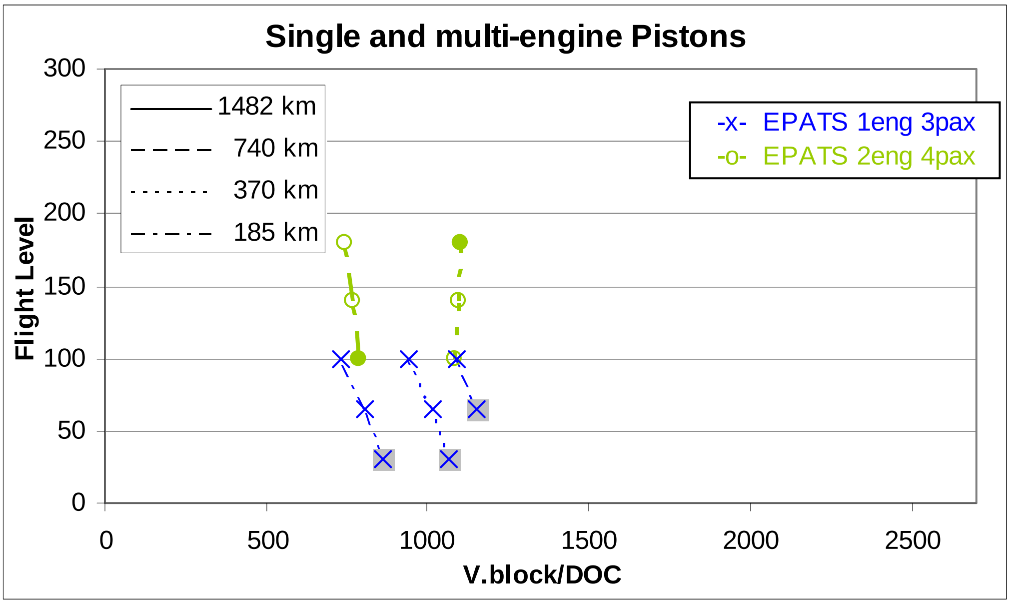


Fig.5. 16 V_{block}/DOC ratio for future EPATS pistons.

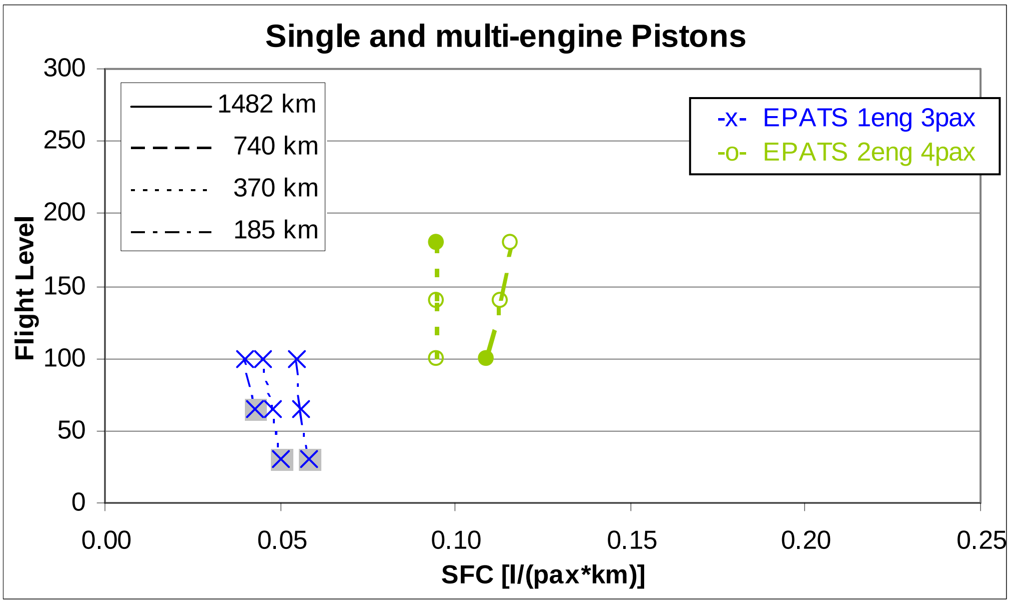


Fig.5. 17 SFC for future EPATS pistons.

- **Multi-engine turbo-prop.**

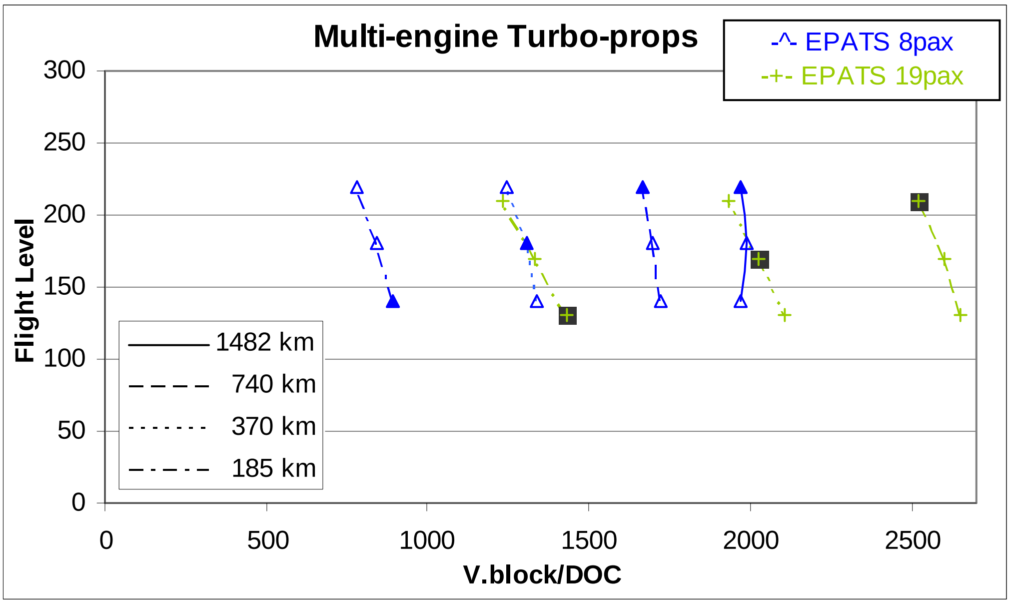


Fig.5. 18 V_{block}/DOC ratio for future EPATS turbo-props.

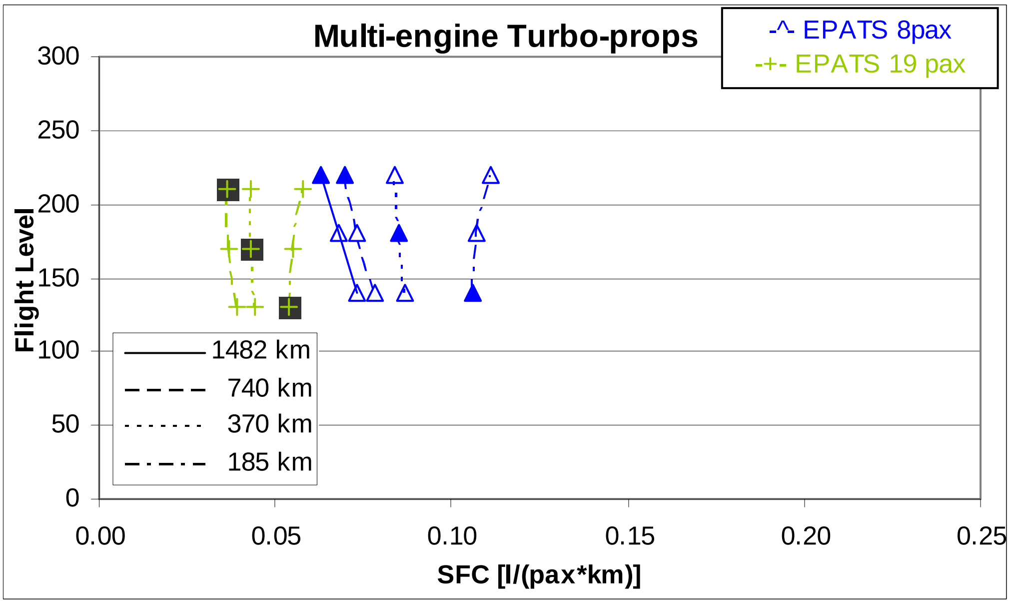


Fig.5. 19 SFC for future EPATS turbo-props.

- **Multi-engine jets.**

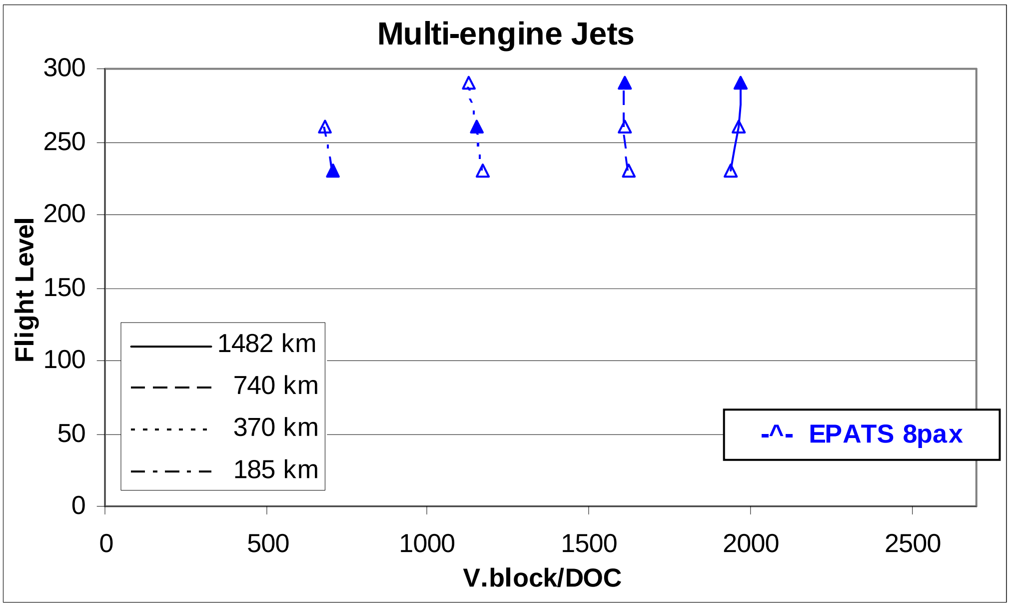


Fig.5. 20 V_{block}/DOC ratio for future EPATS jets.

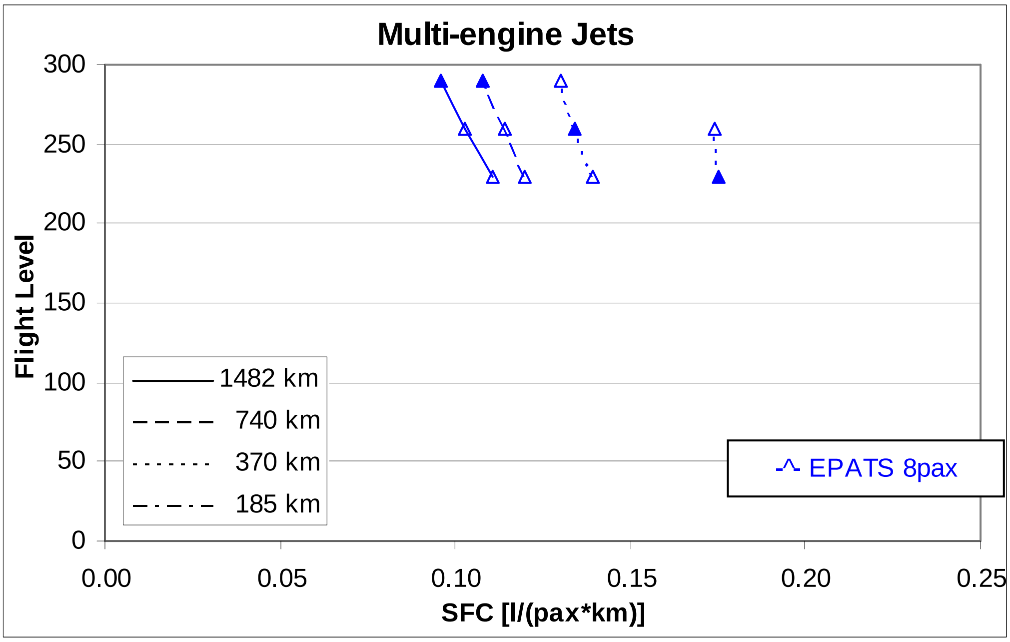


Fig.5. 21 SFC for future EPATS jets.

- **Fuel price impact.**

The fuel prices have risen about 5 times for last 6 years and they are not likely stop rising. Let's compare the same size turbo-prop and jet. Currently (4$ per U.S. gallon) fuel cost fraction equals 21% for turbo-prop and 26% for jet. If it increased by a 100% DOC would rise by 22% and 28% respectively and fuel cost fraction up to 33 and 39%. Therefore it seems clear that fuel price may be a crucial not only for EPATS but for all aviation too. The discussed example is shown on the Fig.5.19.

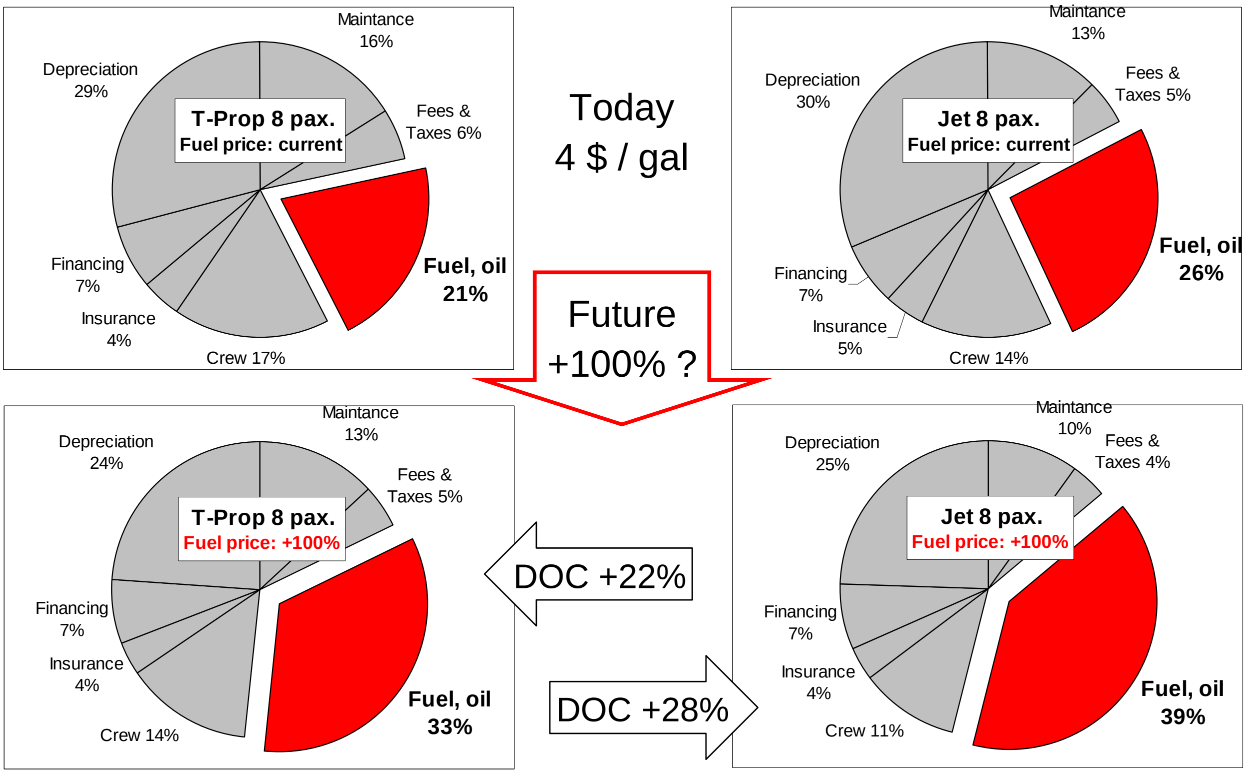


Fig.5. 22 Fuel price impact on DOC for the same size t-prop and jet (block distance 740 km, annual utilization 600 block hours)

6 CONCLUSIONS

The analyses shows that affordable personal transport is real and the most suitable for the mission are pistons and turbo props. 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)

Further work if successful, requires closer cooperation with manufacturers, operators and other European programs(e.g. CESAR, SESAR). In general detailed data and feedback information are needed (current and future predictions):

- airplanes characteristics,
- engine characteristic,
- avionics
- materials
- production technology,
- avionics,
- business models,

We identify several topics which might be the scope of future European programs. There should help to reach the EPATS goal: affordable, accessible , fuel efficient, environmental friendly, personal air transport.

- Diesel-pistons (high fuel efficiency)
- Modern propellers (efficient and silent)
- Geared turbofan: new propulsion system- intermediate between turbo-prop and turbo-fan (jet)
- Aerodynamics: new technologies and configurations:
- Avionics/ATM which combine safety and low prices; improve and/or eliminate flight holding patterns (flight straight lines between points).
- Research and development cost reduction program (CESAR)
- New materials (light, high strength, affordable)
- Manufacturing cost reduction – close cooperation with automotive industry.

The proposal of future activities (EPATS 2):

- Choice of rational structure of park of small transport aircrafts for future local, interregional mini-airline network of middle-west Europe
- EPATS aircraft requirements versus CESAR, SAFAR, CREATE, SOFIA, HAPATS project representatives
- Workshop EPATS – Users – FP projects (CESAR, SAFAR, CREATE, SOFIA, HAPATS)
- Agreed EPATS aircraft requirements with R&D Community to fully deploy of EPATS system in Europe.
- Definition of future improved PTS technologies in relation to ATM, Environment, Safety, Security, Cost

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Manufacturer Name:

	AIRCRAFT	**Country**	**Web site adress**
1	ADAM	USA	www.adamaircraft.com
2	ANGEL	USA	www.angelaircraft.com
3	ATI	USA	www.avtechintl.com
4	AVIA	Russia	www.avialtd.ru/tech.htm
5	AVOCET	USA	www.flug-revue.rotor.com/FRtypen/FRProJet.htm
6	BRITISH AEROSPACE (BAE)	UK	www.regional-services.com/ur_products.html www.baeam.com/brochure.aspx?m=2&mi=98&ms=0
7	BEECHCRAFT	USA	www.raytheonaircraft.com/beechcraft/
8	BRITTEN-NORMAN (BNG)	UK	www.britten-norman.com
9	CESSNA	USA	www.cessna.com
10	CIRRUS	USA	www.cirrusdesign.com
11	COLUMBIA	USA	www.flycolumbia.com
12	DIAMOND	Austria	www.diamond-air.at www.diamondair.com
13	ECLIPSE	USA	www.eclipseaviation.com
14	EMBRAER	Brazil	www.embraer.com
15	EPIC	USA	www.epicaircraft.com
16	EVEKTOR (EV)	Czech	www.evektor.cz
17	EVIATION JETS	Brazil	www.eviationjets.com
18	EXCEL-JET Ltd.	USA	www.sport-jet.com
19	EXPLORER	USA	www.exploreraircraft.com
20	EXTRA	Germany	www.extraaircraft.com
21	FARNBOROUGH	UK	www.farnborough-aircraft.com
22	GAP KESTREL	Inter.	www.gulf-aircraft-partnership.com
23	GIPPSLAND AERONAUTICS	Australia	www.gippsaero.com
24	GROB AEROSPACE	Germany	www.grob-aerospace.net
25	HONDA	Japan	www.world.honda.com/HondaJet www.hondajet.honda.com
26	IBIS AEROSPACE	Inter.	www.ibisaerospace.com
27	INTRACOM	Switzerland	www.intracom-ch.com
28	MAVERICK	USA	www.maverickjets.com
29	MMZP	Poland	www.marganski.com.pl
30	MOONEY	USA	www.mooney.com
31	OMA SUD	Italy	www.omasud.it
32	PAC	New Zeland	www.aerospace.co.nz
33	PIAGGIO AERO	Italy	www.piaggioaero.com
34	PILATUS	Switzerland	www.pilatus-aircraft.com
35	PIPER	USA	www.newpiper.com
36	QUEST	USA	www.questaircraft.com
37	SKYDESIGN	France	www.skylander-aircraft.net
38	SOCATA (EADS)	France/Inter.	www.socata.eads.net
39	SPECTRUM	USA	www.spectrum.aero

40	VULCANAIR	Italy	www.vulcanair.com
			-
	ENGINES		-
	General Electric		
1	HONDA		www.gehonda.com
2	Pratt & Whitney Canada		www.pwc.ca
3	Rolls-Royce		www.rolls-royce.com
4	Teledyne Continental		www.tcmlink.com
5	Textron Lycoming		www.lycoming.textron.com
6	Thielert Motoren GmbH		www.thielert.com
7	Williams International		www.williams-int.com

APPENDIXES

APPENDIX I LIST of ABBREVIATIONS (AVIONICS)

According to: NLR-Memorandum ASAS-2007-066, Ref.[16].

ACAS	Airborne Collision Avoidance System
ADF	Automatic Direction Finder
ADS-B	Automatic Dependent Surveillance-Broadcast
ALT	Altitude
AP	Autopilot
A-SMGCS	Advanced-Surface Movement Guidance and Control System
ASAS	Airborne Separation Assistance System
AT	Auto Throttle
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATT	Attitude
B-RNAV	Basic aRea NAVigation
CONOPS	Concept of Operations
CPDLC	Controller Pilot Data Link Communications
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
ECAC	European Civil Aviation Conference
EFB	Electronic Flight Bag
EFIS	Electronic Flight Information System
EGNOS	European Geostationary Navigation Overlay Service
EGPWS	Enhanced Ground Proximity Warning System
EPATS	European Personal Air Transport System
ELT	Emergency Locator Transmitter
ES	Extended Squitter
ESIS	Emergency Standby Instrument System
EVS	Enhanced Vision System
FAA	Federal Aviation Association
FADEC	Full Authority Digital Engine Control
FDR	Flight Data Recorder
FIS	Flight Information Service
FL	Flight Level
FMS	Flight Management System
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

HMI	Human Machine Interface
HOTAS	Hands On Throttle And Stick
HSI	Horizontal Situation Indicator
HUD	Heads Up Display
IEEE	Institute of Electrical and Electronics Engineers
IFD	Integrated Flight Deck
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LOC	Localizer
MFD	Multi Functional Display
NASA	National Aeronautics and Space Administration
NDB	Non Directional Beacon
NLR	National Aerospace Laboratory
PFD	Primary Flight Display
P-RNAV	Precision aRea Navigation
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	aRea NAVigation
RVSM	Reduced Vertical Separation Minimum
SATS	Small Aircraft Transportation System
SBAS	Satellite Based Augmentation System
SES	Single European Sky
SESAR	Single European Sky ATM Research
SP	Single Pilot
SPD	Speed
SVS	Synthetic Vision System
SWIM	System Wide Information Management
TAS	Traffic Advisory System
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Alert System
TIS	Traffic Information Service
TIS-B	Traffic Information Service-Broadcast
TMA	Terminal Manoeuvring Area
VDL2	VHF Digital Link Mode 2
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni directional Range
WIMAX	Worldwide Interoperability for Microwave Access

APPENDIX II REFFERENCE AIRCRAFT AVIONICS

According to: NLR-Memorandum ASAS-2007-066, Ref.[16].

5 Reference aircraft avionics

In order to have a good sense of avionics currently in use and installed onboard the EPATS reference aircraft, the database has been enhanced by listing relevant avionics that come with standard delivery of these aircraft. This means that all avionics are offered as either standard or optional but come solely from the airplane manufacturer per brochure.

Appendix B presents a list of standard avionics installed onboard the EPATS reference aircraft. The database is also sorted in a similar manner as the reference aircraft database: aircraft are grouped by engine category. The emphasis has been put into gathering up to date information on the standard avionics package that the manufacturer offers to ensure a fair compilation for comparison. Customized, after-market avionics that can be installed per explicit customer wish are excluded. The following paragraphs will elaborate on each particular item down on the list.

In the tables, the initial left rows describe the following information:

- Manufacturer model: specifies the aircraft model and particular type
- Configuration: describes the aircraft with what standard avionics package onboard and what the integrated flight deck (IFD) is if applicable.

5.1 Navigation / communications

The navigations and communications avionics installed are described in this category together because they often coupled together in a single functional device.

Unit: hardware device(s) installed that provide navigation and/or communications function, consisting of either an integrated unit or separate devices. The Garmin GNS 430 for example combines very high frequency (VHF) radio communications, VHF Omni directional Range/Global Positioning System (VOR/GPS) navigation and instrument landing system (ILS) functions in one device.

Navigation: which navigation services can the aircraft make use of; this comprises of the traditional terrestrial radio navigation aids such as VOR, distance measuring equipment (DME), non directional beacons (NDB), ILS landing systems and satellite based navigation such as GPS. If a multiplier is stated in front, then this means that the functions listed thereafter are present in multitude for redundancy.

FMS: is it basic equipment that stores a simple programmable flight plan in the radio/navigation unit or a full flight management system (FMS)? If listed under “GPS navmap”, this means the GPS navigation avionics provides programmable flight plans. Under “yes” would fall

equipment that have a separate functional flight management computer (FMC) (with specified unit where information is available).

Compliance: what kind of navigation precision is the aircraft compliant with? B-RNAV or P-RNAV[1], RVSM[2], ILS category landings[3]? See Appendix D for details on ILS landing categories.

Communications: what voice radio functions is present and which frequency spectrum is utilized? And if applicable at what frequency spacing do these operate?

Satellite: what satellite link is present and for what services? From a simple setup as satellite music radio for entertainment, satellite data links or up to a high speed broadband connection for internet.

Audio: hardware device that provides aural alerts to pilot such as cockpit warnings or navigation beacon alerts?

5.2 Surveillance

Surveillance consists of various items to basically support three aspects: traffic, weather and terrain.

Transponder: mode A/C or S equipped? Mode A/C transponders provide air traffic control (ATC) with aircraft altitude and identity information. Mode S is the successor to Mode A/C and brings more precision and additional data capabilities.

Traffic: consists of different levels of surveillance capabilities [5]. Traffic Information Service (TIS), is a US ground based system where the aircraft receives surrounding traffic information via Mode S data link. Traffic Advisory System (TAS) is a scaled down version of the Traffic Collision Avoidance System (TCAS) for general aviation that actively seeks out traffic via transponder response. TCAS itself was developed for the large commercial airliners and comes in two levels: TCAS I & TCAS II, where the latter also provides resolution advisory (RA). Automatic Dependent Surveillance-Broadcast (ADS-B) is the latest technology that enables

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[1] B-RNAV or P-RNAV stands for basic or precision area navigation respectively. This specifies the lateral navigational, track keeping accuracy of an aircraft. For B-RNAV this is ± 5 nautical miles for at least 95% of the time, and for P-RNAV ± 1 nautical mile [9].

[2] Reduced Vertical Separation Minimum reduces the vertical separation between aircraft from 2000 feet to 1000 feet between FL 290 and FL410 in order to maximise airspace usage. For compliance, the aircraft has to fulfil the minimum system avionics requirements [9].

[3] Instrument Landing System has 3 main categories which define the capability of the aircraft to be able to approach the runway under limited visual conditions and to a certain minimum height with the avionics onboard, see Appendix D for more details.

aircraft to broadcast more accurate information (aircraft type, identity, GPS position) to other ADS-B users.

Weather: there are three techniques to get weather information [6]. First is a lightning detection system, also known as sferics, which uses antennas that passively detect radio signals emitted by lightning. Second is a weather link that provides a weather picture as detected from the ground and uplinked to the aircraft via ground based transmitters or satellite relay. Finally, onboard weather radar provides active, autonomous scans ahead of the aircraft and can even detect turbulence.

Terrain: to help warn about possible terrain conflicts, there are basically three categories of systems [7]. Firstly, there is a basic terrain map that displays terrain elevations from a database but it is up to the pilot to judge whether there is sufficient ground clearance. Next there are two Terrain Awareness & Avoidance Systems: TAWS-A and TAWS-B; these systems scans for impending ground conflicts and warn the pilot. TAWS-A adds more safety features such as a mandatory terrain display and radio altimeter.

ELT: emergency locator transmitter is a device that emits a distress signal after a plane crash.

5.3 Instrumentation

PFD/MFD: what hardware unit is installed to provide the display functions for the primary flight display and/or multi function displays. Also if the PFD is not integrated on a single glass display, then the relevant individual gauges are mentioned.

Size: what is the screen size and resolution of the displays: SVGA (800 x 600 pixels), XGA (1024 x 768) and WXGA+ (1440 x 900) [8].

EFB: electronic flight bag is a device that provides electronic charts, checklists, approach plates as a solution to a paperless cockpit. This usually means a software upgrade to the integrated glass displays to enable the desired features.

Backup: these are the standby instruments for use after a primary instrument display failure. This list provides information on which display gauges are available as backup and what kind of device it is as in mechanical, electric standby or reversionary only[4] mode. ATT means attitude, SPD stands for airspeed, ALT for altitude, HSI is a horizontal situation indicator and compass

[4] Reversionary mode is the backup mode that in case of a PFD failure transfers all flight instrumentation automatically to the adjacent display

means a simple magnetic compass is available as a mechanical backup instrument. If ESIS is listed, this means there is a small electronic stand by instrument system present, giving basic flight critical information as found on the PFD but on a much smaller display. Full legacy indicates that the aircraft has a full set of duplicate individual mechanical gauges for backup purposes. If listed as “no”, this means the aircraft has only the reversionary mode of the glass cockpit available in case of PFD failure and no other backup instruments to rely upon.

5.4 Flight

This category covers the flight control interface the pilot uses and autopilot that assists the pilot with steering the aircraft.

Interface: type of flight controls the pilot can manipulate with his hand to directly control the plane i.e. centre yoke, centre stick or side stick.
Autopilot: which autopilot (AP) hardware unit is installed and how many are present?
AP type: how many axes can the autopilot control? Dual axis means it is capable of controlling pitch and roll whereas a triple axis controller can handle yaw in addition.
AP modes: what functions can the autopilot perform such as heading pre-select/hold, altitude pre-select/hold, course intercept, VOR/localizer (LOC) track, GPS track, reverse course track, yaw damper, pitch trim.

5.5 Extra

Extra (safety) or remarkable features the aircraft comes equipped with.

SP ops: this indicates that the aircraft is certified for single pilot operations.
a/c parachute: emergency brake parachute system present that can be deployed to lower aircraft to a survivable hard landing
FADEC: full authority digital engine control; engine is controlled via a computer upon direct throttle manipulation; the pilot isn’t required to operate other engine controls like fuel mixture which reduces pilot workload.
EVS: enhanced vision system is a device that provides a synthetic representation of the aircraft’s surrounding in low visibility conditions through a forward looking low light or infrared camera. This enables a pilot to land at lower landing minima conditions and provides additional safety.
FDR: flight data recorder, records critical flight parameters indispensable for reconstructing a crash
CVR: cockpit voice recorder, records voice conversations made by the pilots in the cockpit
AT: auto throttle, the throttle can be controlled automatically when coupled to an autopilot enabling true hands free flying.

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