Abstract

This Technical Note discusses a method to estimate the market price of an aircraft at the stage of the conceptual design in function of the technical characteristics defined by the designer. During the conceptual design the designer has to make some technical choices in order to design the best aircraft which meets the design specification. It is very important for the designer to know what will be the impact of these choices on the aircraft's final cost. This method has been validated on a large number of aircraft of different categories: UL, LSA, Propeller driven aircraft and Business jet aircraft.

Table of contents

Introduction

A large number of aircraft (147) have been analyzed. To make an estimate of the cost, the first step in the analysis is place the aircraft into one of the following categories:

(1) UL-LSA,
(2) Propeller driven aircraft (piston & turboprop, FAR23) & Very Light Jet aircraft and
(3) Business Jet aircraft (FAR25).

The analysis has shown that the market price is affected by the general layout (= configuration?) and of the technical options of the aircraft. With a major difference between the UL-LSA category and the others: the market price for the UL-LSA category is also function of the performance of the aircraft (cruise speed) , while the market price of the other categories is rather a function of the empty weight of the aircraft.

Propeller driven aircraft (Piston & Turboprop)

In a first step, aircraft of standard configuration (Std.Config.) have been analyzed. For this category, Standard configuration means:

- Four seats
- Metal aircraft
- 4 stroke engine, normally aspirated
- Fixed landing gear
- Unpressurized fuselage
- Standard avionics
- Standard furnishing
- Conventional configuration
- Large production number

From this first analysis, an equation to estimate the market price (USD) against the aircraft glider weight (lbs) has been defined:

$$\mathrm{Pr}_{\text{Market est.}} = 100.000 \cdot \left(0.002444 \cdot \mathrm{W}_{\text{glider}} - 0.625269\right) + \mathrm{Pr}_{\text{Engine est.}} + \mathrm{Pr}_{\text{Propeller est.}}$$

In a second step some correction factors (CF) have been defined to take into account some technical options. These correction factors will be applied to the estimated glider price. The engine and propeller prices have been estimated with the method given by J.Roskam, Airplane Design Part VIII.

	Characteristics	Std.Config.	CF	Options	CF	Options	CF
1	Number of seats	4	0%	Lesser than 4	- 3%/occ.	Greater than 4	+3%/occ.
2	Material	Metal	0%	Composite	+25%	Tube	-40%
3	Engine	Piston	0%	Turboprop	+50%	Turbojet	+25%
4	Turbocharger	No	0%	Yes	+10%		
5	Landing gear	Fixed	0%	Retractable	+25%		
6	Fuselage	Unpressurized	0%	Pressurized	+20%		
7	Avionics	Standard	0%	Business	+4%		
8	Furnishing	Standard	0%	Business	+2%/occ.		
9	Configuration	Conventional	0%	Three-Surface	+15%		
10	Production	Large number	0%	Business	+30%		

To validate this method, 30 aircraft with an empty weight range from 830lb (376kg) to 6900 lb (3129kg), have been analyzed. The estimated market price has been compared with the manufacturer's market price. 87% of the estimated market prices are given with an accuracy of +/- 15%

ΔPr		Qty	+/- 5%	+/- 10%	+/-1 5%	+/- 20%
< -30% - < -25%	Under estimation	-				
< -25% - < -20%		-				
< -20% - < -15%		1				
< -15% - < -10%		2				
< -10% - < -5%		4				
<-5% - < 0%		6	50%	77%	87%	97%
< 0% - < +5%	Over estimate	9				
< +5% - < +10%		4				
< +10% - < +15%		1				
< +15% - < +20%		2				
< +20% - < +25%		-				
< +25% - < +30%		-				

Business jet aircraft

The analysis is performed in the same way as for the propeller driven aircraft. Aircraft of standard configuration have been analyzed. Standard configuration means:

- Nine seats
- Metal aircraft
- Jet engine
- Retractable landing gear
- Pressurized fuselage
- Business class avionics
- Business class furnishing
- Conventional configuration
- Low production number

From this first analysis, an equation to estimate the market price (USD) against the aircraft glider weight (lbs) has been defined:

$$\mathrm{Pr}_{\text{Market est.}} = 100.000 \cdot \left(0.013495 \cdot \mathrm{W}_{\text{glider}} - 18.096689\right) + \mathrm{Pr}_{\text{Engine est.}}$$

In a second step some correction factors (CF) have been defined to take into account some technical options. These correction factors will be applied to the estimated glider price. The engine price has been estimated with the method given by J.Roskam, Airplane Design Part VIII.

	Characteristics	Std.Config.	CF	Options	CF	Options	CF
1	Number of seats	9	0%	Lesser than 9	- 3%/occ.	Greater than 9	+3%/occ.
2	Material	Metal	0%	Composite	+25%		
3	Configuration	Conventional	0%	Three-Surface	+15%		

To validate this method, 20 business jets with an empty weight range from 12300lb (5578kg) to 18000 lb (8163 kg), have been analyzed. The estimated market price has been compared with the manufacturer's market price. 53% of the estimated market prices are given with an accuracy of +/- 15%

ΔPr		Qty	+/- 5%	+/- 10%	+/-1 5%	+/- 20%
< -30% - < -25%	Under estimation	-				
< -25% - < -20%		-				
< -20% - < -15%		-				
< -15% - < -10%		1				
< -10% - < -5%		3				
<-5% - < 0%		3	18%	41%	53%	65%
< 0% - < +5%	Over estimate	-				
< +5% - < +10%		1				
< +10% - < +15%		1				
< +15% - < +20%		2				
< +20% - < +25%		1				
< +25% - < +30%		1				

UL & LSA aircraft

In a first step, aircraft of standard configuration have been analyzed. Standard configuration means:

- Two seats
- Composite aircraft
- 4 stroke engine, 80hp, naturally aspirated
- Fixed landing gear
- Conventional configuration
- UL airworthiness requirements

From this first analysis, an equation to estimate the market price (€) against the aircraft performance in cruise (km/h) has been defined:

$$Pr_{Market\ est.} = 362.01 \cdot V_{cr} - 13544$$

In a second step some correction factors (CF) have been defined to take into account some technical options. These correction factors will be applied to the estimated market price.

	Characteristics	Std.Config.	CF	Options	CF	Options	CF
1	Number of seats	2	0%	1	- 30%		
2	Material	Composite	0%	Tube	+5%	Metal	+8%
3	Engine	4 stroke	0%	2 stroke	-25%		
4	Engine power	80cv	0%	<80cv	+25% |ΔP|	>80cv	-25% |ΔP|
5	Landing gear	Fixed	0%	Retractable	+25%		
6	Configuration	Conventional	0%	Seaplane	+40%		
7	Airworthiness	UL	0%	LSA	+20%		

To validate this method, 97 aircraft with a cruise speed range from 100 km/h (62 mph) to 275 km/h (171 mph) have been analyzed. The estimated market price has been compared with the manufacturer's market price. 63% of the estimated market prices are given with an accuracy of +/- 15%

ΔPr		Qty	+/- 5%	+/- 10%	+/-1 5%	+/- 20%
< -30% - < -25%	Under estimation	4				
< -25% - < -20%		4				
< -20% - < -15%		3				
< -15% - < -10%		11				
< -10% - < -5%		8				
<-5% - < 0%		11	24%	42%	63%	73%
< 0% - < +5%	Over estimate	12				
< +5% - < +10%		10				
< +10% - < +15%		9				
< +15% - < +20%		7				
< +20% - < +25%		10				
< +25% - < +30%		2				

Example 1

Does it worthwhile to modify an aircraft with a fixed landing gear to a retractable landing gear in order to improve the performance in cruise?

	Original aircraft	Modified aircraft
Landing gear	Fixed	Retractable
Cruise speed	290 km/h	306 km/h
Drag coefficient (cd_0)	0.02630	0.02171
Estimated market price	**82,901 USD**	**113,145 USD**

Example 2

What should be the best modification to do on an existing aircraft in order to improve the maximum rate of climb performance? 2 solutions could be investigated: (1) increase the engine power or (2) modify the propeller characteristics?

	Original aircraft	Modified aircraft (1)	Modified aircraft (2)
Engine model	Lycoming O-235-N2A	Lycoming O-320-B1A	Lycoming O-235-N2A
Engine power	**116 hp**	**160 hp**	**116 hp**
Propeller	**Fixed pitch**	**Fixed pitch**	**Constant speed**
Empty weight	410.3 kg	464 kg	418.5 kg
Maximum rate of climb	5,499 m/s	6,625 m/s	6.827 m/s
Takeoff run	247 m	334 m	140 m
Engine market price	20,099 USD	23,264 USD	20,099 USD
Propeller market price	1,931 USD	2,791 USD	5,792 USD
Aircraft market price	**120,925 USD**	**146,603 USD**	**126,479 USD**

Conclusions

The method presented in this technical note for estimating the market price of a new aircraft at the stage of the conceptual design seems to be a very good guide for the designer in order to visualize the impact of his choices on the final cost of the aircraft. Even if this concerns the early stage of the design process, the accuracy is very high, especially for the propeller driven aircraft category.

At this stage of the design process the most important is not to estimate the market price with a perfect accuracy but rather to visualize the effect of the technical characteristics of the aircraft on its final cost.