B7E7 CASE STUDY

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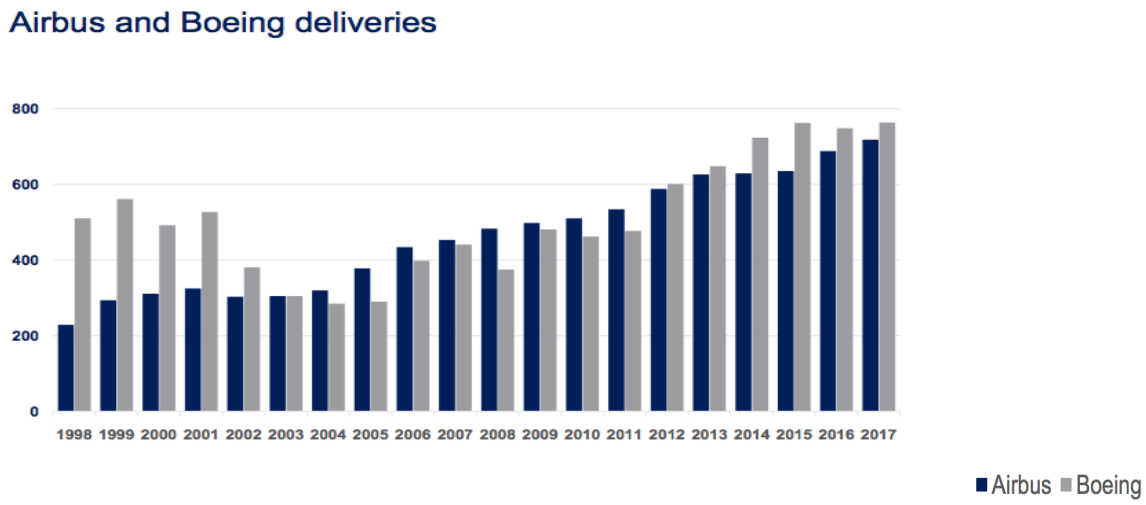
Introduction

The world's two largest aircraft manufactures, Boeing and Airbus, sought new opportunities in the increasing demand for aircrafts. Boeing's response to the market's growing demand was the development a new passenger aircraft that was in a category of its own. An aircraft capable of mid to long-range flight with improved fuel efficiency and low maintenance cost; the 7E7. Michael Bair, Boeing 7E7 project leader, encountered several stumbling blocks in order to present a profitable business model to the board of directors. With the 7E7 business plan equating to $10 billion, Bair's largest concerns were how to keep the development expense of a whole new class of aircraft capable of both, short-haul and long-haul operations under the budget designated by the board of directors.

Industry Background

Subsequent to 777's success, the Boeing had several plans for new models, such as the Sonic Cruiser. However, none of the post-777 projects went in to production. Meanwhile, airlines struggled in reducing operational cost to maximize profit. In 2002, Boeing was split into two primary segments: commercial aircrafts and integrated defense systems. Lockheed Martin, Lockheed Martin, the Boeing's primary competitor in the defense sector, was ahead of the game by landing defense contracts equating to $17 billion. However, with $16.6 billion contract, the Boeing was not too far behind. On the other hand, the Boeing's largest rival in commercial sector was the Airbus. In 2002, the Boeing produced six main airframes: 717, 737, 747, 757, 767, and 777. While Boeing and Airbus are dominating the 100+-seat market, Bombardier and Embraer were more prominent in the 50 to 100 seat sector.



Graph 1 Airbus and Boeing Deliveries from 1998-2017 (Airbus, 2017)

The demands for aircrafts from Boeing and Airbus were on a sharp rise until the attack on the World Trade Center after which the growth of aviation industry reversed. The existing orders from and scheduled deliveries to the airlines were put on halt due to the dramatic the fall in air travel.

The adverse effect on demand for air crafts induced by the September 11 was depicted on Graph 1. Until 2003, the Boeing exceeded Airbus in its deliveries. The order was revered in 2004. Not only the Boeing and Airbus but the entire airline industry took a big hit. The airline industry's loss in revenue by the September 11 attack equated to $22 billion which took the industry three years to recover (IATA, 2018.)

With the increase in fixed costs, the Boeing recognized the need for mid-size fuel-efficient aircrafts capable of long-haul connectivity. On the contrary, Airbus introduced the Airbus A380. The A380 is the largest passenger aircraft ever built and was due to fly in 2006 with a 550-passeger configuration and long-distance range of up to 8,000 miles. The absence of competition from its greatest rival, the Boeing proceeded to create 7E7, the *Dreamliner*. The Boeing's

engineers needed to figure out how build the 7E7 by using new composite material which weighted less than the currently used material. However, the researches revolved around the use of new material drove up the R&D expense. Therefore, it was crucial for Bair to develop a thorough understanding of the project's business model to convince the board of directors.

Project Calculations

The goal of our analysis is to identify the cash flows of the 7E7 project and its riskiness. The project was financed through equity and debt. Hence, an accurate estimate of the cost of financing was mandatory. Out calculation uses the capital asset pricing model (CAPM) and weighted average cost of capital (WACC). Below is a more detailed methodology we have adopted.

Methodology

1. Estimate cost of capital
    a. Identify the expected rate of return of similar projects
    b. Identify the risk-free rate, the market risk premium, and the beta
    c. Calculate the cost of equity and cost of debt using CAPM
2. Calculate the overall average weighted cost of capital using WACC
3. Sensitivity and scenario analysis

Cost of Capital

Two approaches can be used to find the appropriate expected return of the B7E7 project. First approach is to use the expected return of projects that has comparable risks. However, there is no standard or verified expected return number for similar projects in the current research. Therefore, the second approach is adopted.

According to Hillier et al., in 2013, the *expected return* of a project is synonym to *discount rate* and *cost of capital*. Since the B7E7 project is financed through both equity and debt, we will need to determine the weight of equity and debt financing for B7E7 project and calculate the weighted cost of capital using WACC.

The WACC formula is:

$$WACC = percent\ equity \times R_e + percent\ debt \times R_d \times (1 - t_c)$$

Where:

Percent equity = $\frac{market\ value\ of\ equity}{market\ value\ of\ debt + market\ value\ of\ equity}$

Percent debt = $\frac{market\ value\ of\ debt}{market\ value\ of\ debt + market\ value\ of\ equity}$

R_e = Cost of equity

R_d = Cost of debt

T_c = Corporate tax rate

Percent Equity and Percent Debt

From Exhibit 10 of the case study it is stated that the **market value debt/equity ratio** is **0.525**. Meaning for every equity there is 0.525 debt. Rearranging the percent equity and percent formula we get:

$$percent\ equity = \frac{1}{1 + 0.525} = 0.6557$$

$$percent\ debt = \frac{0.525}{1 + 0.525} = 0.3443$$

Cost of Equity

The CAPM approach helps to describe the risk of the project and the expected return of the project. CAPM takes the market price of stock into consideration as well as the associate risk of pursing a project than if the money is invested elsewhere without any risks.

CAPM formula:

$$R = R_f + \beta \times (R_m - R_f)$$

Where,

R_f = Risk-free rate

β = Beta = risk

R_m = Market rate of return

Market Price Premium $= MPR = (R_m - R_f)$

The return on equity for stockholders is symmetrical to the cost of equity for the company because the dividends and capital gains for stockholders are costs to the company (Hillier et al., 2013). Boeing consists of two major business sectors, commercial and defense, and that the B7E7 project's profit is only specific to the commercial sector. Hence, the weight of the commercial and defense sectors must be considered. Rearranging the CAPM formula to find cost of equity:

$$R_e = R_f + \beta_c \times MRP$$

Where,

R_e = return on equity = cost of equity

R_f = Risk-free rate of B7E7

β_c = Beta of commercial sector

MRP = Market risk premium

Risk-free Rate (R_f)

It is stated in the case-study that a 30-years treasury bond in 2003 has a yield of 4.56%. According to the U.S. Department of Treasury, the YTM of a 20-year treasury bill in 2004 January 2nd was 5.21%. We select to use the 5.21% because our calculations will be based on the 20-year time frame and the treasury bill is closest to a risk-free asset. We use the early yield rate of 2004 because Boeing is acquiring confirmation with board of directors in early 2004. Hence,

$$R_f = 0.0521$$

Estimation of β Beta, Risk

Beta measures how sensitive the project is to a change in the market condition. The beta of 60months, 21months, and 60 trading-days timeframe are available. These beta are not selected for our analysis because we believe a beta of a bigger horizon is more suitable. Aircraft projects has more than ten years of project lifecycle. Many events may happen during the project lifetime. For example, Boeing did not know US is going to war against Iraq and SARS is going to embark. These events impacted the travel industry and the market environment. There we chose the 1.05 beta in Exhibit 10 for our analysis. The beta of Boeing (β_b) in general is 1.05, which calculated against the NYSE 5-years index. We think out of all the choices of beta provided by the case study, this is a better timeframe for our analysis.

An important thing to keep in mind is that when calculating against and industry index we would assume the industry average beta to be 1.

To identify the beta of commercial sector we need to first find the weights of the commercial sector and defense sector for Boeing. Using Revenue data in 2002, 2001 and 2000, Exhibit 1, we calculated the average weight of commercial sector (W_c) and defense sector (W_d), see Table 1 below.

Table 1. Calculation of average weights of sectors

	Year ending 2002	2001	2000
Commercial Revenue	$ 28,387.00	$ 35,056.00	$ 31,171.00
Defense Revenue	$ 24,957.00	$ 22,815.00	$ 19,963.00
Total Revenue less accounting eliminations and other	$ 53,344.00	$ 57,871.00	$ 51,134.00
Commercial %	53.21%	60.58%	60.96%
Defense %	46.79%	39.42%	39.04%
Wc	**58.25%**		
Wd	**41.75%**		

Next, we need to find out the beta of the defense sector. To do so, we need to calculate the unlevered beta of the defense industry using the information of similar companies in the defense industry in Exhibit 10. In addition, the company will also have a degree of financial leverage. Financial leverage is the degree to which the company relies on debt financing. Increasing financial leverage, the debt, means increasing risk, the beta. We would like to use the levered beta in our CAPM calculation because it takes debt into account. Levered beta will measure the risk of Boeing to the market volatility with its selected capital structure.

Table 2. Calculating Defense Industry Beta

Company	D/E Ratio	Percent defense	Pure Business Beta	Tax	Unlevered Beta
Lockheed Martin	0.4100	93%	0.60	35%	0.4737
Northrop Grumman	0.6400	91%	0.70	35%	0.4944
Raytheon	0.6240	73%	0.73	35%	0.5194
				Industry Unlevered Bd	**0.4958**

Boeing levered defense beta calculation:

$$\beta_{levered,defense} = \beta_{unlevered,industry} \times (1 + (1 - T_c) \times market\ value\ of\ \frac{Debt}{Equity} ratio$$

$$\beta_{levered,defense} = \beta_d = 0.4958(1 + (1 - 0.35) \times 0.525 = 0.6650$$

Boeing levered commercial beta calculation:

$$\beta_{levered,commerical} = \beta_c = \frac{\beta_b - (\beta_d \times W_d)}{W_c}$$

Where,

β_b = Boeing beta

β_d = Boeing defense beta

W_d = average weight of defense sector

W_c = average weight of commercial sector

Therefore,

$$\beta_c = \frac{1.05 - (0.6650 \times 0.4175)}{0.5825} = 1.3259$$

Table 3 below summarized the beta found. It is important to remember that the beta calculated would only be an estimation and it will not stay the same throughout the project life-time because in real-life any changes in the technology or in the market will cause the beta to vary.

Table 3. Beta summary

Bb	Beta of Boeing	1.0500
Bc	Beta of Commercial Sector	1.3259
Bd	Beta of Defense Sector	0.6650
Wc	Average Weighted Commercial Sector	0.5825
Wd	Average Weighted Defense Sector	0.4175

Market Risk Premium (MRP)

Attempt 1: Equity MRP Approach

Below is the equation used to determine the equity market risk premium of Boeing Company in 2004. We obtained the Q1 dividend in 2004 as $0.17 and Q4 is $0.20 and the weighted share price is $43.68 (Boeing, 2004).

$$EMRP = (Dividend\ yield + Dividend\ Growth\ Rate) - Rf$$

Therefore,

$$EMRP = \left(\frac{\$0.20}{\$43.68} + \frac{\$0.20 - \$0.17}{\$0.17}\right) - 0.0521$$

$$EMRP = 0.1289$$

Determining Cost of Equity using CAPM

$$R_e = R_f + \beta_c \times MRP$$

So far, the following variables are found, which enables us to estimate the Re.

$R_f = 5.21\%$

$B_c = 1.3259$

EMRP = 12.89%

Attempt 2: Use the EMRP conducted by trusted organizations

$$2004\ EMRP = 3.00\%$$

KPMG recorded a 3.00% EMRP for the S&P 500 in 2004. This is very different from the 12.89% we have calculated. We believed KPMG is more reliable than our own calculation because they have more data and they are a trusted financial body. Therefore,

$$R_e = 5.21\% + 1.3259 \times 3.00\% = 9.19\%$$

Cost of Debt

To calculate the cost of debt, *Rd,* we had first evaluated the weighted average Year *to* Maturity from each of the bonds and divided this over the total market value of the debt. The sum of this result was the total Cost of Debt, shown in table 4, 5.335% cost of debt.

Table 4. Boeing Company 10-Q, Bloomberg Financial Services, and Mergent Online.

Outstanding Bonds of the Boeing Company as of June 2003 ($ Values in millions)								
Debt amount	**Debt Rating**	**Coupon**	**Maturity**	**Price**	**Yield to Maturity**	**Market Value of Debt**	**Weight**	**Weighted Average YTM**
$202.00	A-	7.63%	2/15/2005	106.175	3.91%	$ 214.47	4.27%	0.167%
$298.00	A-	6.63%	6/1/2005	105.593	3.39%	$ 314.67	6.27%	0.213%
$249.00	A-	6.88%	11/1/2006	110.614	3.48%	$ 275.43	5.48%	0.191%
$175.00	A-	8.10%	4/1/2012	112.65	4.05%	$ 197.14	3.93%	0.159%
$349.00	A-	9.75%	2/15/2013	129.424	5.47%	$ 451.69	8.99%	0.492%
$597.00	A-	6.13%	8/15/2021	103.59	4.66%	$ 618.43	12.31%	0.573%
$398.00	A-	8.75%	8/15/2024	127	6.24%	$ 505.46	10.06%	0.628%
$300.00	A-	7.95%	6/15/2025	126.951	5.73%	$ 380.85	7.58%	0.435%
$247.00	A-	7.25%	9/15/2031	114.506	6.05%	$ 282.83	5.63%	0.341%
$249.00	A-	8.75%	11/15/2031	131	6.34%	$ 326.19	6.50%	0.412%
$173.00	A-	8.63%	2/15/2033	138.974	5.81%	$ 240.43	4.79%	0.278%
$393.00	A-	6.13%	2/15/2038	103.826	5.85%	$ 408.04	8.12%	0.475%
$300.00	A-	6.63%	8/15/2042	106.715	6.15%	$ 320.15	6.37%	0.392%
$100.00	A-	7.50%	4/15/2043	119.486	6.17%	$ 119.49	2.38%	0.147%
$173.00	A-	7.83%	4/15/2043	132.52	5.78%	$ 229.26	4.56%	0.264%
$125.00	A-	6.88%	10/15/2043	110.084	6.19%	$ 137.61	2.74%	0.170%
					Total	$ 5,022.12	1	**5.335%**
								Cost of Debt

Calculating WACC

Recap of the WACC formula:

$$WACC = \ percent\ equity\ \times R_e + percent\ debt\ \times R_d \times (1 - t_c)$$

Using information found, the formula becomes:

$$WACC = 0.6557\ \times 0.0919 + 0.3443\ \times 0.0534 \times (1 - 0.35)$$

$$WACC = 0.0722 = 7.22\%$$

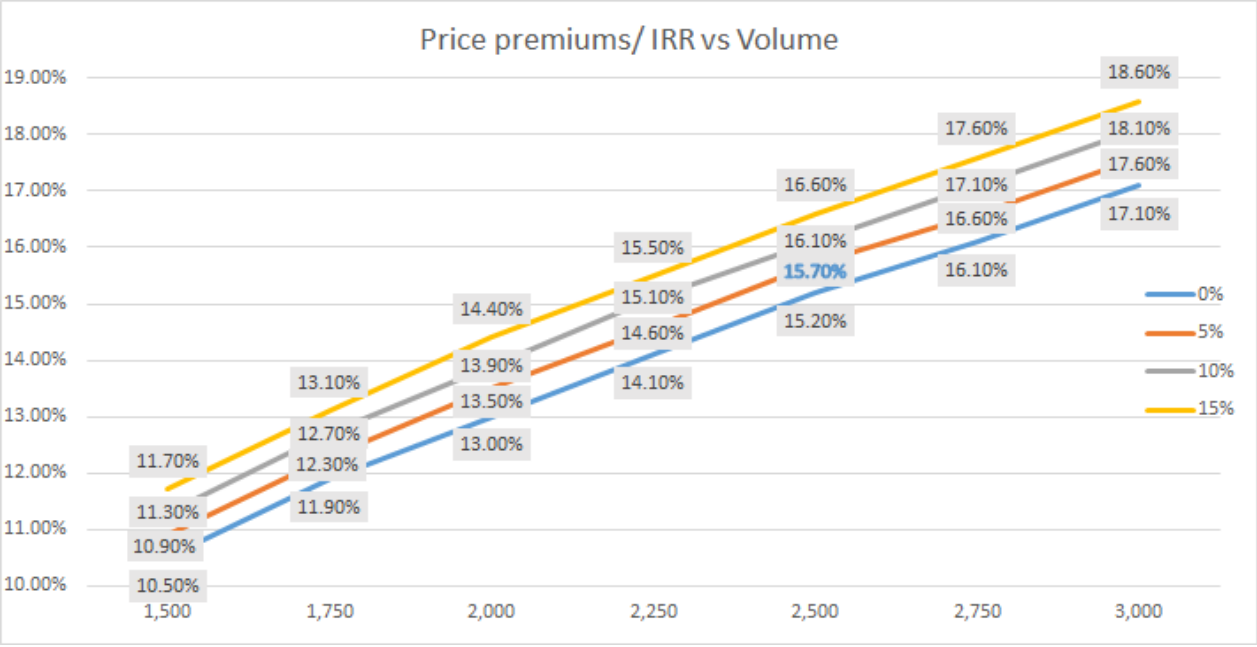
Scenario and Sensitivity Analysis

University of Virginia's Analysis

Internal rate of return is a measure of the project's cash flows and setting its net present value (NPV) to zero. For an investment project, such as the B7E7, the IRR rule indicates to reject the project if IRR is less than expected return and accept if IRR is greater than expected return.

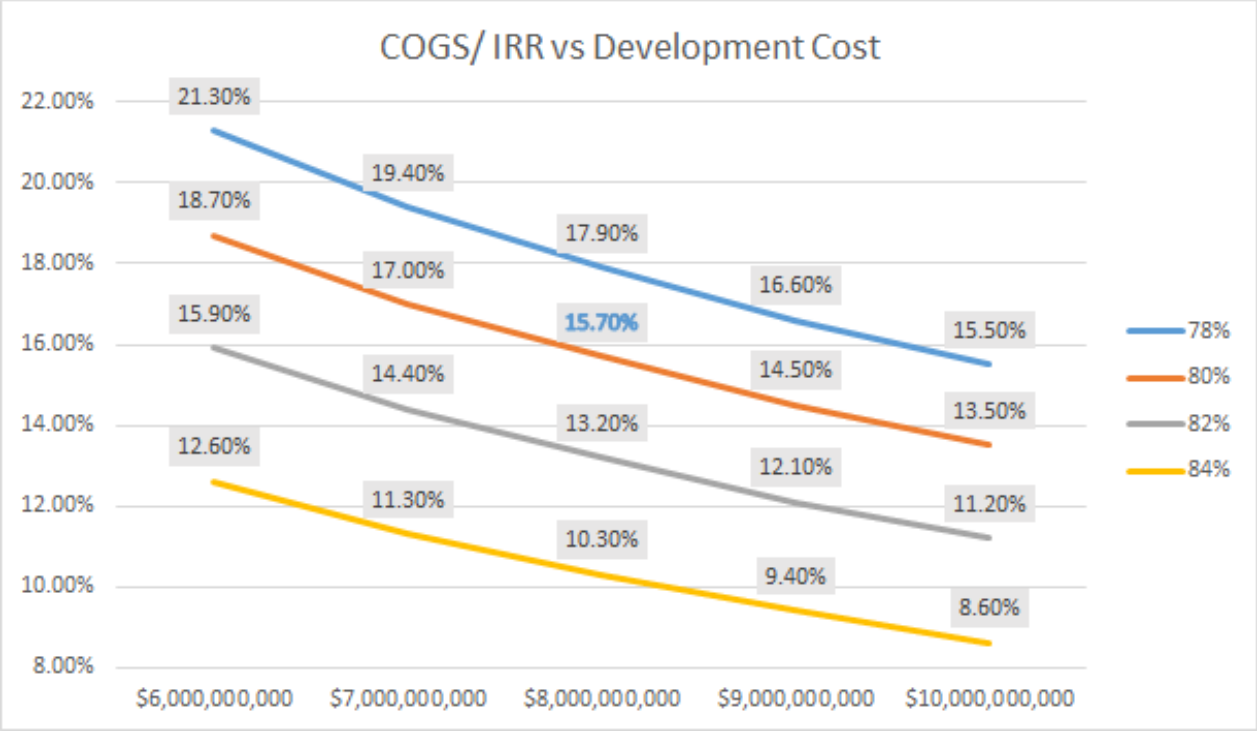
Following our calculations, we are going to analyze some probable situations for the IRR and the NPV of the project and compare our results with the results of University of Virginia's Analysis. First, we are going to look at the IRR predictions of the University of Virginia. Below is graph based on the information and the numbers that were provided by the case study.

The graph below shows the IRR probability based on the volume of sales. The four situations displayed in the graph are based on the premiums charge on the price of the 7E7. According to the University of Virginia, the most probable IRR is 15.66%, which is estimating 2,500 unit volume at a 5% premium.



Graph 2. University of Virginia's IRR sensitivity analysis with different expected price premium levels.

The second graph in the case study analysis shows the IRR variation based on the development costs. The four situations displayed are based on the percentage that the cost of goods sold will represent out of sales. Again, the University of Virginia estimated the most probable IRR to be at 15.70%, which relates to a development cost of $8,000,000 and the cost of goods sold represent 80% of sales.



Graph 3. University of Virginia's IRR sensitivity analysis with different expected cost of goods sold percentage.

Our Scenarios

Table 5. Scenario parameters

All $ values in millions				
INDEPENDENT VARIABLES				
	Distribution	**Min**	**Most Likely**	**Max**
Initial Price of 7E7	Cumul	$130.00	$136.95	$143.90
Initial Price of 7E7 Stretch	Cumul	$162.00	$170.87	$179.74
COGS (%of Sales)	Triang	75.00%	80.00%	81.00%
WCR (%of Sales)	Triang	6.50%	6.70%	7.00%
SG&A (%of Sales)	Triang	7.00%	8.00%	9.00%
R&D Expense (%of Sales)	Triang	1.50%	2.30%	3.30%
Capital Expenditure (%of Sales)	Triang	1.40%	0.16%	1.80%
Development Costs (2004-2009)	Normal	$7,500.00	$8,000.00	$9,000.00
WACC (aka discount rate)	Triang	5.00%	7.22%	16.00%
CONTROL VARIABLES				
Total Volume (2008-2027)		2,500	2,500	2,500
Total Volume (2028-2037)		2,500	2,500	2,500
DEPENDENT VARIABLES				
NPV			$ 75,293.81	
MIRR			12.85%	

Justification of scenario setup:

- The initial price for the Boeing 7e7 has a most likely value of $136.95 millions, the lowest price we can get to maintain the markup that Boeing is expecting to have, is of

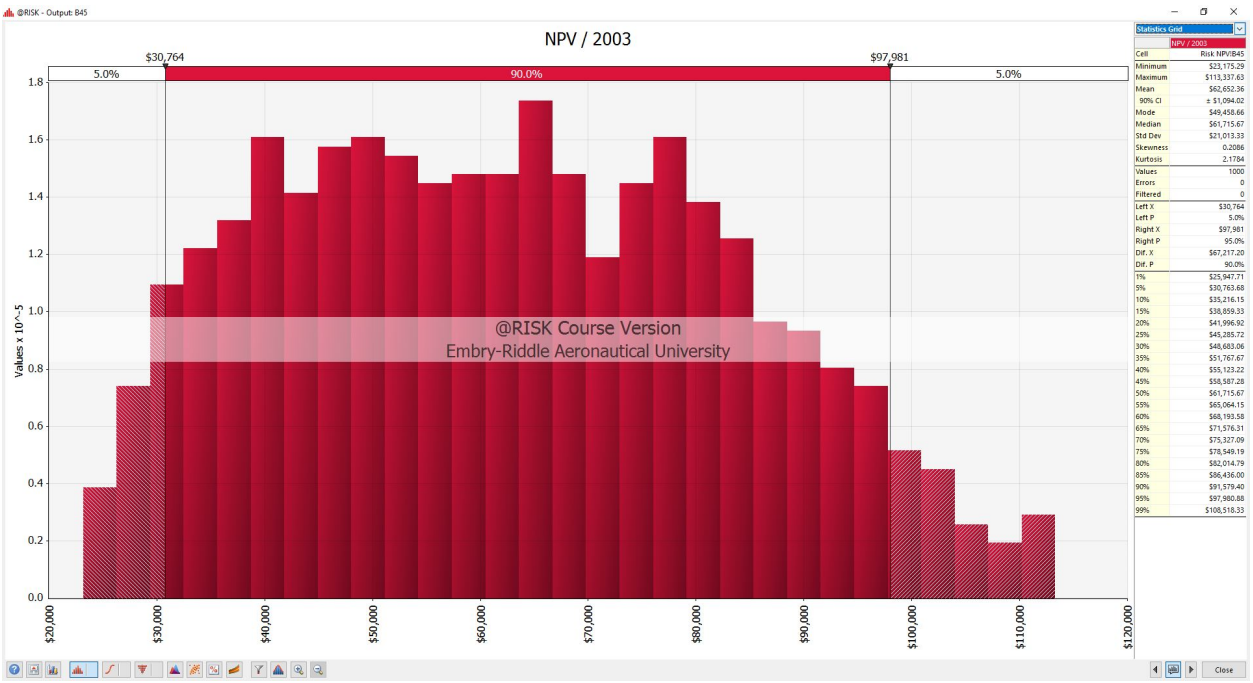
$130 million, it uses a Cumul distribution graph type, because is an analysis for a price that will not go down, it can only reduce its growth

- For the Stretch version of the Boeing 7e7, has a most likely price of $170.87 millions, with a minimum price permitted to maintain the Boeing markup of $162 millions, such as the regular Boeing 7e7, for the @Risk analysis, we used the Cumul distribution graph
- In the cost of goods sold analysis, we decided the minimum percentage of the cost of goods that Boeing was able to get for manufacturing the airplanes was of 75%, this was according to better negotiations with the providers. As this variable doesn't depend on Boeing directly, this distribution done for @Risk was a triangle distribution graph
- Working Capital Requirement also depends on the amount of sales Boeing will have for this type, in this case it can go up to 7% as a maximum, the most likely will be of 6.7% and the minimum according to the minimum price we are having for both prototypes. For this type of analysis, we did a Triangle distribution analysis
- The Selling Goods and Administrative expenses follow the WCR distribution, it has a minimum of 7% and a most likely of 8%. We also used the Triangle distribution @Risk for this type of analysis.
- Although Research and Development doesn't vary directly with the sales of the airplane, the minimum and maximum also vary low, in this case the minimum we decided to have was 1.5%
- Capital Expenditure, if we have the most likely it will be the optimal of 0.16%, but if we use the minimum, according to the percentage of sales, the capital expenditure will be going to 1.4%, for this we also used Triangle distribution graph

- In development cost, we change our distribution graph to Normal. This was the original cost at the initial of the project that we needed to allocate for what Boeing wanted to invest, so the minimal can't be estimated and go down that much, but we got $7500 millions
- Finally, the WACC analysis @Risk, it is a variation from all the above results, so we decided to evaluate if we got a 5% WACC, how the other results changed. For this we had chosen the triangle distribution graph.

NPV Scenario Analysis

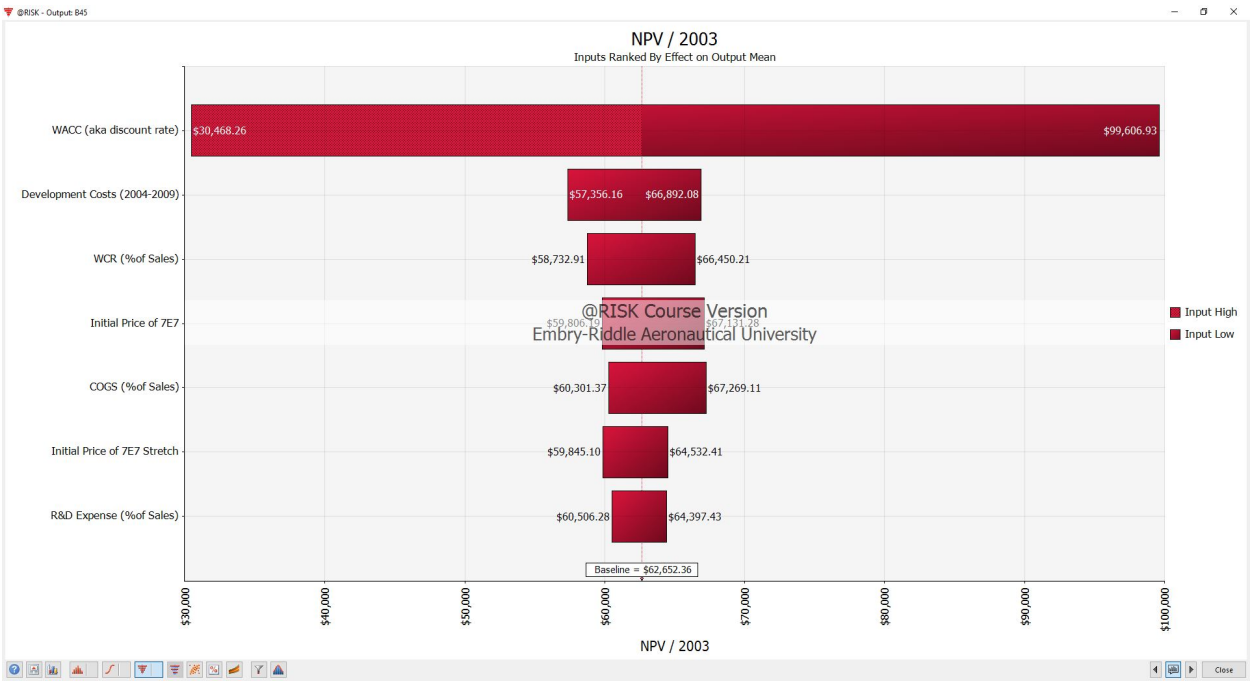
The graph below shows a scenario analysis of the most probable NPV outcomes, setting year zero as 2003 and year 2037 as the last year. Thus, the project lifetime is 34years. By analyzing the graph, we can see that there is a 90% chance for the NPV of the project to fall in between $30,764 and $97,981. The rest of 10% is distributed equally, 5% on each side, showing possible but highly improbable NPV outcomes. The highly improbable values for the NPV fall below $30,764 and over $97,981. Since the scenario analysis results is positive NPVs, we would suggest accepting the project assuming that we do not know the required NPV.



Graph 4. @Risk model of 34-year NPV with year 0 as 2003.

NPV Variable Sensitivity Analysis

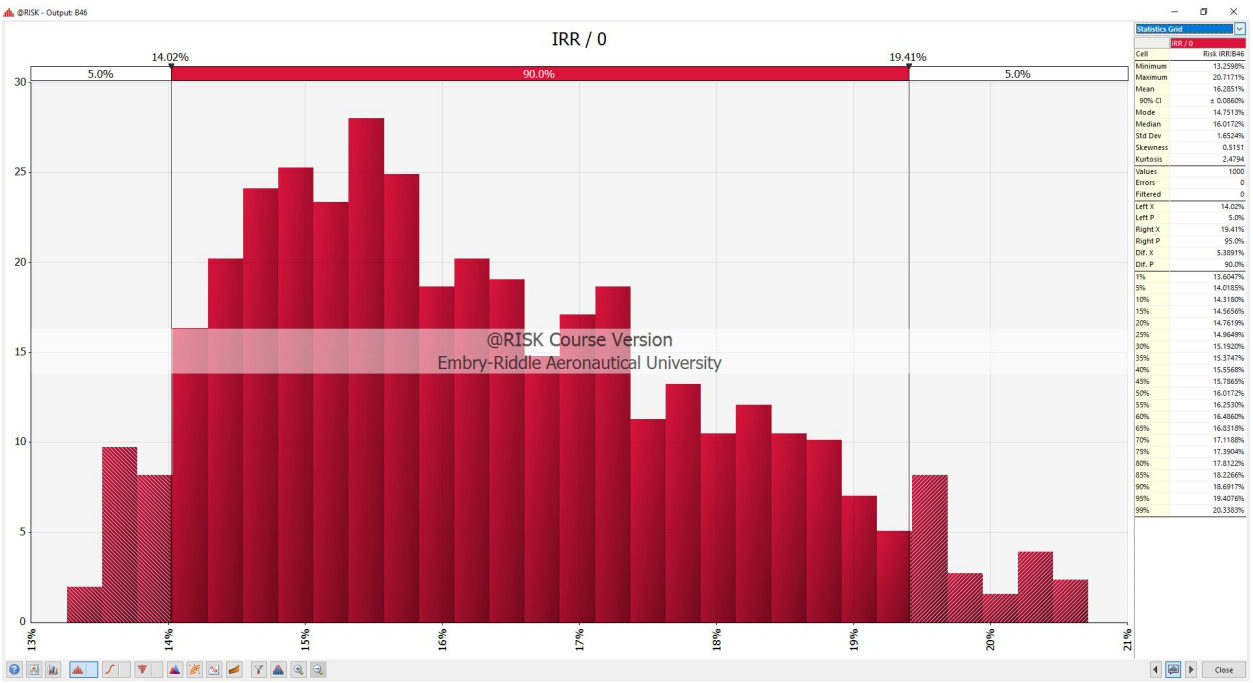
The tornado graph below shows the variables that influence the NPV. By analyzing the tornado graph, we can find out that the WACC has the most influence on the NPV. While most of the variables will have little influence on NPV, varying form a low of $57,356.16 to a high of $67,269.11, a change in WACC can have a great impact on NPV, varying from a low of $30,468.26 to a high of $99,606.93. Conclusively, the projects NPV is very sensitive to the discount rate (WACC).



Graph 5. @Risk model of NPV's sensitivity to different variables with year 0 as 2003 shown on a tornado graph

MIRR Scenario Analysis

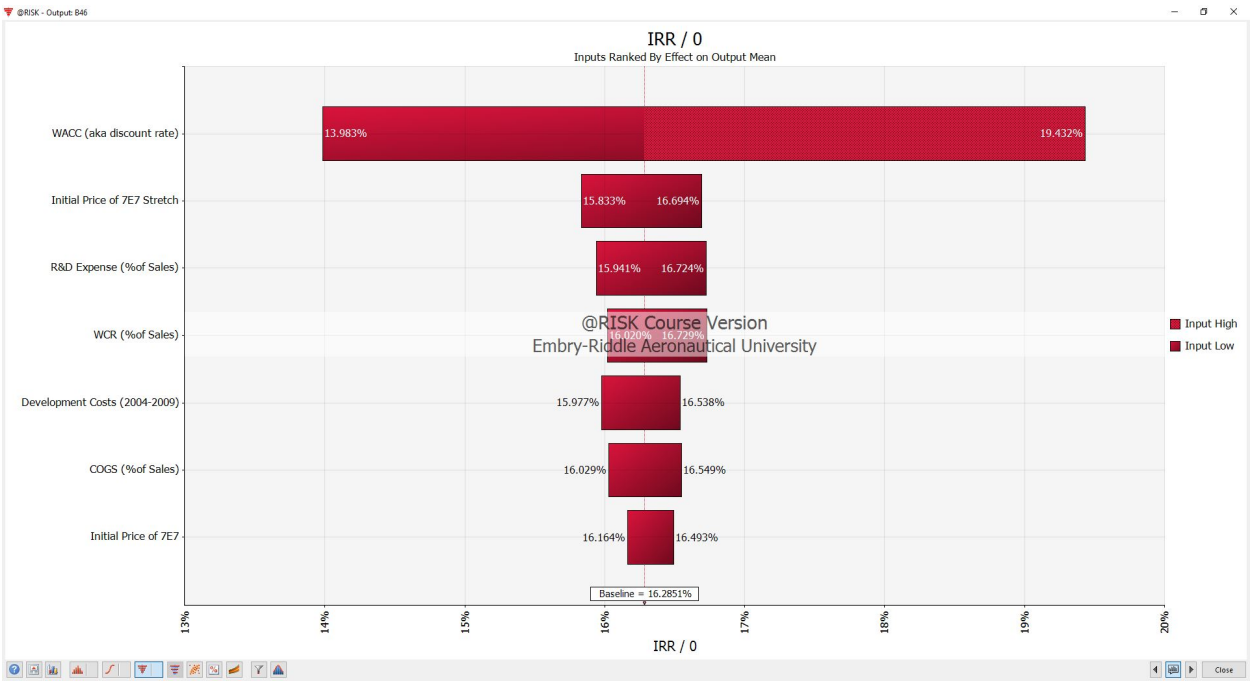
The graph below shows the most probable situations for the MIRR to happen. By analyzing the graph, we can see that 90% of the situations the MIRR will be somewhere in between 14.02% and 19.41%. The most probable situation is for the MIRR to be in between 14.5% and 15.5%. The MIRR range is greater than WACC, 7.22%, so we suggest accepting the project.



Graph 6. @Risk model of MIRR with year 0 as 2003.

MIRR Variable Sensitivity Analysis

The tornado graph below shows the effects of the most important costs on the MIRR of the project. By analyzing the graph, we can see that most of the costs are kept close to a mean of 16.0%, while WACC will have the greatest influence on IRR, varying between 13.9% to 19.4%.



Graph 7. @Risk model of MIRR's sensitivity to different variables with year 0 as 2003 shown on a tornado graph

Key Value Drivers

- Technological improvements: composite material, 20% less fuel
- New market: midsized aircraft with long-range capability
- Cheaper operating costs for airlines
- Reliability and credibility (50% contracts in defense)

Key Gambles

- Sales volume varies
- Uncertainty with future market: midsized aircraft or super large-sized aircraft
- Risk of the market fluctuates, thus beta changes
- Economy's stability, impacts of economy cycles and economic crisis, such as in 2013
- Influence of political instability and terrorism

- Influence of transmittable diseases or epidemics, such as H1N1
- Veto of the board, if development cost was more than 40% of 777 cost

Conclusion

Looking over the entire project, we found some key features that would greatly impact the decision of whether to further pursue the project or not. The first indicator that we calculated is the Weighted Average Cost of Capital (WACC) which we found to be 7.22%. The WACC can be considered the discount rate for the project and will be our reference when making a decision based on the IRR.

After running the sensitivity and scenario analysis we found the range of NPV to be in between $30,764 and $97,981, with a probability of 90%. Since the NPV will be way above 0, the logical decision is to accept the project based on this factor.

To further advance with a final decision, we are also considering the MIRR as a key factor that we need to analyze. Our modelled MIRR analysis gave us a range between 14.02% and 19.41%, with a 90% probability of falling within that range. Since this is higher than the discount rate of 7.22% and we are analyzing an investment project, we should accept the project. The case study written by the University of Virgina found that the most probable IRR is 15.70%, which is also higher than the discount rate, thus their decision should be to accept the project.

Reviewing the key value drivers and the gambles, even though there is a significant amount of gambling at stake, we feel that the key drivers such as the new technology and innovations will lead to a great profit for this project. All the risk of the gambles that we considered, were

analyzed and included in our beta calculation and our sensitivity analysis, thus we have a strong feeling that our analysis is accurate and reliable.

Conclusively, our team believes that this project is a great opportunity for Boeing and the company should keep perusing the development of the B7E7.

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