CSI EU (Cost Scene Investigation – European Union)

Douglas K. Howarth

The commonly accepted story about why the Airbus A380 failed to make a return on its investment centers around its well-publicized development cost and schedule issues. Added to that was the movement of the airline industry from a traditional hub and spoke model to point-to-point routes; and the introduction of planes to the market, which had much more efficient engines and technology. Technology might have gone onto the A380, but, as Airbus CEO Tom Enders stated, "Airbus did not stumble into [building] the A380; we were very aware of the project's risks, but then technology and the market changed faster than anyone thought." [1]

Nico Buchholz, an ex-Airbus executive who later became Lufthansa's head of fleet strategy and ordered the plane for the airline, echoed Enders' sentiment, saying, "In 2000, you could not predict what crystallized in 2005—that the aircraft was technically outdated." [2]

That is exactly incorrect!

As we examine the A380, we'll find all the information needed to prove the aircraft's insufficient viability existed before its launch. Furthermore, its technology had nothing to do with its demise. It sealed its fate at the start.

This is the End:

In her Netflix series, Cunk on Earth, the fictional host of the mockumentary, Philomena Cunk (played by the actress Diane Morgan), asks a professor of Egyptology, "How did the Egyptians build the pyramids? Did they start at the top and work down, or start at the bottom and work up?' [3]

Buried in that silliness is a question with real import – how to come to a project's proper end? As laborers toiled to make the Great Pyramid at Giza reach ever higher, how could they engineer it to hit its tallest point in space within a centimeter or two? There are no drawings left for us to pore over to answer that question, but we know they spent much time pinching their starting points down. Glen Dash, an engineer who studies the Great Pyramid, found that "The builders of the Great Pyramid of Khufu aligned the great monument to the cardinal points with an accuracy of better than four minutes of arc, or one-fifteenth of one degree." [5] Having a well-conceived base foundation can lead to a proper ending.

But your results can vary, especially if you have not given the foundation sufficient thought. A trip through Italy will drive home this point.

Figure 1: The Great Pyramid at Giza has an exact base, which let it grow to previously unimaginable heights [4]

Figure 2 reminds us that the Pisa Tower started tilting because its builders did not realize the soil beneath differed from side to side. Starting in 1172 and completed in 1372, its construction team did not incorporate the lessons of the past.

Just over the Apennine Mountains, a little over 70 miles by air, another similar fiasco took place scant decades before.

Figure 3 shows that two towers lean precariously toward one another in downtown Bologna, Italy. The city has had to put straps around them to prevent them from crashing into one another. These towers, completed by 1119, might have given others some pause. Early on, intelligence about the lean of the Bologna Towers was insufficient for architects and

Figure 2: The Leaning Tower of Pisa went sideways because its builders didn't understand that the ground below one side was softer than the other [6]

Figure 3: The Bologna Leaning Towers [7]

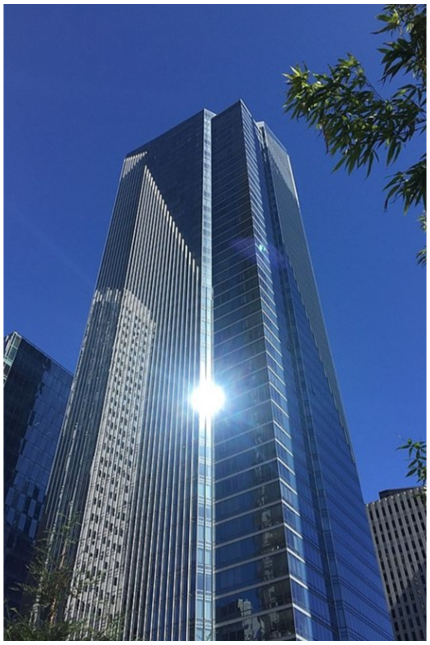


Figure 4: San Francisco's Millennium Tower [8]

engineers to take adequate measures to prevent Pisa's Tower from leaning.

Of course, such miscalculations are not solely a thing of the past. Figure 4's Millennium Tower lists 28 inches to the northwest as of 2022, as measured from the roof. [9]

In these instances of buildings going off-axis, builders aimed for a point in the sky and missed. To know how well or poorly a completed aerospace program did financially, we must first characterize where it aimed. Then we need to know the cost and associated revenues it would take to get to that point and how close it came to its target or by how much it missed.

The Targets:

If we think of the pinnacle of the Great Pyramid of Giza as a point in the sky, we can know where the structural architects wanted it to be and compare it to where it is. Such records of their intent are lost to history.

The aiming points of some more recent projects are easier to find. In Figure 5, we see that the Airbus people, as they launched their A380, thought they could sell 1250 units with a 2000 list price of $220M. At the same time, as Figure 6 reveals, in 1999-2000, the vehicle had a target weight of

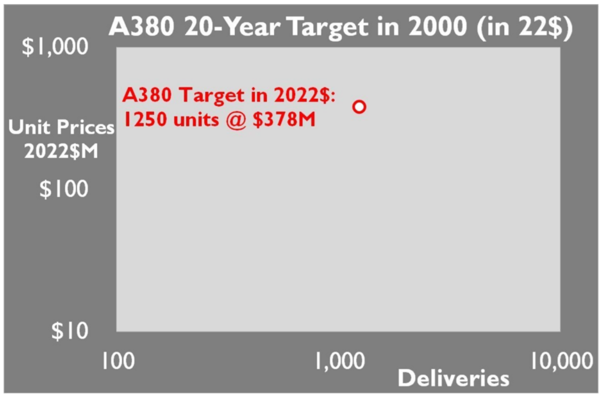


Figure 5: In 2000, Airbus projected 1250 A380 Units Sold [10] at a list price of $378M (in 2022$) [11]

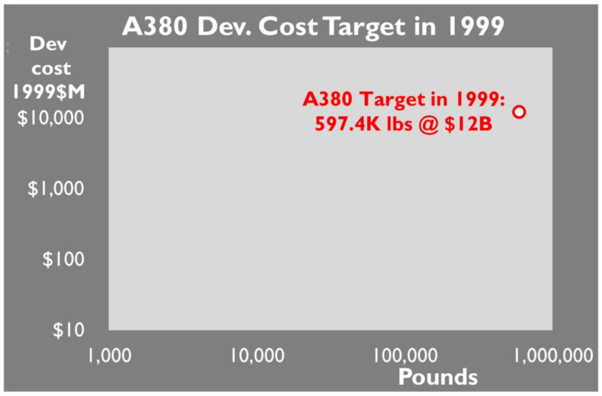


Figure 6: Airbus targeted $20.6B [12] (in 2022$) to develop an A380 weighing 597,400 pounds [13]

597,400 pounds and a development cost goal of $12B. Those targets are without any reference points.

With these views, they are not unlike the builders of the Great Pyramid. While each aims for a point, neither offers enough perspective to gain insight. What happens when we take time to add some understanding to these issues?

Cost Target - Weight:

To see if the empty weight goal of the A380 was, at its start, a viable target, we might think of studying its weight. For context, we'll need to compare its weight history (as Manufacturer's Empty Weight, or MEW) to that of other programs. In Figure 7, we retrieve the weight data for 16 unnamed programs.

It turns out that these programs do not typically stay on target. Indeed, as Figure 8 shows, they often have a specific weight goal before they launch, one that drops upon the go-ahead. Then, over time that amount of mass grows.

When we normalize (to a starting value of "1" at program launch) and plot the empty weight data from each of the 16 models over time, we get Figure 8. Note there seems to be an upward trend over time. We can take advantage of that.

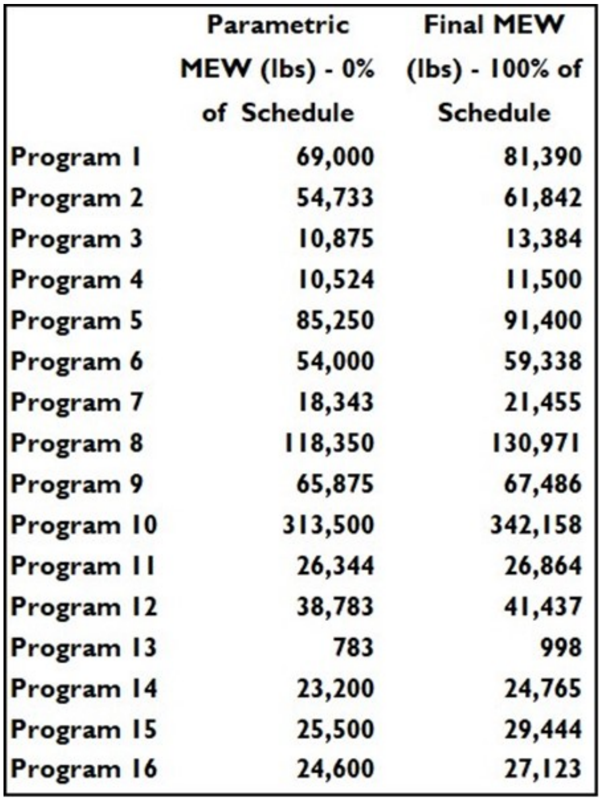
Using the data in Figure 7, we can try to predict the final Empty Weight from the like figure used at the program's start. When we do, we get Equation 1:

$$\text{Final MEW} = 1.48 * \text{Starting MEW}^{0.973} * \varepsilon \qquad (1)$$

Where:

Final MEW = Ultimate MEW, in pounds
Starting MEW = MEW at Go-Ahead, in pounds
ε = Error term for the equation

Equation 1 is well-correlated, with an Adjusted R^2 of 99.4%, a Mean Absolute Percentage Error (MAPE) of 4.3%, a Standard Error of 4317, and a P-Value of 8.93E-20. Any application of it outside its data range would be an extrapolation. If we were to apply it to smaller vehicles, say, one with a beginning empty weight of one pound, it suggests the aircraft would grow by nearly a half to 1.48 pounds.



	Parametric MEW (lbs) - 0% of Schedule	Final MEW (lbs) - 100% of Schedule
Program 1	69,000	81,390
Program 2	54,733	61,842
Program 3	10,875	13,384
Program 4	10,524	11,500
Program 5	85,250	91,400
Program 6	54,000	59,338
Program 7	18,343	21,455
Program 8	118,350	130,971
Program 9	65,875	67,486
Program 10	313,500	342,158
Program 11	26,344	26,864
Program 12	38,783	41,437
Program 13	783	998
Program 14	23,200	24,765
Program 15	25,500	29,444
Program 16	24,600	27,123

Figure 7: Target vs. Actual Empty Weights [14]

If we venture outside the database in the other direction for the exercise at hand, we could use Equation 1 to predict the A380 final weight from its starting condition. When we do that, as we discover in Figure 9, it forecasts a final A380 empty weight up 3.4%. In the end, though, the vehicle's MEW grew by 5.2% to 628,317 pounds. [15] While this increase is not trivial, it cannot explain the doubling of the program's projected Development Costs. Owing to the pervasive optimism in the industry, the weight prediction model projects it would take a vehicle with a starting MEW of 1,972,960 pounds to finish without any weight increases. Given the industry push to smaller and smaller unmanned aircraft, it would be beneficial to add such tiny planes to this mix, to see how the analysis of weight growth might be extended.

High Travel, Low Compatibility

To get a broad customer base for the A380, Airbus officials deliberately spread the work for its airplane about its several subsidiaries and critical suppliers. As we see in Figure 10A, this system, known as the Itinéraire à Grand Gabarit (in English, it roughly translates to "oversize convoy route"), is a water and road route in which the consortium invested

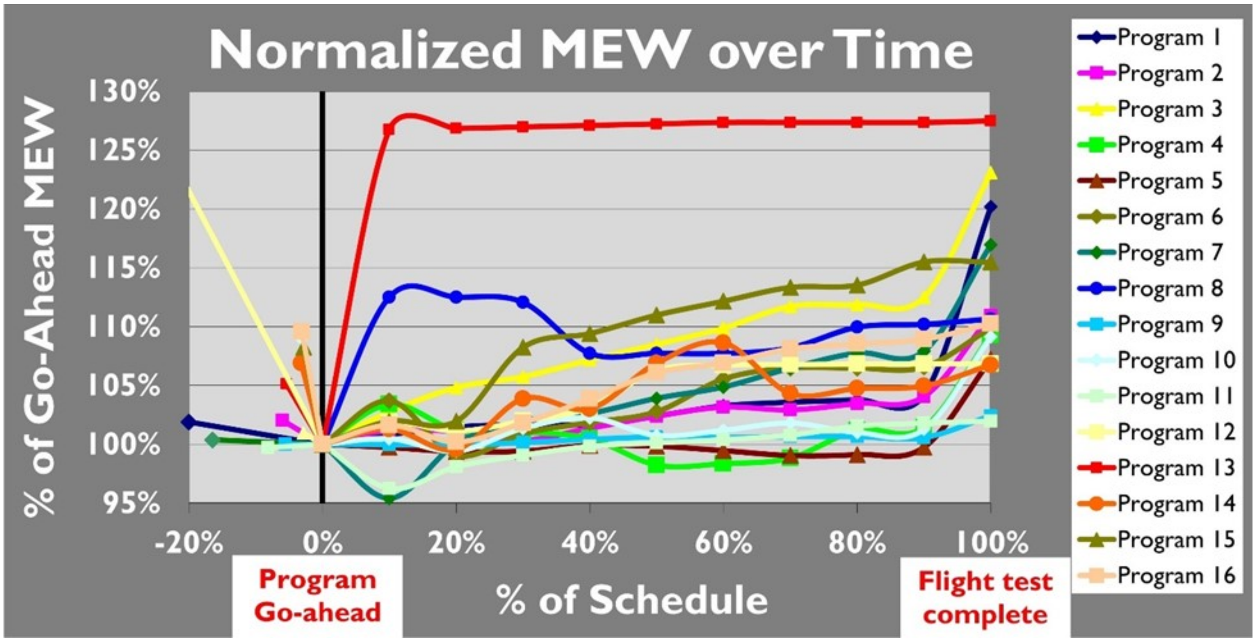


Figure 8: Aircraft Empty Weights typically fall as programs reach the Go-Ahead, then grow over time. The drop from the pre-launch figures to the ones at Go-Ahead represents systemic unfounded optimism.

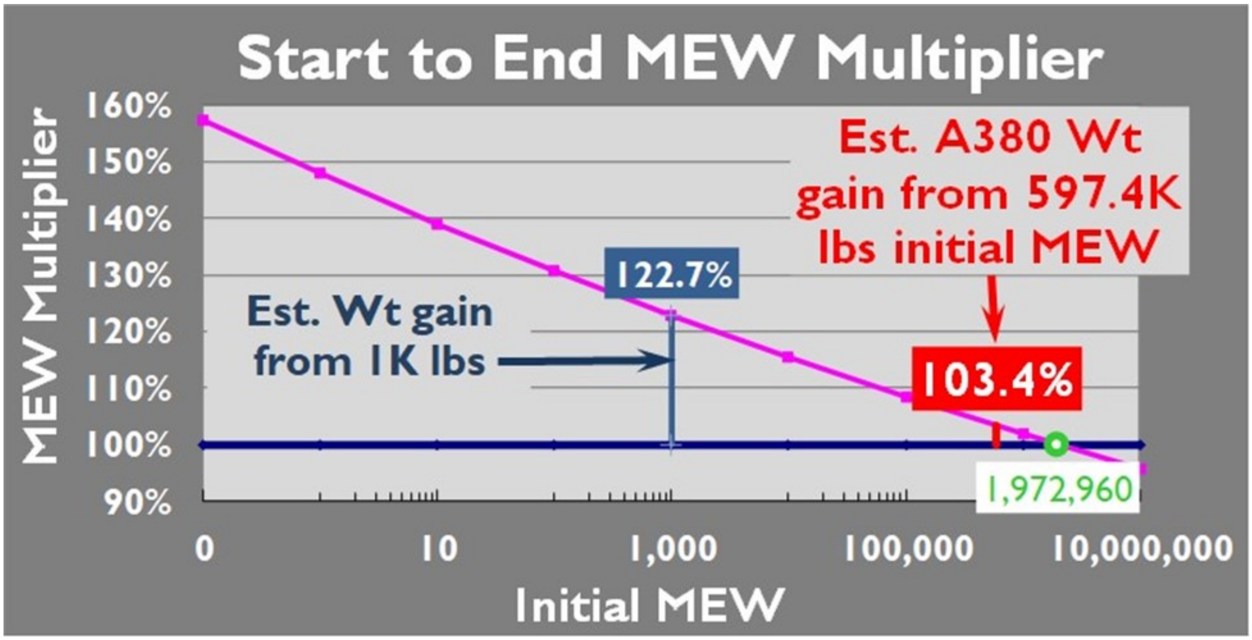


Figure 9: We find predictable weight growth when we take the Figure 7 estimated go-ahead Manufacturer Empty Weights and compare them to their ultimate weights. That growth, as a percentage, is higher for smaller vehicles than for larger ones. Here, a vehicle nominally weighing 1000 pounds at launch grows by 22.7% to its ultimate weight. Extrapolating the data, our weight increase models suggest that the A380's empty weight should have grown by 3.4% - available records show it grew by 5.1%.

hundreds of millions of dollars. The added time for pieces of the plane to get to final assembly in Toulouse added time and expense, but, more and more, getting several firms involved in a project seems to be the model for getting it launched in the first place.

More troubling than the parts moving long distances was the incompatibility of the software platforms across the consortium member countries. The CATIA (an acronym for computer-aided three-dimensional interactive application), invented by the French company Dassault Systems, offered added capability to engineers and designers. Initially released in 1982, it went through several revisions over the years. [18] By the time the program began, Spanish and German engineers were up to Version 4. Their French and British equivalents, however, were using Version 5.

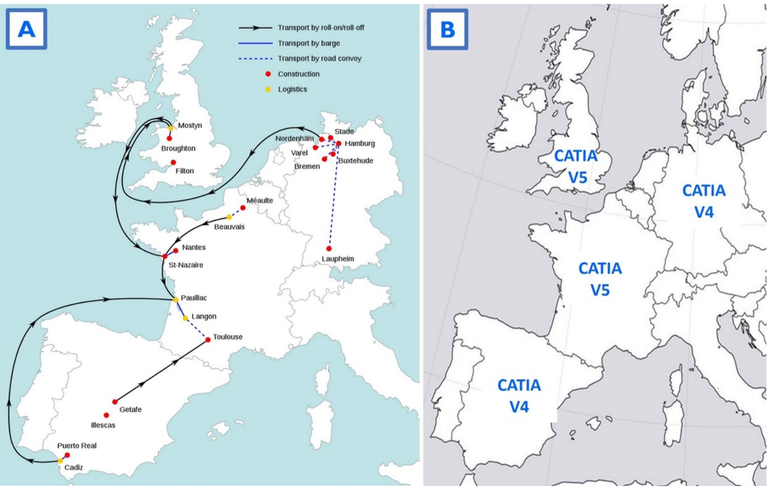


Figure 10: The building of the A380 was an international affair. The thinking was that if many countries participated in making the machine, lots of countries would buy the plane. Figure 10A shows the significant travel paths completed assemblies took to get to Toulouse, France, where the final assembly occurred. While that added cost to the plane, more significant was the difference in computer-aided design packages offered by CATIA. Spain and Germany worked from CATIA V4, while the United Kingdom and France used V5, a complete rewrite of the previous version. The lack of compatibility cost the program nearly two years in schedule and about $6.1B in then-year development cost dollars. [16]

The releases were not fully compatible, which created problems, most noticeably, in the electrical systems. Most wire harnesses came up short, forcing the program to endure a nearly two-year overall delay at $6.1B.

To get an idea of that issue's impact on Development costs, we should begin with an notion of what those costs should be. For that, we'll use the Figure 11 data (in 2022$), Development Cost information available to Airbus at their launch.

If we analyze the data in Figure 12, we'll have the information available to Airbus in 2000.

When we run a linear regression on the data, we get Equation 2:

$$\text{Dev Cost \$2022M} = 0.0486(\text{MEW}) - 1110 + \varepsilon \quad (2)$$

Where:

Dev Cost 2022$M = predicted development cost in 2022$M
Final MEW = Ultimate MEW, in pounds
ε = Error term for the equation

Equation 2 has an adjusted R^2 of 92.6%, a MAPE of 46.0%, a Standard Error of $1,404,504,870, and a P-value of 8.73E-08.

Plotting the data in Figure 12, we find that if Airbus had used this equation as they launched, they would have predicted a 2022$ Development Cost of $27.9B using their projected starting weight (the blue point), or $29.4B (the green point) if they had allowed for weight growth to their final posted MEW. These figures compare to the Airbus estimate of $20.6B (their initial estimate of $12B inflated to 2022$). Richard Aboulafia put the final development cost between $31B and $37B. Using the midpoint of that range, or $34B, means the Airbus estimate was off by $34B - $20.6B = $13.4B, or 9.6 Standard Deviations from the estimate.

The company blamed its problems on schedule issues, but that doesn't seem to be the prime culprit. In Figure 13, we study the effect of size on schedule, as Operating Empty Weight (OEW) against the 1) Days from Launch to 1st Flight (Upper Right Chart), Days to 1st Certification (Lower Left Chart), and 3) Days to 1st Delivery (Lower Right Chart). Interestingly, we find the A380 actual schedule in keeping with the general trend, despite the company's position that their software compatibility issues cost them nearly two years of schedule. Surprisingly, the A380 took less time to develop than its smaller sister plane, the A350, which is less than half its size.

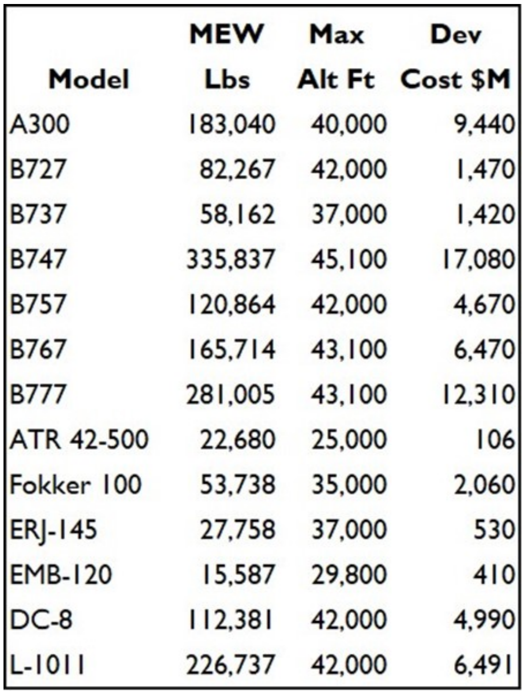
So, Airbus created a mess in their development phase, but they must have made up for it when they began delivering the planes.

Not really.

You'd want a production line to get its costs below its price as early as possible. However, well after their 200th delivery, "the [then] $445 million price tag of each aircraft was insufficient to cover the production cost. [That meant] …Airbus [was] losing money on each A380, and with orders evaporating, it made economic sense to shut down production."’ [19] [20]It was probably much worse than they let on, as we have seen in Figure 14. [21]

The Starting Point

Both Boeing and Airbus considered a plane that would eventually become the A380 or something like it. For a brief time in the early 1990s, they even considered working on such a project together. [22]But Boeing decided not to pursue the new jumbo aircraft, while Airbus did.



Model	MEW Lbs	Max Alt Ft	Dev Cost $M
A300	183,040	40,000	9,440
B727	82,267	42,000	1,470
B737	58,162	37,000	1,420
B747	335,837	45,100	17,080
B757	120,864	42,000	4,670
B767	165,714	43,100	6,470
B777	281,005	43,100	12,310
ATR 42-500	22,680	25,000	106
Fokker 100	53,738	35,000	2,060
ERJ-145	27,758	37,000	530
EMB-120	15,587	29,800	410
DC-8	112,381	42,000	4,990
L-1011	226,737	42,000	6,491

Figure 11: Development Cost Database Before A380 Launch Date

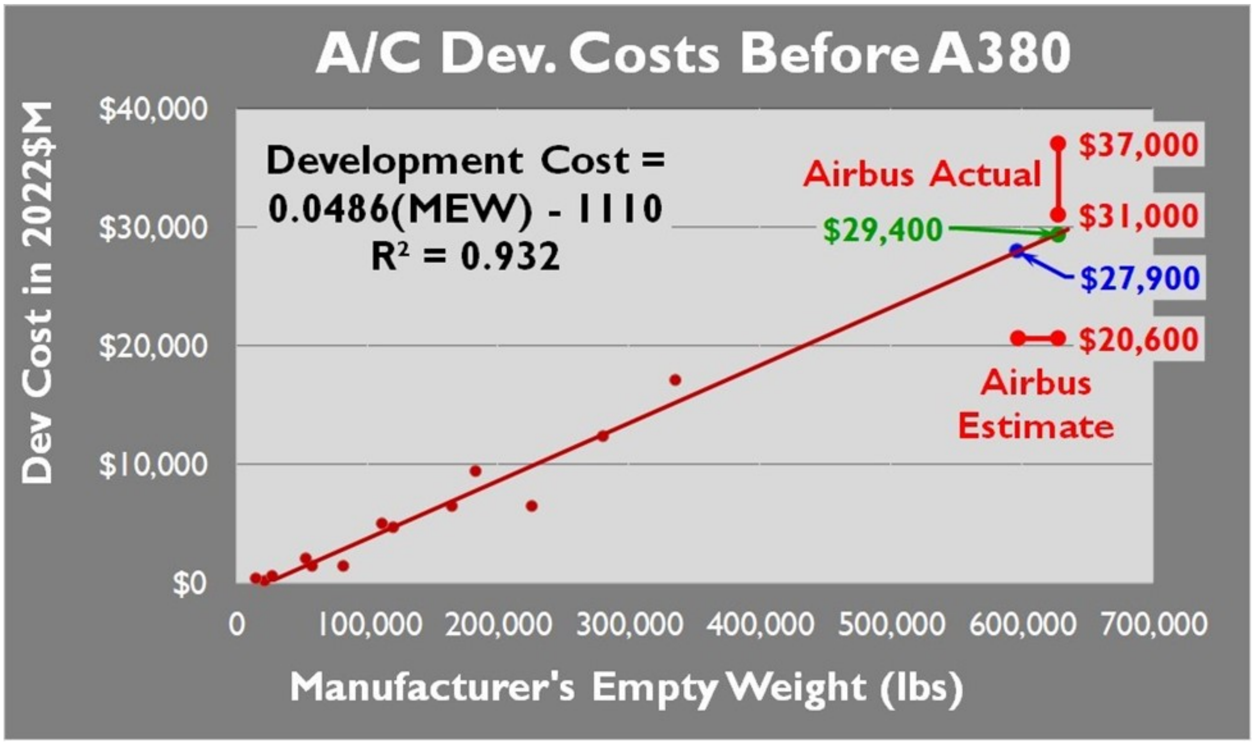
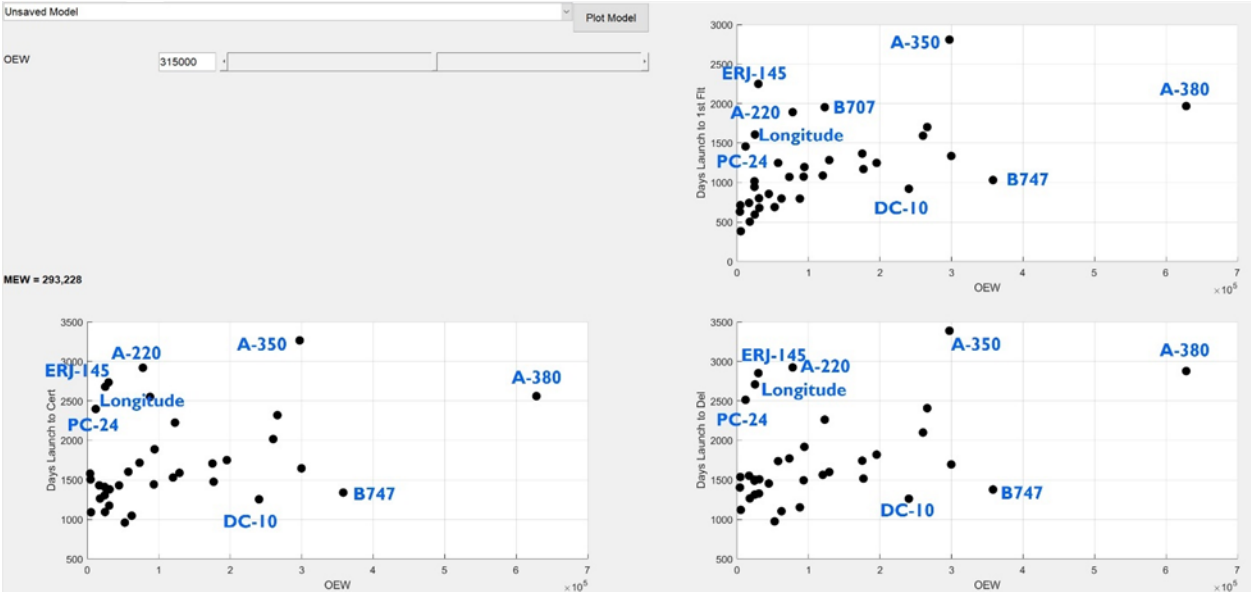


Figure 12: The original Airbus estimate for the A380 was 597,400 pounds, at $12B in 2000, which inflates to $20.6B in 2022. That's the leftmost of the points called the Airbus estimate – the rightmost one represents the exact cost of the A380's final weight. Had Airbus used this equation, their estimate would have been $27.9B. Its cost eventually rose to between $31B to $37B.



OEW 315000

MEW = 293,228

Figure 13: Airbus claimed a nearly two-year delay due to software incompatibility, leading to many of the A380's wire harnesses falling short. However, when we compare Operating Weight Empty (OEW) to 1) Days from Launch to 1st Flight (Upper Right Chart), Days to 1st Certification (Lower Left Chart), and 3) Days to 1st Delivery (Lower Right Chart), it does not appear to be the case. Instead, we find the A380 completed more quickly than its sister aircraft, the A350, at less than half its Operating Empty Weight. In this context, its Development Schedule looks reasonable. ***What About Production?***

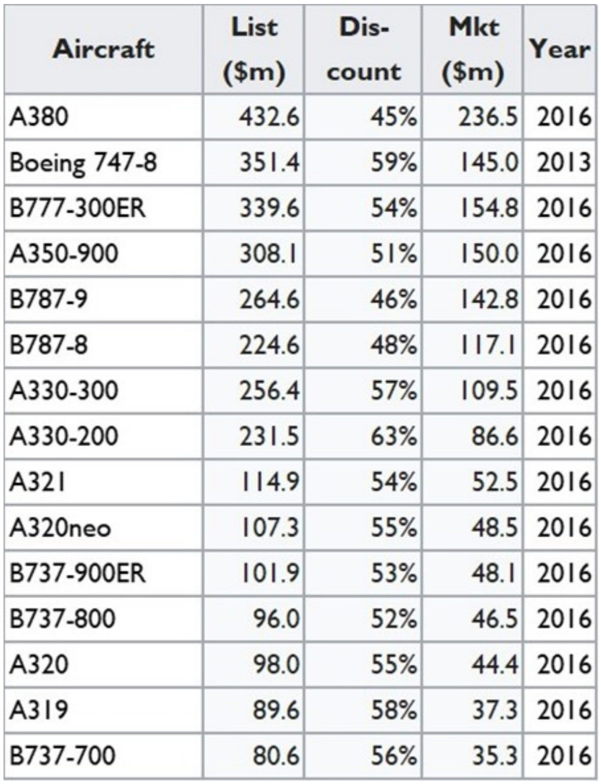
The break was due, in large part, to the differences in each firm's market projections, which we can observe in Figure 15. [23]

In 2000, as Airbus was about to launch the A380, they took little notice of how their market reacted to other products.

Had they examined their prime competitor, the Boeing 747, over the then past 20 years, they would have discovered the following in Figure 16:

The then-current models of the competitor's jumbo jet, the Boeing 747-200, -300, and -400, all had a much lower price tag than the Airbus entrant, selling for roughly 25% to 35% less than the A380. That fact is valuable information and is not to be ignored.

The primary observation we can make about Demand and Demand Curves is this: a higher price will tend to make fewer sales than competitors with lower price tags. Airbus had projected to sell over 1.5 times the number of A380s as Boeing sold B747s in the preceding two decades. They justified their numbers as being a function of seat cost. But eventually, sales will be limited by prices, no matter how hard program management tries to convince others otherwise.



Aircraft	List ($m)	Dis-count	Mkt ($m)	Year
A380	432.6	45%	236.5	2016
Boeing 747-8	351.4	59%	145.0	2013
B777-300ER	339.6	54%	154.8	2016
A350-900	308.1	51%	150.0	2016
B787-9	264.6	46%	142.8	2016
B787-8	224.6	48%	117.1	2016
A330-300	256.4	57%	109.5	2016
A330-200	231.5	63%	86.6	2016
A321	114.9	54%	52.5	2016
A320neo	107.3	55%	48.5	2016
B737-900ER	101.9	53%	48.1	2016
B737-800	96.0	52%	46.5	2016
A320	98.0	55%	44.4	2016
A319	89.6	58%	37.3	2016
B737-700	80.6	56%	35.3	2016

Figure 14: To attract enough customers, both Boeing and Airbus have to offer significant discounts

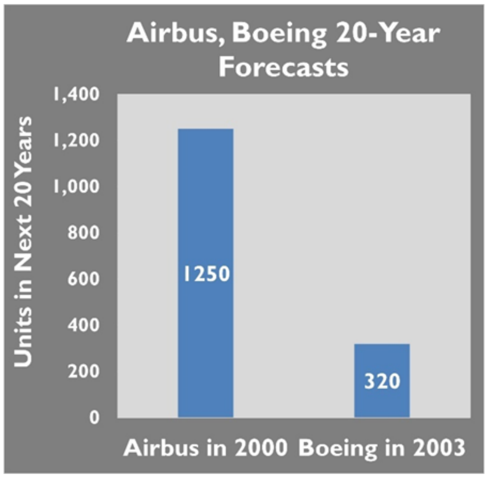


Figure 15: Airbus saw a market for its product that was nearly four times Boeing's projection

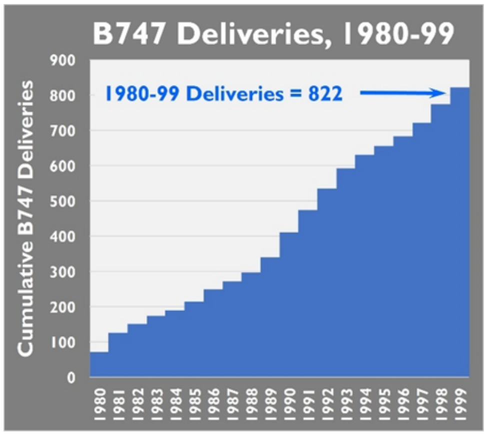


Figure 16: Boeing sold 822 B747s in the 20 years before the Airbus A380 launch; Airbus wanted to sell over 1.5X as many A380s in the following 20 years

In 2000, the world witnessed a multibillion-dollar example of this phenomenon. That year, Northrop Grumman completed the 21st and last example of their B-2 bomber. As revealed in Figure 17, the United States Air Force (USAF) originally wanted 132 vehicles, enough to form 11 squadrons of 12 aircraft each. However, the eventual recurring price of $1.2B was substantially more than the B-1B bomber, which the USAF purchased 100 units. While Northrop Grumman might have argued that they did not plan for the price to go so high, when it did, it came with consequences. The USAF Fighter/Bomber/Attack Aircraft Demand Frontier, which changed by about 2% from 1996 to 2021, was and remained a barrier to the number of units the service branch could absorb. While the variability about the curve allows for some margin of error, it did not allow for going over 6 times past (132 units (the original target) divided by 21 (the number delivered) = 6.29X) that limit.

Not surprisingly, we see the same behavior in commercial markets, specifically for airliners. In Figure 18, we plot 20-year quantities (from 1/1/1980 to 12/31/1999) and prices (which, in this industry, are much harder to find than like figures for USAF aircraft, as the United States Government (USG) must publish this data) for the then-current airliners for sale in 2000. We had to combine configurations (or "Dash Numbers," as they say in the aviation industry) to get the entire series produced over the period.

When we do, we find the 20-year Demand expressed by Equation 3:

$$1999\$M = 197Qty^{-0.188} * \varepsilon \qquad (3)$$

Where:

1999\$M = Aircraft Model Price in 1999\$M
Qty = Quantity sold from 1/1/1980 to 12/31/1999
ε = Error term for the equation

Equation 3, while not well-correlated with an R^2 of 45.8%, has a P-value of 3.5%, just below the 5% threshold typically used for this metric. The implication is that the opening position of the A380 sales target was about 9.7 standard deviations past its mean. Though widely off target, this miss approximates the error of 9.6 standard deviations calculated for their prediction of Development Cost. Note the eventual sales figure of 251 units is still vastly past the Demand Frontier.

Airbus A380 Summary

It is a too frequently appealing idea to find a product metric in which your firm excels and assume that it alone will draw in more customers than your competition. For Airbus, that measure was the cost per seat mile. While that is no doubt a crucial factor, there are always other market forces at work which suppliers must consider.

Supposing you will sell over 50% more units than your closest competitor with a product priced much higher is not borne out by Demand Frontier analysis. Without doing that work in advance, you might imagine you could exceed that limit by nearly 10 standard deviations. And that is what Airbus did. In the end, they lost tens of billions of Euros. But, for the lack of a detailed Demand Study before launch, the whole fiasco need not have happened.

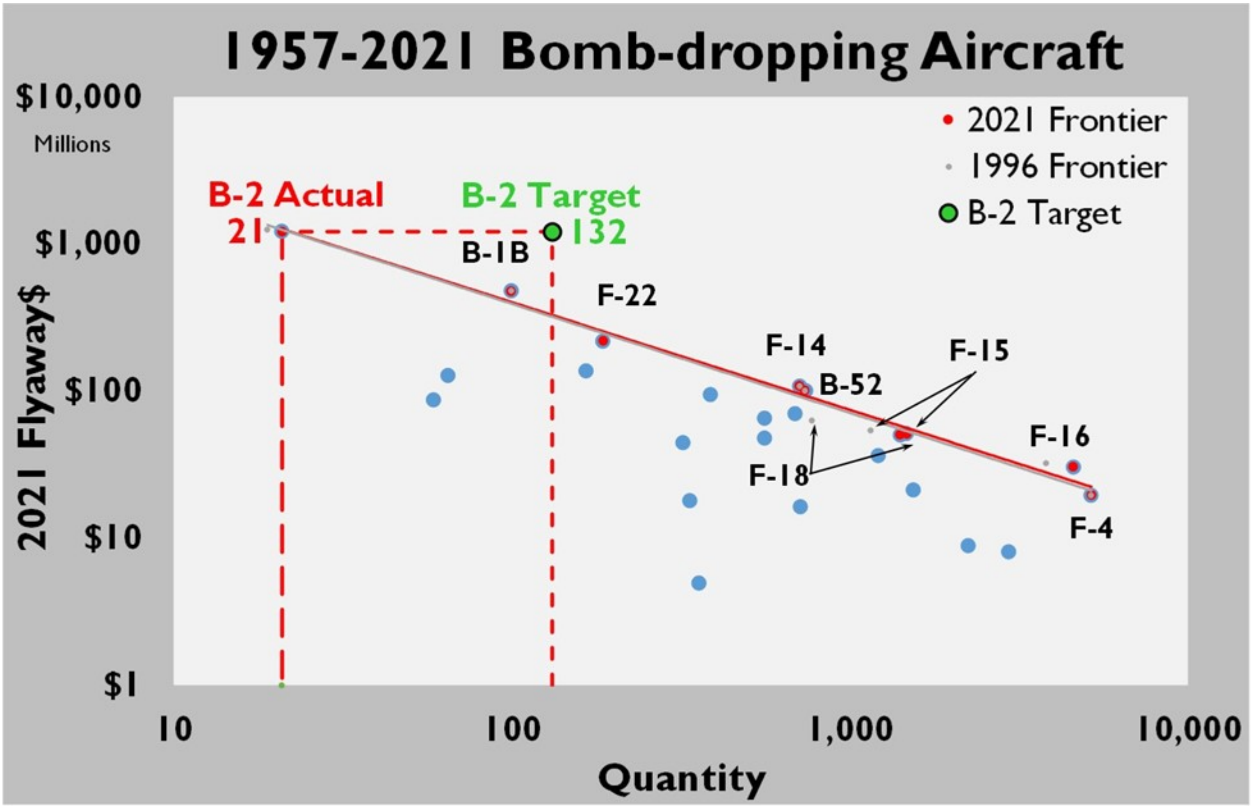


Figure 17: Northrop Grumman and the United States Air Force wanted to build 132 B-2 bombers. But, as the price rose, they found their sales limited to 21 units, almost precisely what the Demand Frontier limit was.

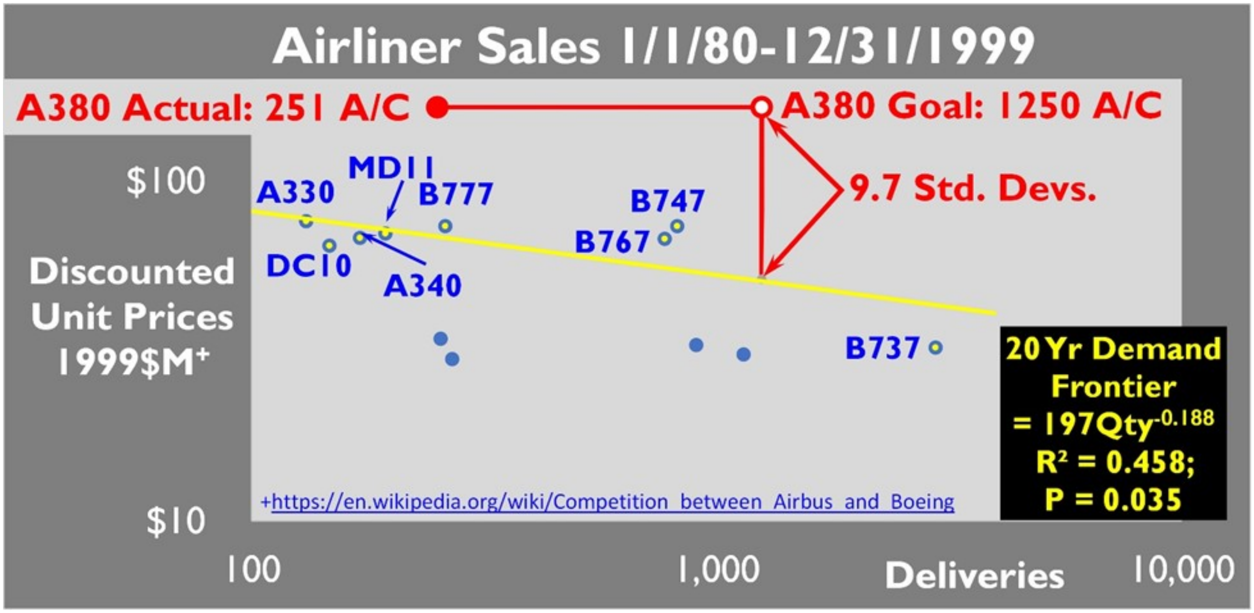


Figure 18: Airbus hoped to sell 1250 aircraft at their target price. But even their discounted price exceeded the Demand Frontier by 9.7 Standard Deviations at their goal quantity. Even the eventual sales figure of 251 units was vastly beyond the Frontier, implying many, if not most, or even all, sales at a loss.

Figure 19: The DeLorean DMC-12 [24]

Precursor: The DeLorean Debacle

It's not as if Europe had not previously seen how improperly constructed business analyses could lead to financial disaster. Less than two scant decades earlier, they endured the rapid rise and quicker demise of the DeLorean Motor Company.

The DeLorean DMC-12, pictured in Figure 19, with its gull-winged doors, mid-engine, and stainless steel body, was the brainchild of John DeLorean. The youngest person to become an executive at General Motors, he went to Northern Ireland to pursue his goal of building his innovative machine. He thought the gull doors, stainless steel body, and mid-engine design would attract sufficient buyers, similar to Airbus's thinking a lower cost per seat mile would attract customers.

To its credit, Airbus offered its customers an excellent value proposition with its A380, as the vehicle offered substantially more range and was slightly faster than its Boeing 747 counterparts.

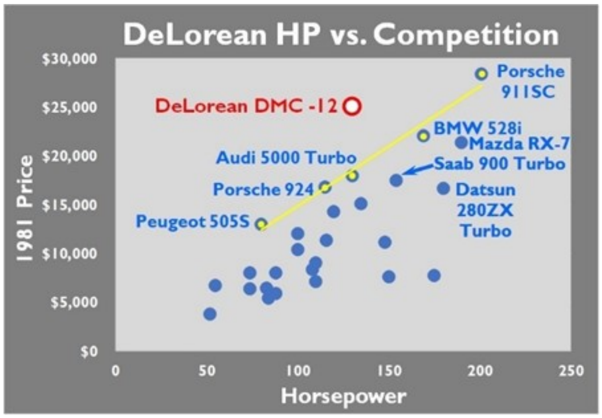


Figure 20: The DMC-12 wanted a lot more money per Horsepower than its competitors

Here is one critical area in which DeLorean failed to understand the business proposition from his customers' points of view. After many schedule delays and cost overruns, DMC-12 production began in late 1980. While good looks and innovation will always draw car buyers, those who buy sports cars want Horsepower—and the DMC-12 did not have nearly enough of it. Figure 20 shows the horsepower ratings and prices for the leading cars in 1981.

Usually, several features determine the Value or sustainable price of a product. For 1981 cars, that came down to Horsepower and the number of units sold, as depicted by Equation 4.

$$1981\ \text{Price} = 8546HP^{0.494} * 1981\ \text{Qty}^{-0.197} * \varepsilon \quad (4)$$

Where:

1981 Price = 1981 car model sales price
H/P = Installed Horsepower on each model
1981 Qty = Quantity sold in 1981
ε = Error term for the equation

In Figure 22A, we see that the set of features DeLorean put forth was worth, according to Equation 4, only $15,500, compared to its list price of $25,000. That puts it 1.43 Standard Deviations past its prediction (($25,000-$15,500)/$6,645 = 1.43). That proved to weaken Demand, as we'll see presently. Figure 22B shows us that to reach the desired target, without considering the Demand Frontier, DeLorean should have taken the vehicle up to 262 horsepower. Importantly, as we might have guessed, the phrase "without considering the Demand Frontier" hints that we ought to analyze Demand thoroughly.

Figure 23 depicts the interaction between the Demand Frontier, which applies to and limits the entire market, and Product Demand. This curve shows how the market-determined Value of a 1981 car falls as more units are produced. In that year, Product Demand fell according to its exponent (-0.1971), equating to an 87.2% Learning Curve if it were one of those. That means if a firm has found itself with a Learning Curve of, say, 90%, the Product Demand Curve and its associated Learning Curve might intersect. Figure 23 reminds us that Product Demand Curves are always flatter than the Demand Frontier they collectively comprise.

As we discover in Figure 24, in 1981, DeLorean built past the Demand Frontier. The company made 7,500 DMC-12s, but the market's self-imposed unit sales limit of $25,000 that year was 6,000. As

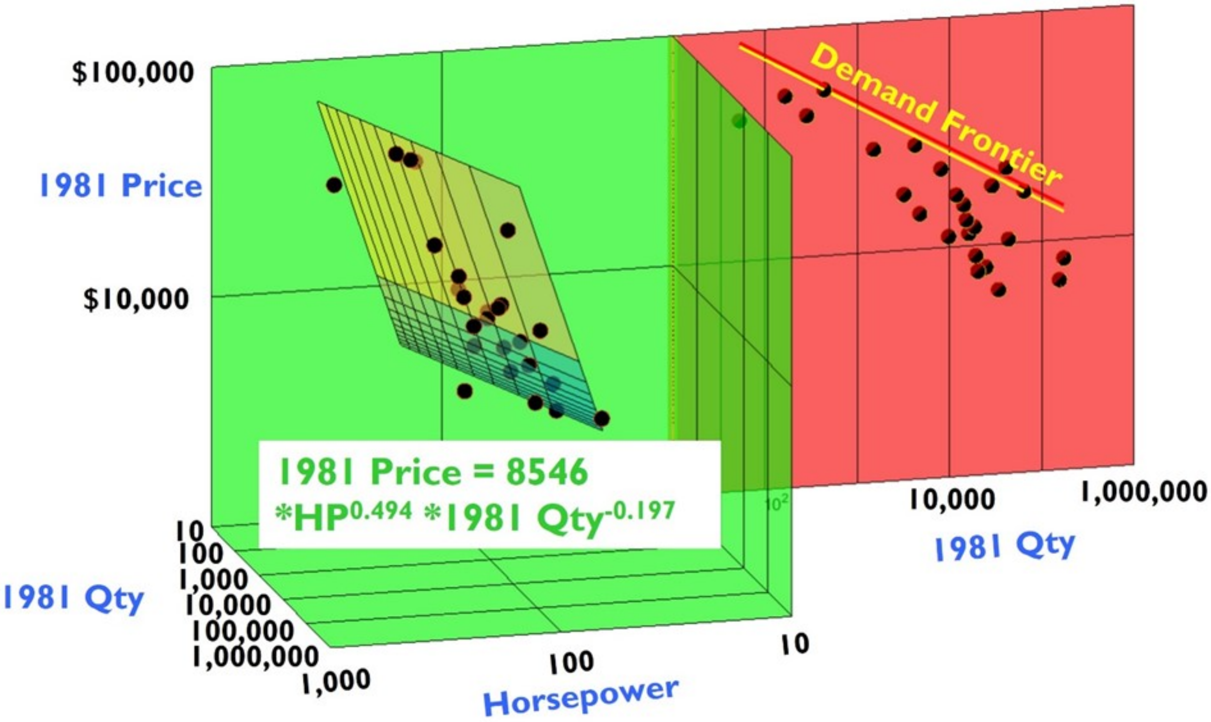


Figure 21: The prices for cars in 1981 went up with added Horsepower and down as quantities increased

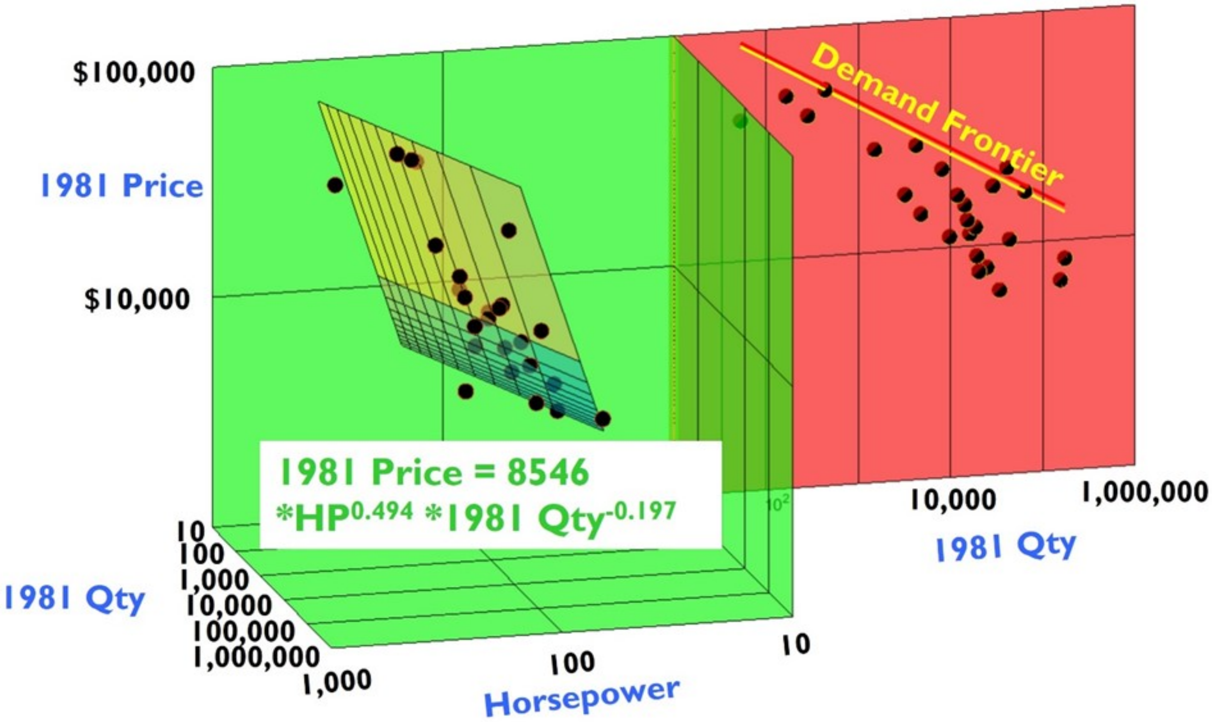


Figure 22: The DeLorean DMC-12 had insufficient Horsepower to sustain the price they wanted for the 7,500 units they hoped to sell that year. Their 1981 price was $25,000, but, as shown in A, that combination was only good for $15,500. In B, we discover that to make the $25,000 price, DeLorean would have had to install an engine with 262 horsepower, not the one with 130 they used equation 4's Adjusted R2 is 76.3%, a MAPE of 24.9%, a Standard Error of 6625, and a P-Value for the entire equation of 5.08E-08, and P-Values of 0.94% and 2.0E-05 for Horsepower and Quantity, respectively. This equation states that sustainable prices go up with Horsepower and down with Quantity, as shown in Figure 21.

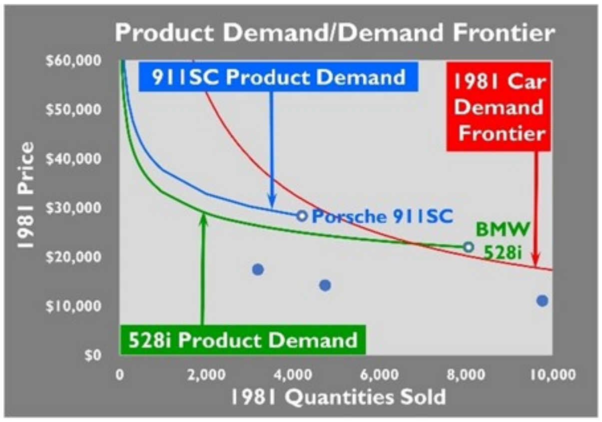


Figure 23: Product Demand Curves (as the Porsche 911SC and BMW 528i) are always flatter than their associated Demand Frontiers.

always, not all firms can make it to the Demand Frontier, and in that year, DeLorean fell far short, only selling 3,000 models. They were left holding thousands of DMC-12s in inventory.

DeLorean DMC-12 Summary

There are many ways to sink a program, and DeLorean found most of them. Cost overruns can be fatal to a program, and the DMC-12 had them from the start and managed to get into production despite those setbacks. But, crucially, miscalculations regarding Value and Demand can be, and here were, equally devastating.

DeLorean bet its sleek design would be enticing, and, to an extent, it was. In the end, making a sports car requires a sporty engine. Value Analysis reveals they offered a little less than half of what they would need to sustain their price.

Disappointing for the firm was their miscalculation of Demand. Having not studied the applicable Demand Frontier, they were only too happy to attempt to exceed it dramatically. That approach seldom works, and it didn't work for DeLorean.

Conclusion

In market analytics, as in construction and rocketry, knowing where you are aiming is essential. Steps need to be taken to ensure that one's foundation is sound. The A380 and DMC-12 did not take the time to do that, just like the towers in Italy and San Francisco.

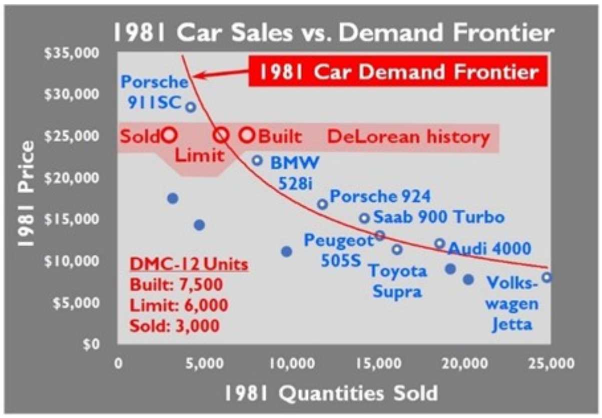


Figure 24: DeLorean built more DMC-12s (7,500) than the 1981 Demand Frontier would sustain (6,000) and ended up selling 3,000 units in 1981

To date, market analysis has focused chiefly on cost and schedule. Both are crucial. Missing either of those targets by a large margin can make a program, or even a firm, go bankrupt.

The European firms Airbus and DeLorean Motor Company missed cost and schedule goals, impacting both greatly.

For the Airbus A380, well-researched analytics at the beginning of the program might have convinced the firm not to proceed. All the data needed to make that decision existed and was retrievable before the program launch. Firms in this pre-launch mode often rely on customer surveys to gauge market interest. They will take polls, sum up the results, discount them by some method, and then suppose they have a clear market picture. Ultimately, we should rely on buyers' actions, not their words. Observing past and present market reactions is the best way to predict future behavior.

DeLorean supposed, without analysis, that the beauty and innovation in his DMC-12 would more than make up for its lack of horsepower. It did not. Combining that error with guessing about Demand rather than analyzing it, the company created a recipe for financial ruin.

Between a firm's cost and schedule data, and the information its buyers reveal through their purchases, there is ample knowledge to refine new business cases compared to the ones done before.

Doug Howarth pioneered Hypernomics, the study of market actions across four or more dimensions. Hypernomics reveals the linked, opposing, non-physical forces known as the Law of Value and Demand, replacing the Law of Supply and Demand. The new field discovers buyers collectively form discernable patterns that may be statistically quantified and move over time. Analysis of those movements permits users to predict market positions with greater accuracy. Mr. Howarth has issued 15 peer-reviewed papers across four continents. His company, Hypernomics Inc., founded on his ideas, has worked for NASA, Virgin Galactic, Lockheed Martin, Raytheon Technologies, and Northrop Grumman. The US Patent Office issued US Patent 10,402,838 to him and two others in his company for the world's first 4D market analytic software. He has addressed the Royal Aeronautical Society and NASA three times each. Wiley published his book, "Hypernomics: Using Hidden Dimensions to Solve Unseen Problems," in 2024.

References

1. https://aviationweek.com/shownews/dubai-airshow/what-went-wrong-airbus-a380, retrieved Jan 31, 2023
2. Ibid.
3. https://www.netflix.com/watch/81594700?trackId=14170286, Episode 1, Retrieved February 5, 2023
4. https://commons.wikimedia.org/wiki/File:Kheops-Pyramid.jpg
5. Dash, Glen, "Occam's Egyptian razor: the equinox and the alignment of the pyramids," The Journal of Ancient Egyptian Architecture, Vol. 2, 2017, p. 1
6. Leaning Tower of Pisa. (2022, December 15). In https://en.wikipedia.org/wiki/Leaning_Tower_of_Pisa
7. Photo by Author, June 9, 2022
8. Millennium Tower (San Francisco). (2023, January 24). In Wikipedia. https://en.wikipedia.org/wiki/Millennium_Tower_(San_Francisco)
9. Van Derbeken, Jason (May 12, 2022). "Underground Wall Could Be Hitch for SF's Millennium Tower Fix Plan." NBC Bay Area.
10. https://www.globalsecurity.org/military/world/europe/a380.htm
11. Etsy, Benjamin C., and Ghemawat, Ghemawat, "Airbus vs. Boeing in Superjumbos: Credibility and Preemption," Harvard Business School Working Paper 02-061, August 3, 2001
12. Ibid
13. www.flug-revue.rotor.com/FRTypen/FRA3xxx.htm
14. Howarth, Douglas K., "The Checkmark Function," given to the 2008 ISPA Conference
15. https://en.wikipedia.org/wiki/Airbus_A380
16. https://calleam.com/WTPF/?p=4700
17. https://calleam.com/WTPF/?p=4700
18. Aboulafia, Richard, Airbus A380: The Death Watch Begins, Forbes, Jun 6, 2016
19. Goldstein, Michael, "Is Airbus Finally Ready To Shut Down A380 Production? Forbes December 27, 2017
20. https://en.wikipedia.org/wiki/Airbus_A380
21. https://en.wikipedia.org/wiki/Competition_between_Airbus_and_Boeing
22. DeLorean Motor Company. (2023, January 10). In Wikipedia. https://en.wikipedia.org/wiki/DeLorean_Motor_Company

The International Cost Estimating and Analysis Association is a 501(c)(6) international non-profit organization dedicated to advancing, encouraging, promoting and enhancing the profession of cost estimating and analysis, through the use of parametrics and other data-driven techniques.

www.iceaaonline.com

Submissions:

Prior to writing or sending your manuscripts to us, please reference the JCAP submission guidelines found at

www.iceaaonline.com/publications/jcap-submission

Kindly send your submissions and/or any correspondence to:
jcapeditor@iceaaonline.org

International Cost Estimating & Analysis Association
4115 Annandale Road, Suite 306 | Annandale, VA 22003
703-642-3090 | iceaa@iceaaonline.org