Engineering Risk Management and the 'Conspiracy of Optimism'

Abbott Aerospace
Canada Ltd

www.abbottaerospace.com

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Abstract:

When engineers see the phrase ‘Breaking Barriers of the Impossible’ they naturally believe it to apply to the engineering domain and more specifically the technical aspects of the engineering domain. A rational assessment of critical regulatory and commercial risks of product development is crowded out by the enthusiasm of the engineer for a clever technical idea.

The risks of technical failure are usually understood, relatively easy to assess and nevertheless are often underestimated. The risks of regulatory and commercial failure are less well understood, harder to assess and seldom rationally addressed.

This presentation examines why aerospace programs fail and how engineers can better advise managers and company leaders on the actual likelihood of success of a product or program.

David Zimmerman—Getty Images

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Richard Abbott is the president of Abbott Aerospace Canada Ltd and AAV Ltd. He has spent nearly 30 years in military and civil aerospace development. Richard has moved from being a stress engineer to airframe and flight controls leadership and CTO roles. In the last 20 years most of Richard's work has been with aerospace start up companies in North America.

Richard is the author of a widely used reference book 'Analysis and Design of Metallic and Composite Flight Vehicle Structures' and hundreds of engineering analysis spreadsheets that have over one million downloads. Abbott Aerospace hosts one of the worlds largest digital repositories of public domain technical aerospace information at abbottaerospace.com.

Richard has advised, carried out engineering work for, and helped lead many aerospace projects and companies and likely has ADHD, PTSD or both.

Definition of Terms

Definition of Engineering:

Engineering is the use of scientific principles to design and build machines, structures, and other items, including bridges, tunnels, roads, vehicles, and buildings.
(https://en.wikipedia.org/wiki/Engineering)

Yes……but……something is missing

Definition of Success:

Commercial - ROI – Return on Investment.

Non-Commercial – Complete the mission (not the subject of this presentation)

Understanding the Terms – Real world Implications

Engineering:
Developing a product within a development budget that both satisfies a market need and is in compliance with applicable regulations.

Definition of Success:
Selling enough of a demonstrable safe and reliable product at a high enough margin to pay back the development budget (and other associate costs) and provide a profit, or create a return on the investment

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Breaking Barriers of the Impossible

The impossible often has a kind of integrity which the merely improbable lacks. – Douglas Adams

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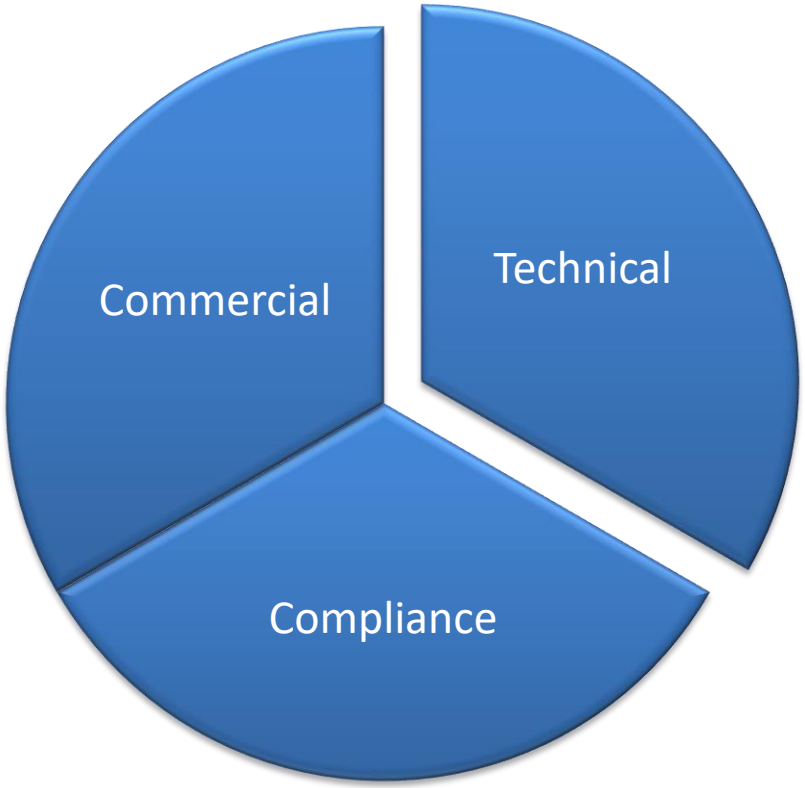
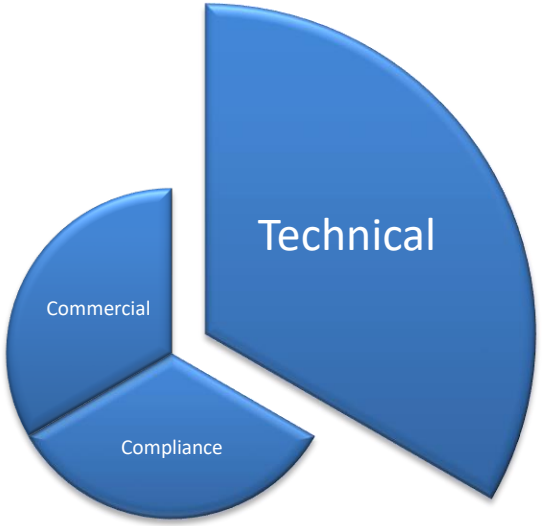
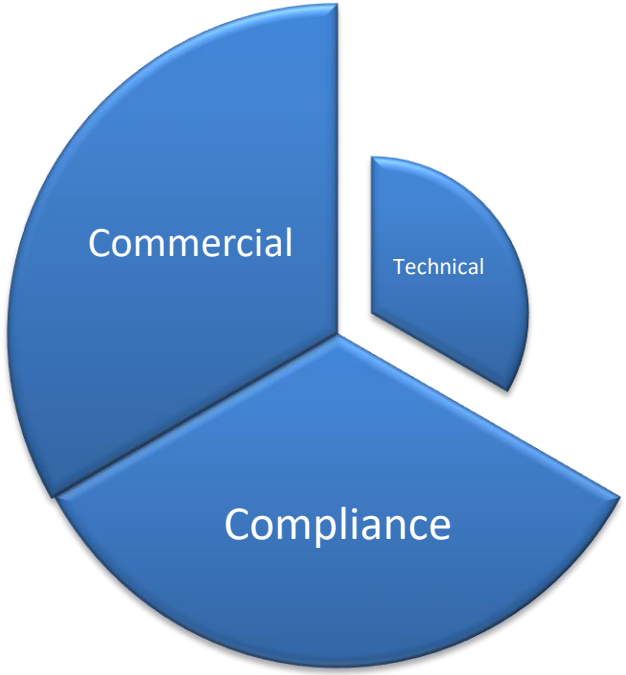
The Trifecta of Failure Inducing Risk







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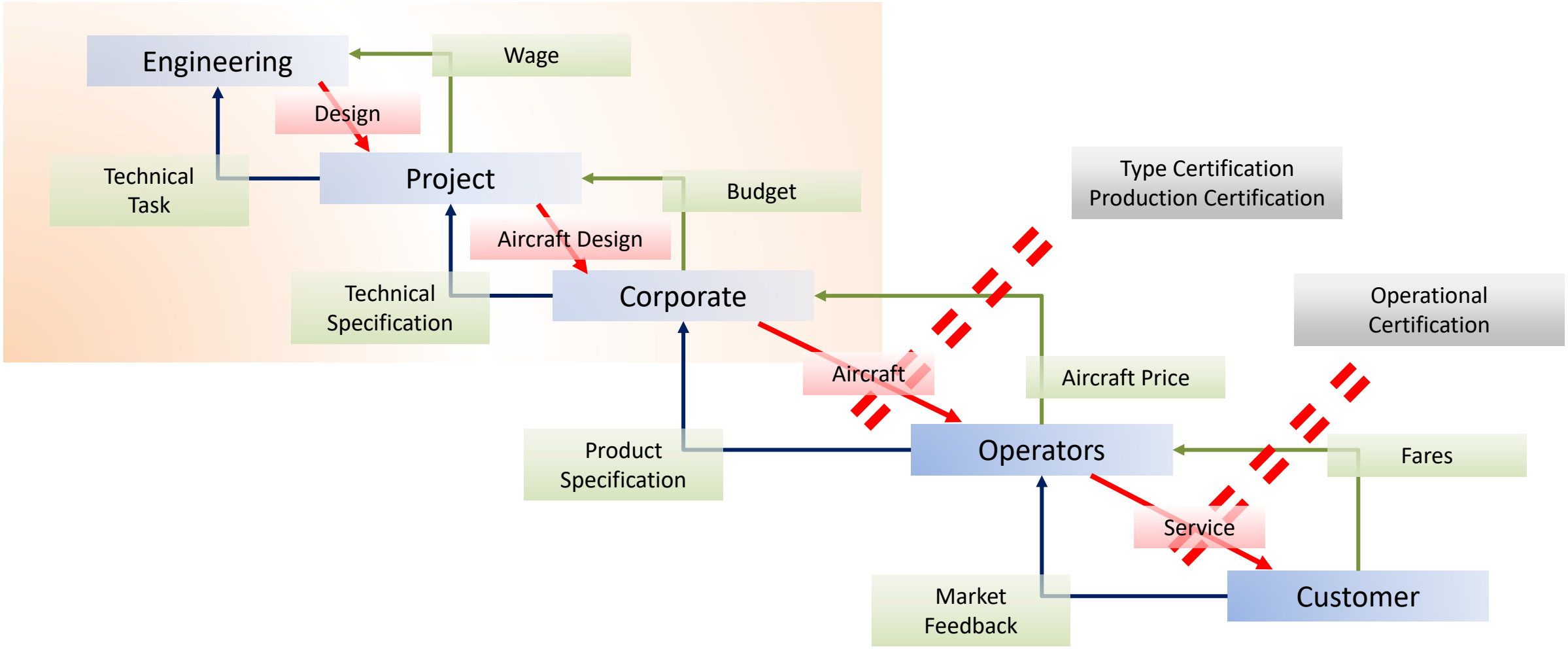
Simple Model of Aircraft Development Projects - 'Flow' – Commercial Codependences



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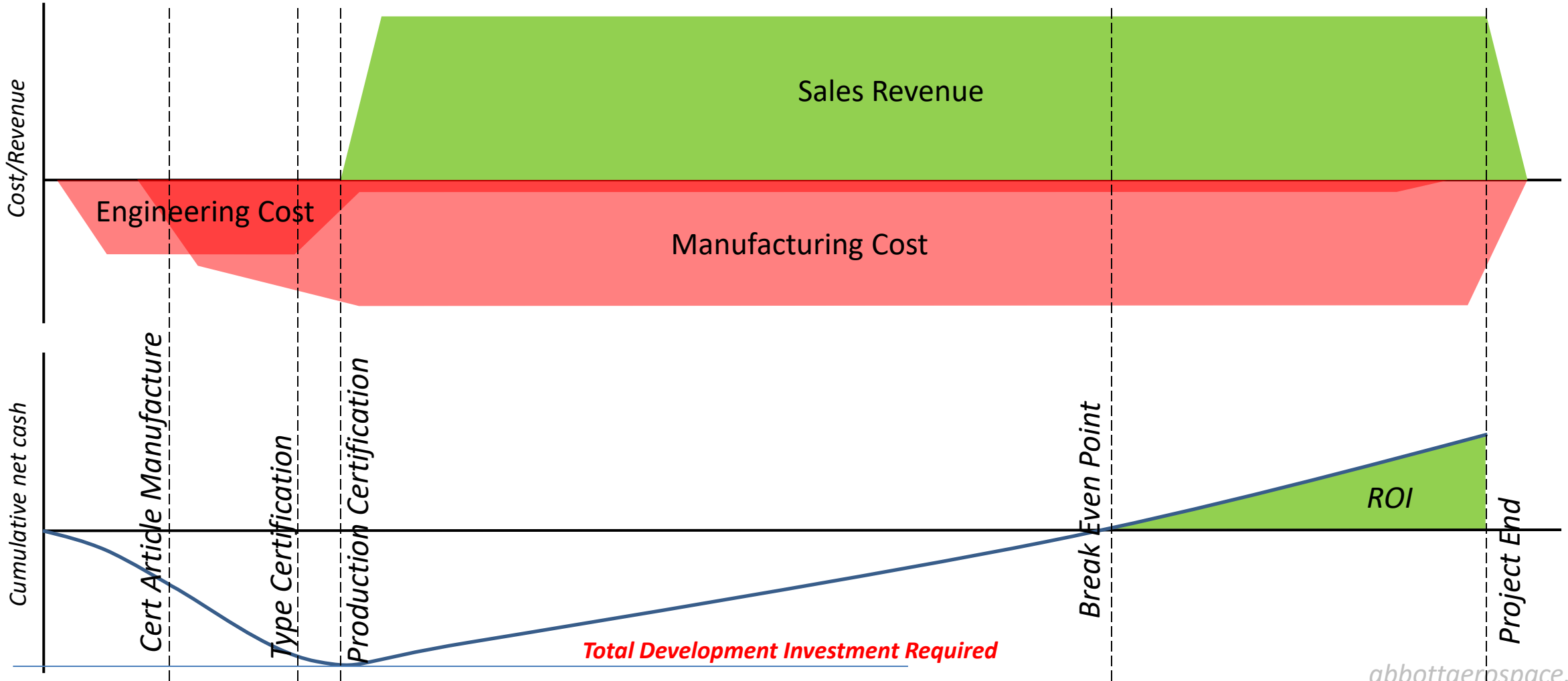
Simple Model of Aircraft Development Projects - Financial Time Line - Commercial



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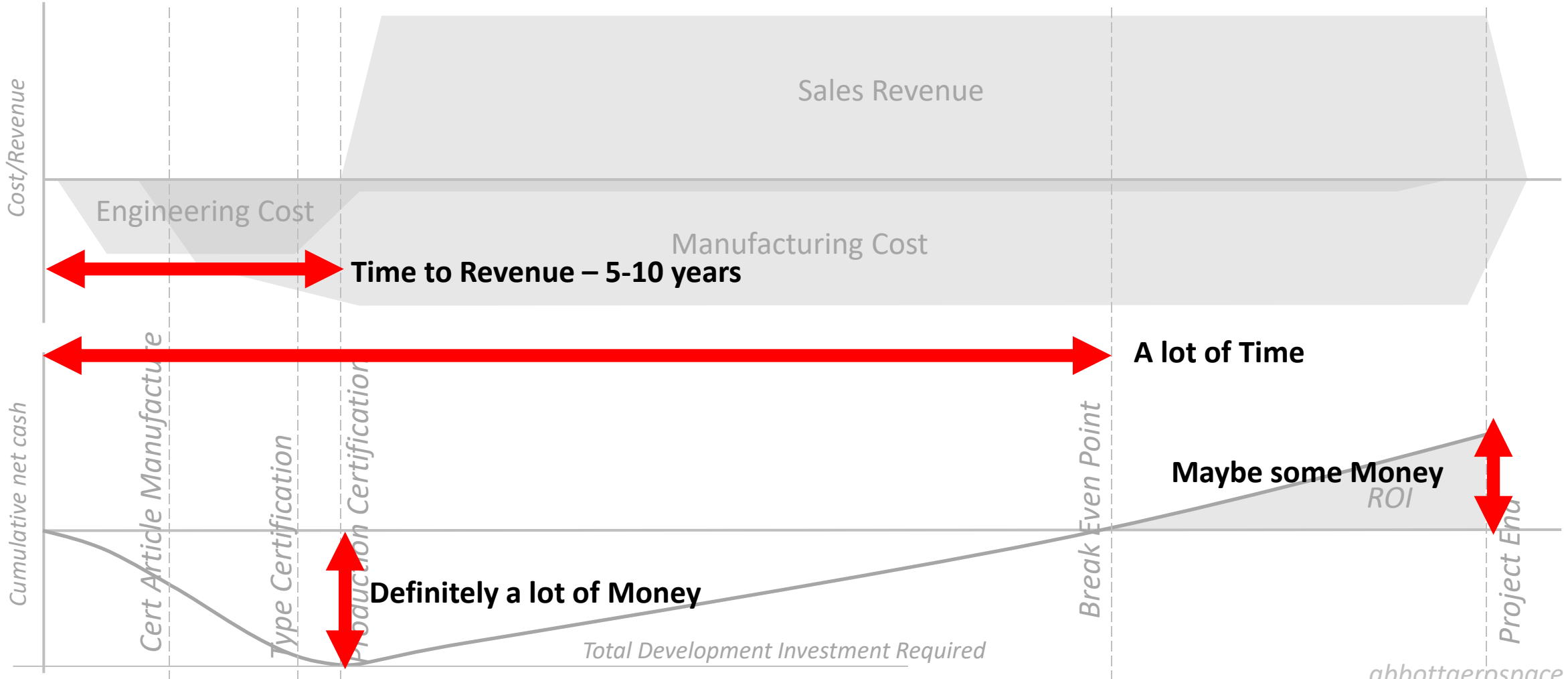
Simple Model of Aircraft Development Projects - Financial Time Line – Commercial



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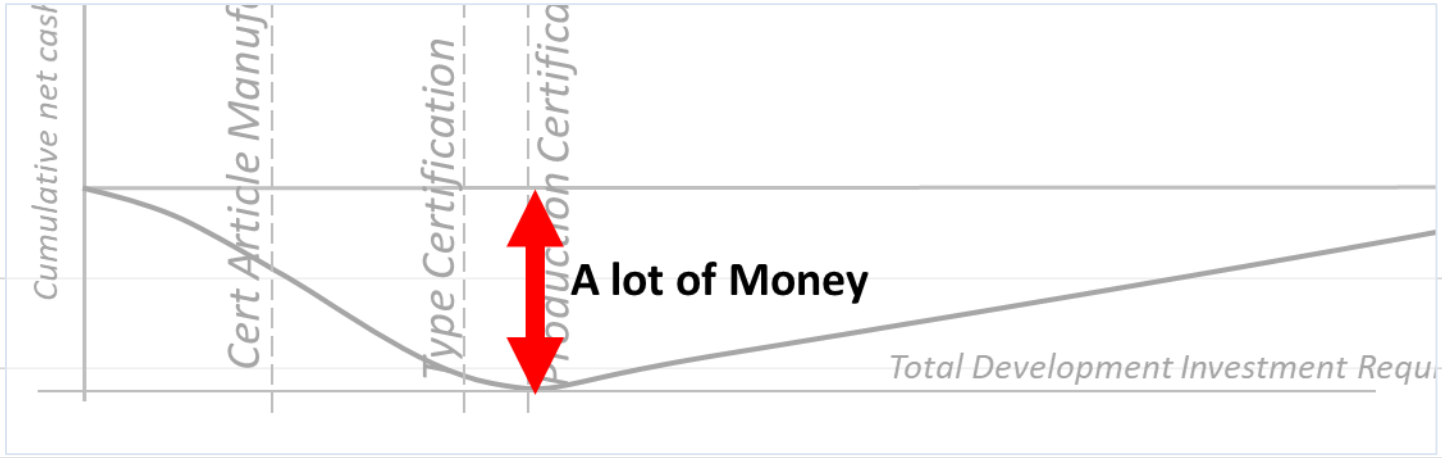
Estimated Cost to Get to Market



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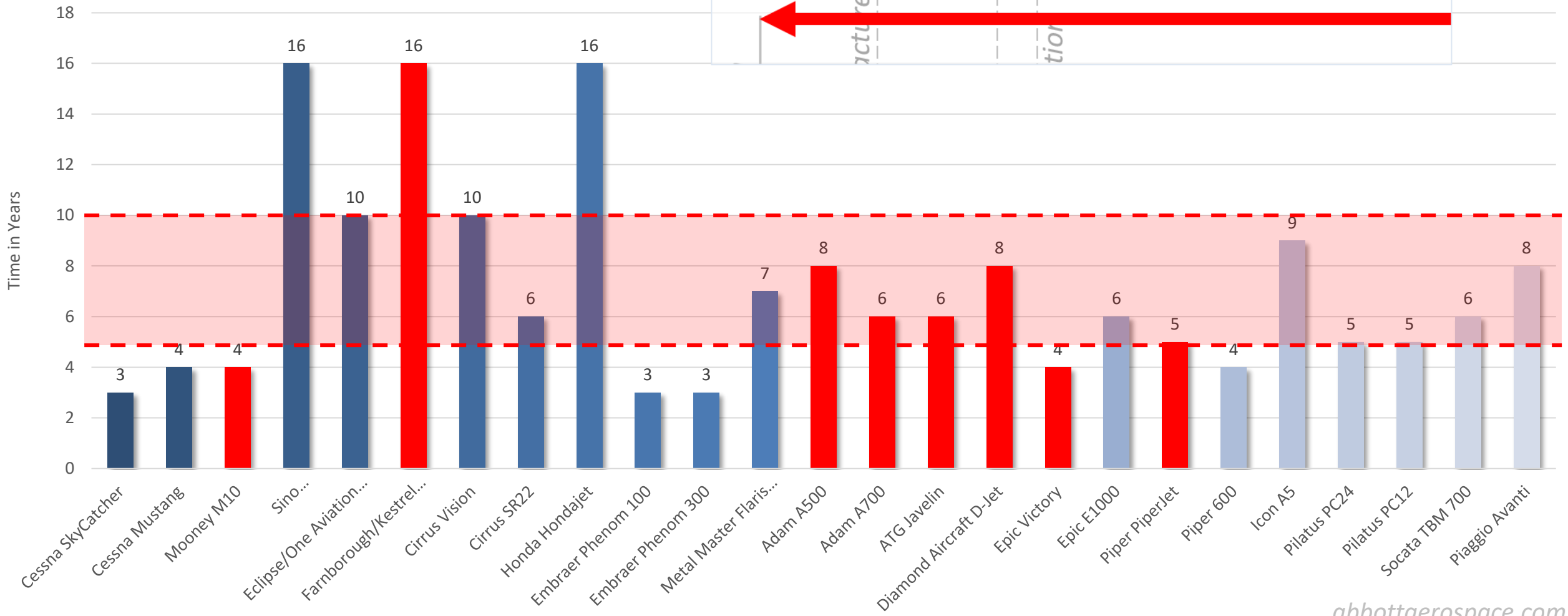
Estimated Time to get to Market



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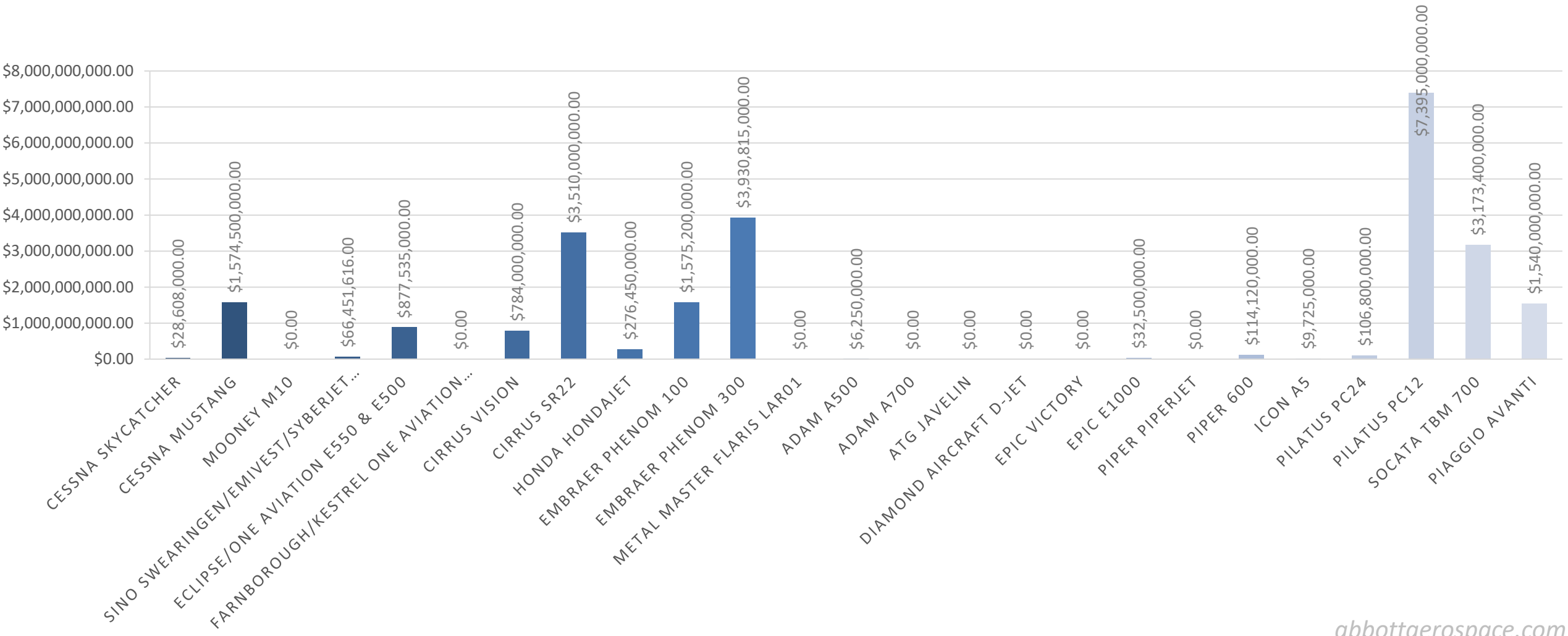
Bad Estimation of Total Revenue



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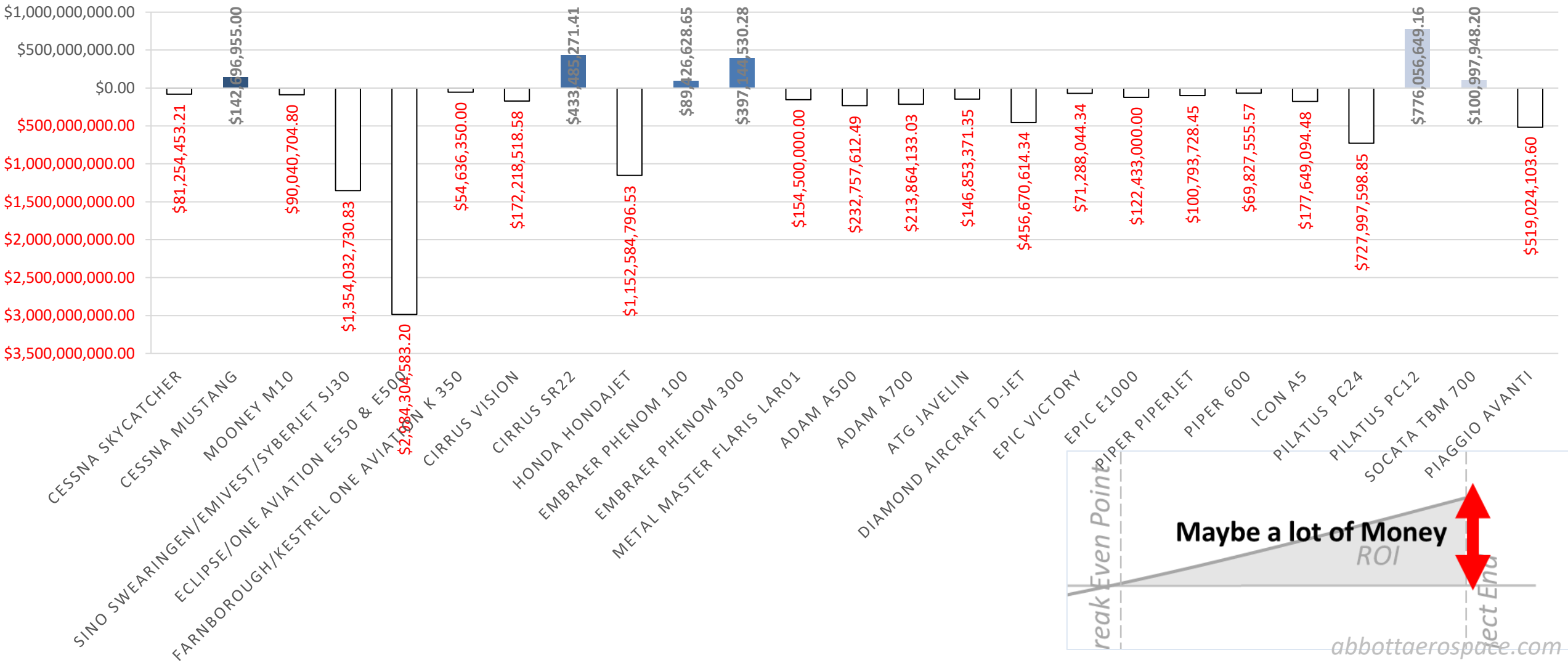
Very, Very Bad Estimation of Total Project Profit & Loss



Assessment of Development Performance - Summary

1. It is very difficult to get an aircraft through the certification process
2. It is very difficult to get to make a return on investment

Duh

Why?

What can an engineer do to help?

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Everything is a model

$$I_x = \int y^2 dA$$

$$I_y = \int x^2 dA$$

$$I_x = \frac{1}{3} \cdot (b \cdot d^3 - (b-t) \cdot (d-t)^3) - A \cdot (d - \bar{x})^2$$

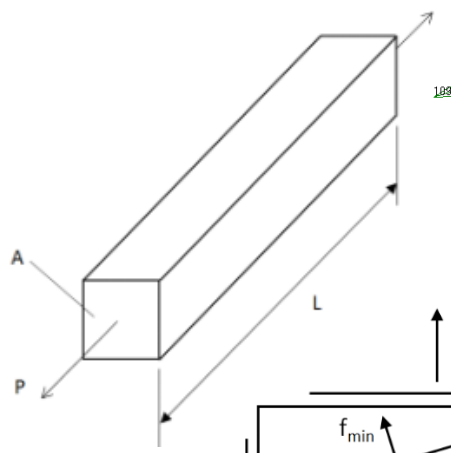
$$I_y = \frac{1}{3} \cdot (d \cdot b^3 - (d-t) \cdot (b-t)^3) - A \cdot (b - \bar{x})^2$$

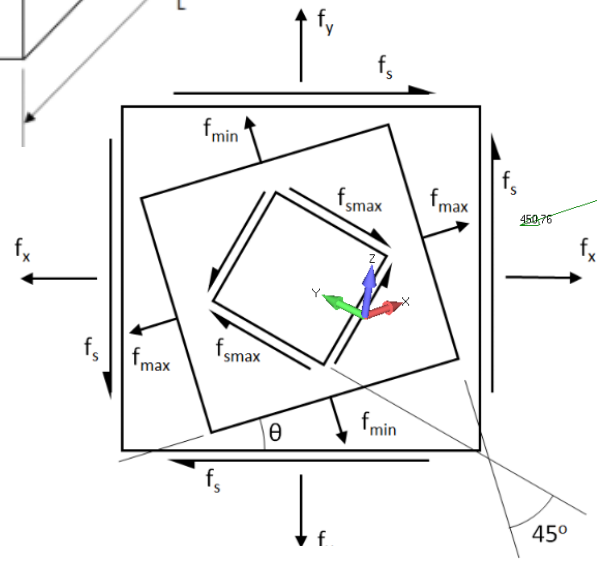
$$Max.y = -\frac{1}{60} \cdot \frac{W}{E \cdot I} \cdot [(5 \cdot a^2 + 10 \cdot a \cdot b + 15 \cdot b^2) \cdot L^3 - a^3 \cdot (4 \cdot L + 5 \cdot b)]$$

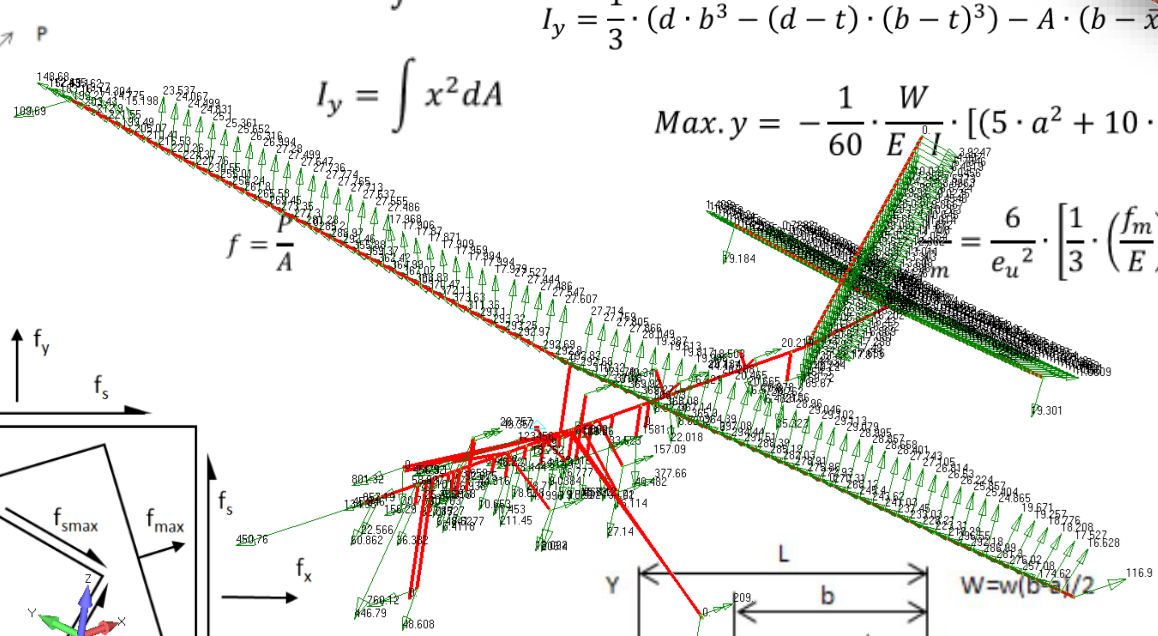
$$f = \frac{P}{A}$$

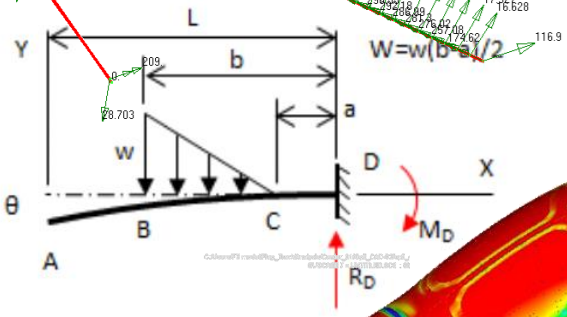
$$\frac{f_m}{E} = \frac{6}{e_u^2} \cdot \left[\frac{1}{3} \cdot \left(\frac{f_m}{E}\right)^2 + e'_u \cdot \left(\frac{n+1}{n+2}\right) \cdot \left(\frac{f_m{}^{n+1}}{E \cdot F_{tu}{}^n}\right) + \frac{n}{2 \cdot n + 1}\right]$$

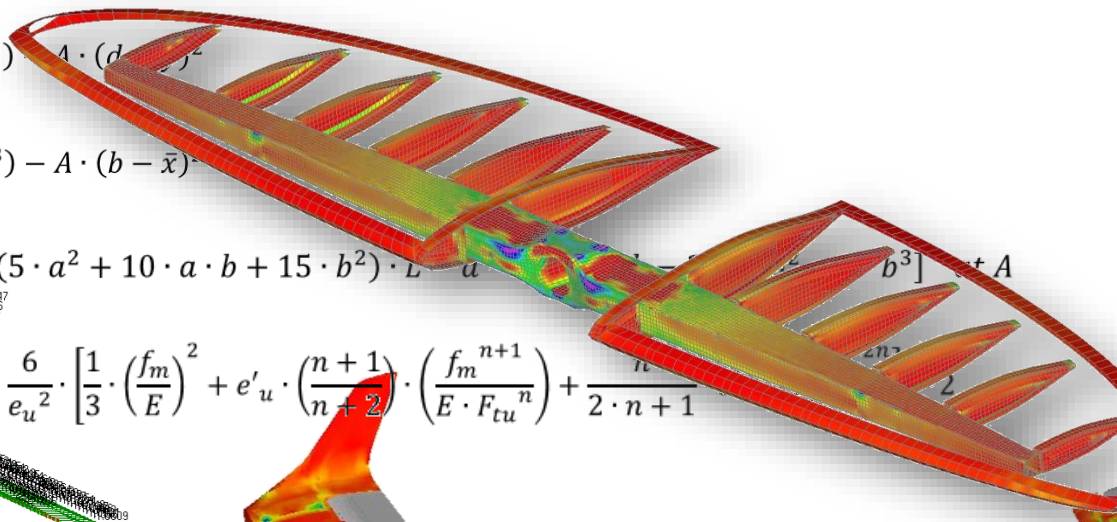
$$f_{max} = \frac{f_x + f_y}{2} + \sqrt{\left(\frac{f_x - f_y}{2}\right)^2 + f_s{}^2}$$

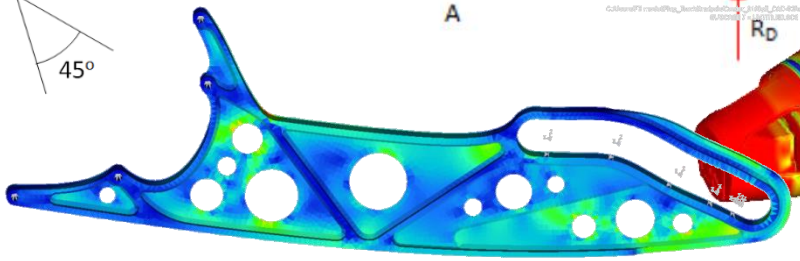


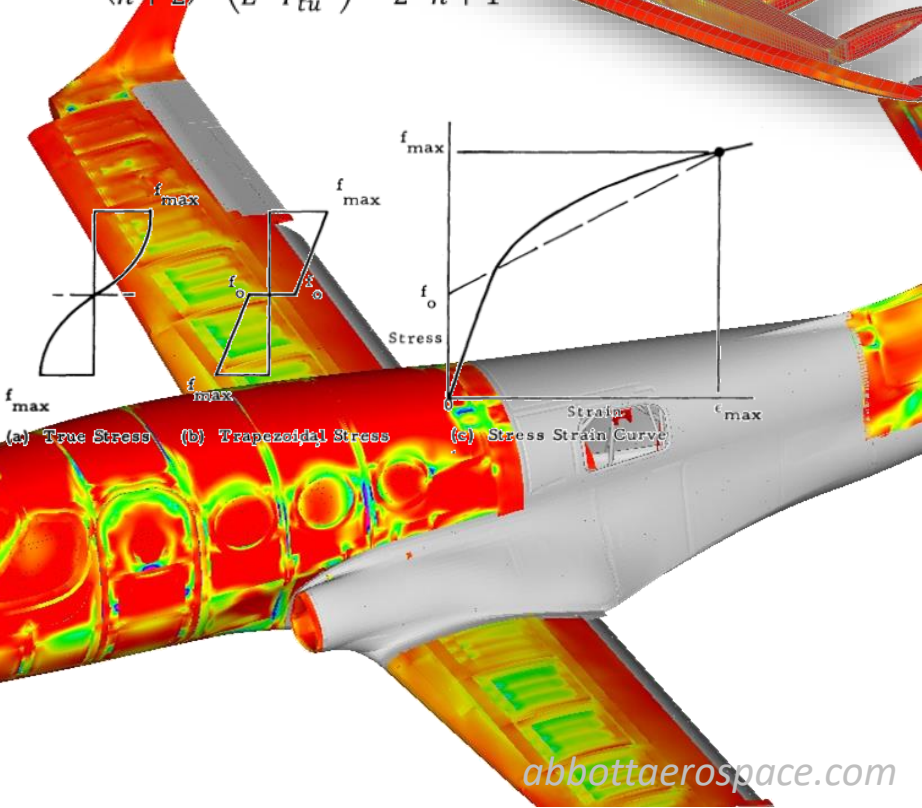












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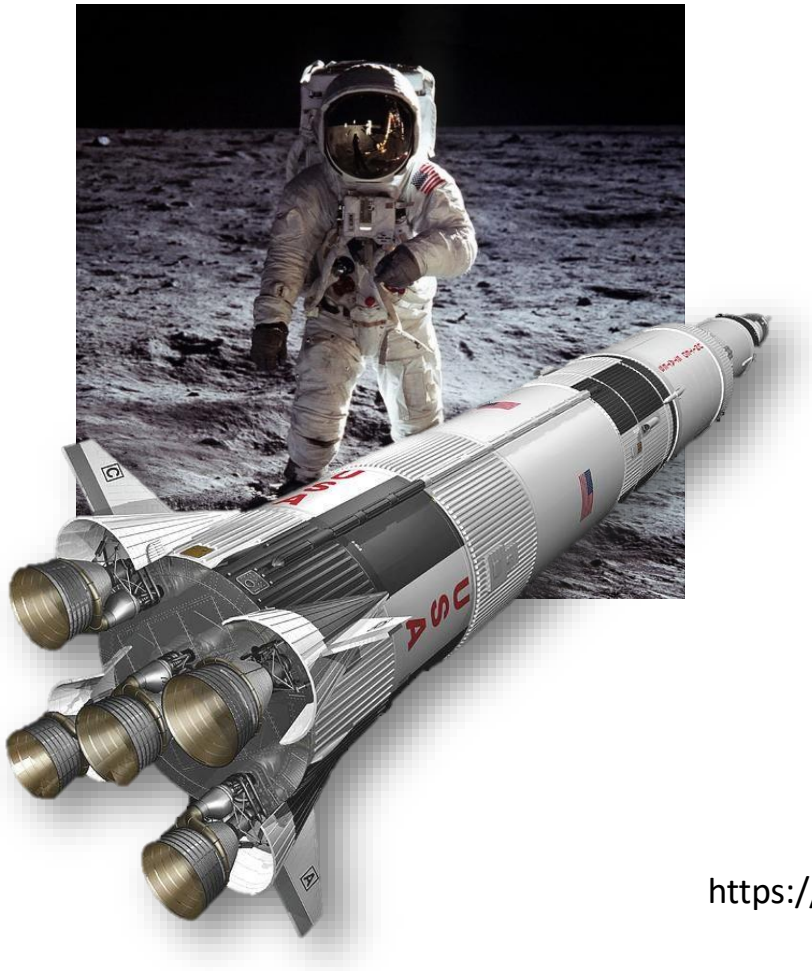
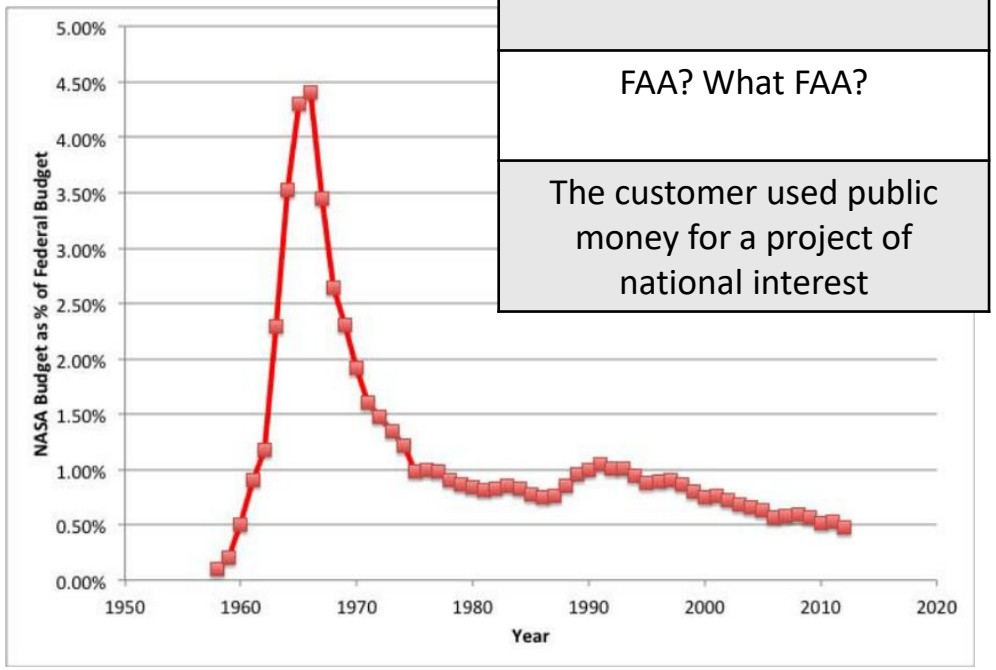
But we put a man on the moon….



Apollo
Government Strategic Policy
Military Program
Government Funded
Little to no regulatory Barrier
Not-for Profit

The Government wanted it
The Military Paid for it
Money No object
FAA? What FAA?
The customer used public money for a project of national interest



https://www.researchgate.net/publication/268078377_Space_Shuttle_Case_Studies_Challenger_and_Columbia

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But we put a man on the moon……

eVTOL
No eVTOL Government Strategic Policy
No Military Program
Not Government Funded
High regulatory Barrier
Profit

The government does not care
The military does not care
No government Money
Regulations are immature
Private investors require an ROI

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Financial Models - Ideal

Revenue

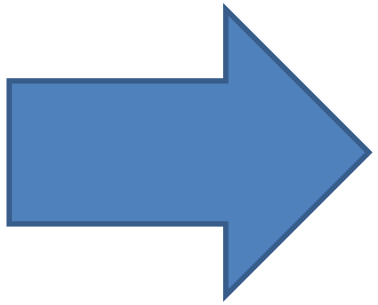
High Unit Sales/Deliveries

Low Cost of Production

Low cost of development

Low time in development

Cost



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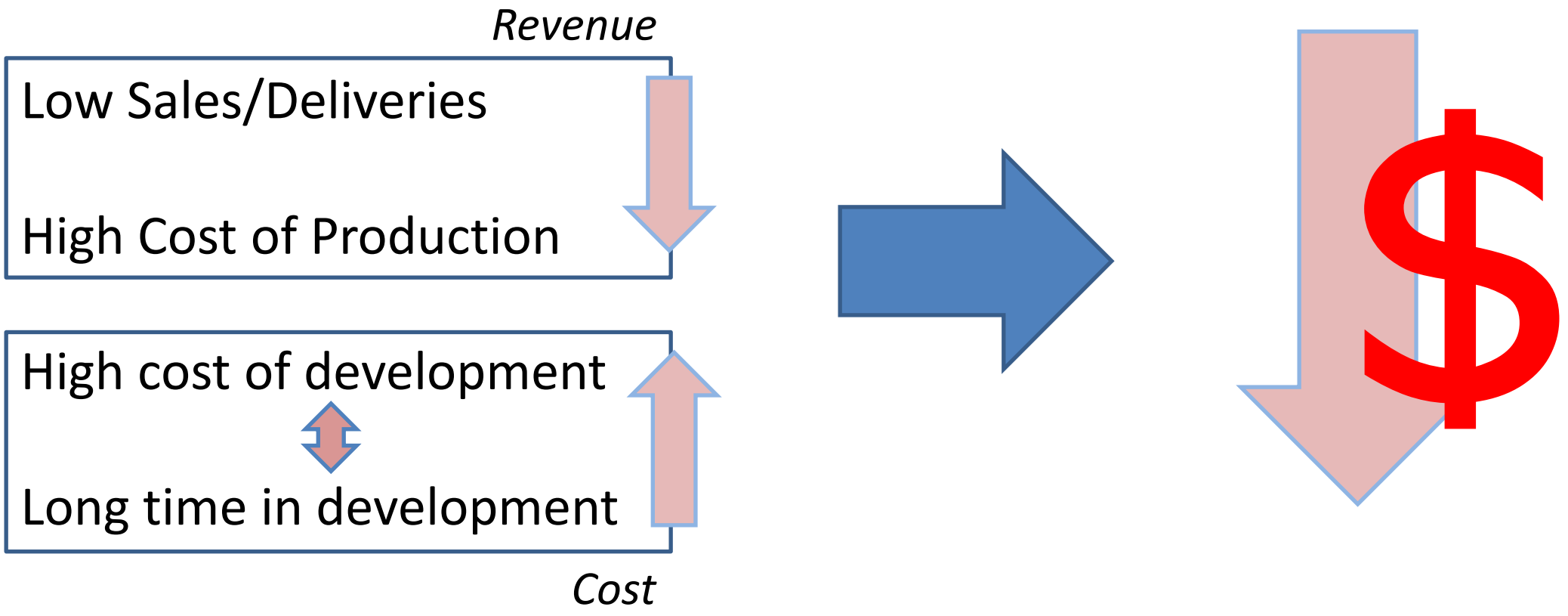
Financial Models - likely



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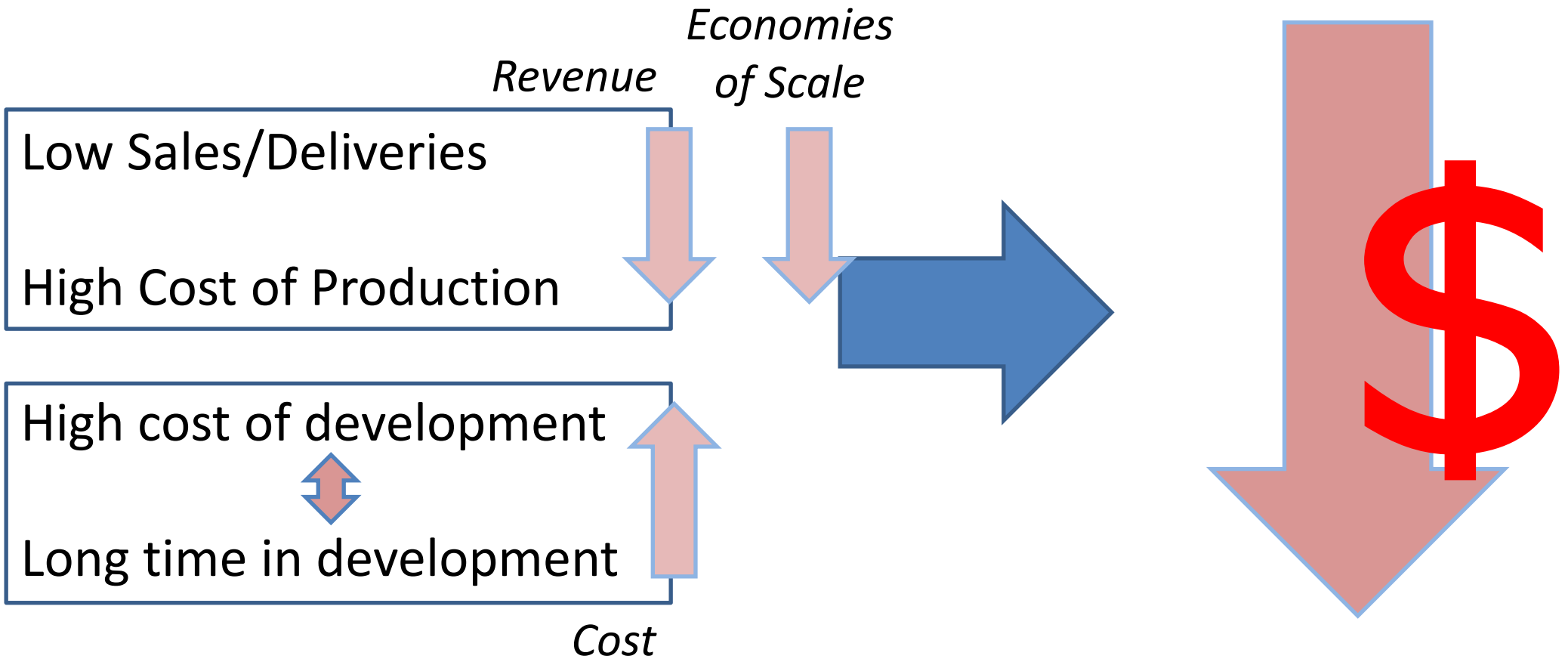
Financial Models - Worse



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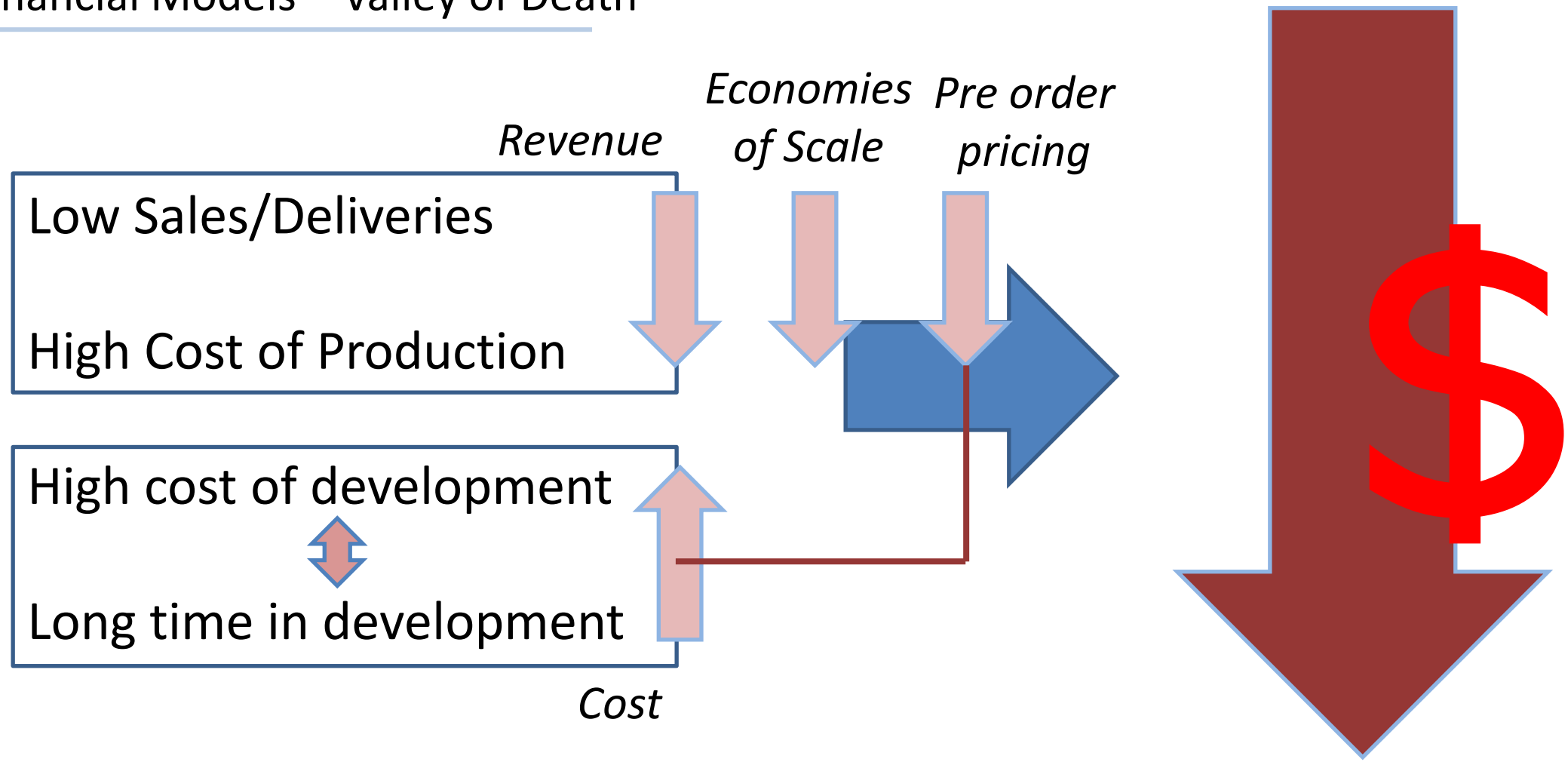
Financial Models – Valley of Death



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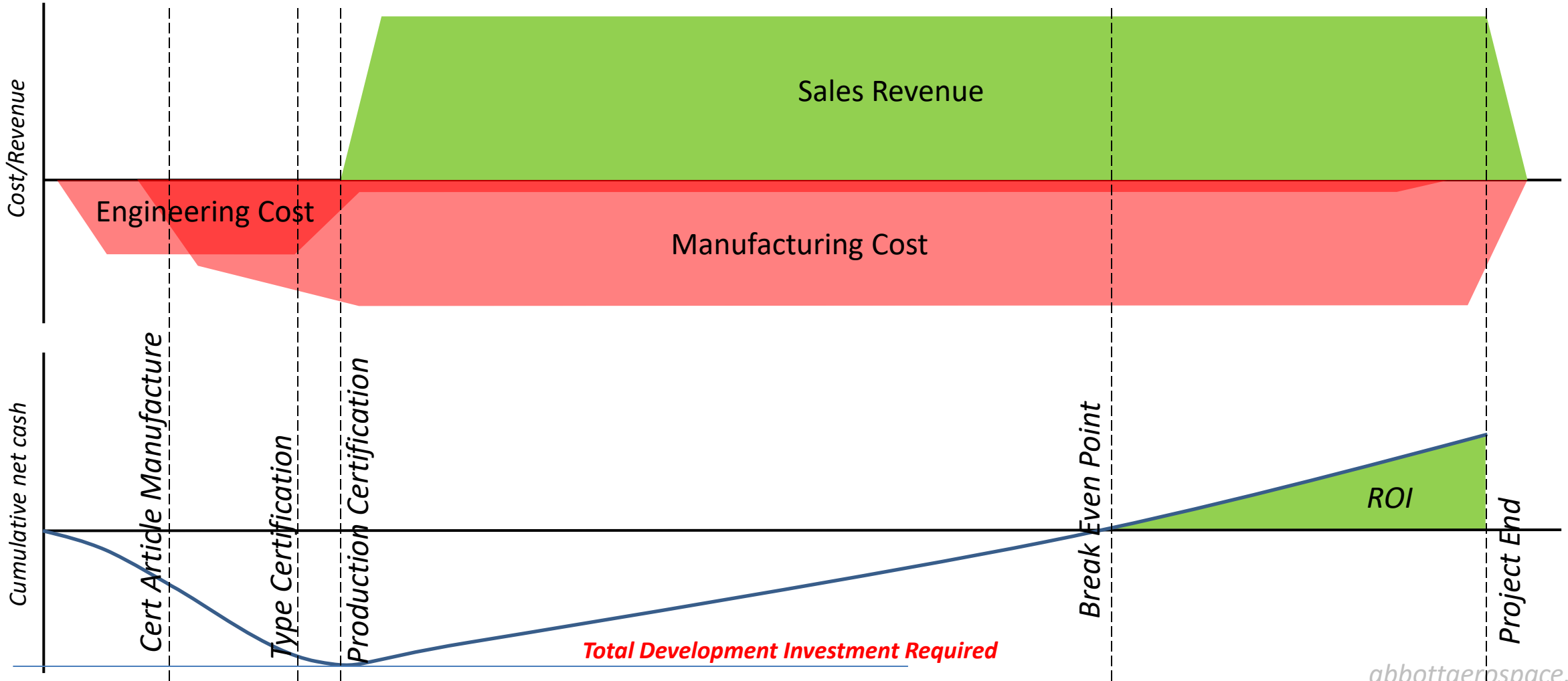
Simple Model of Aircraft Development Projects - Financial Time Line - Commercial



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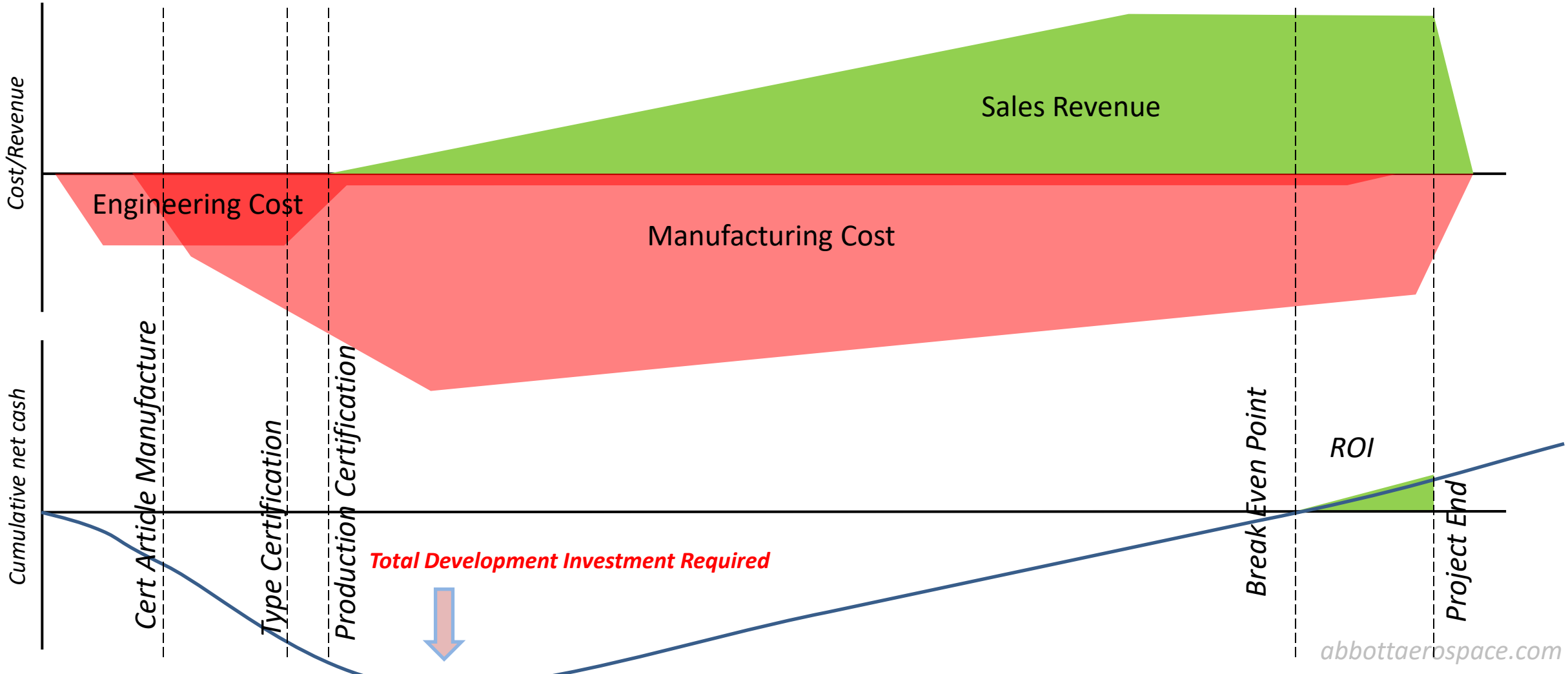
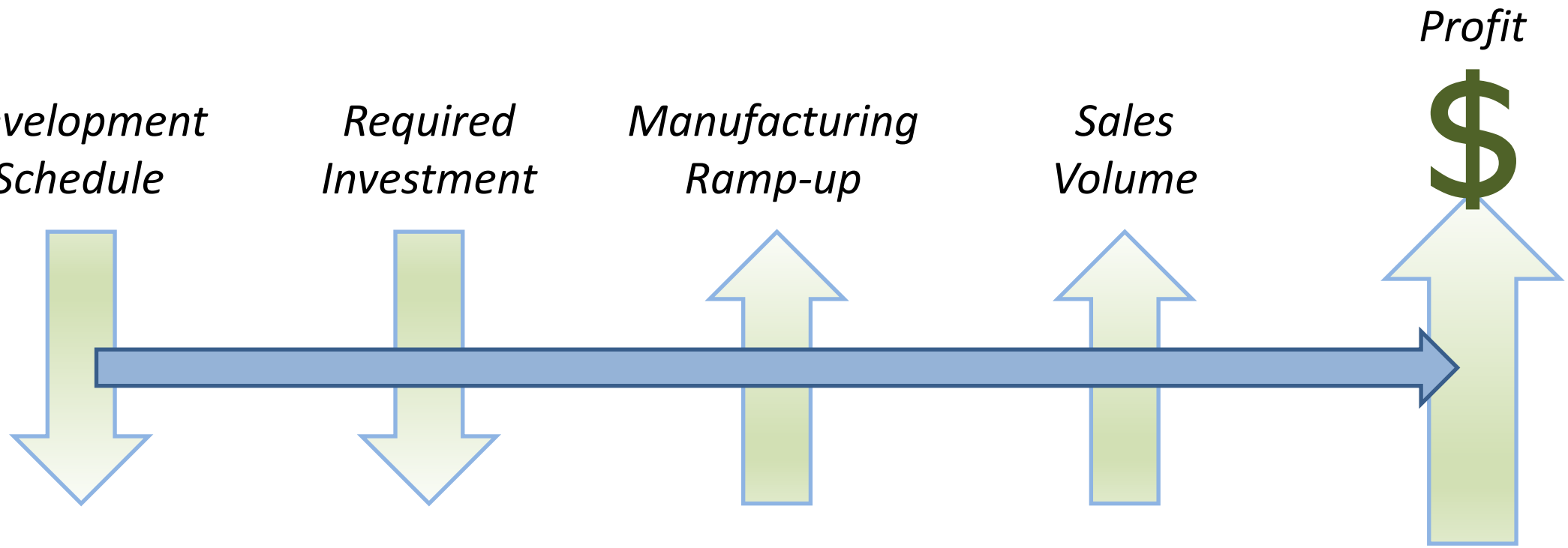


Financial Models – Happy Thoughts



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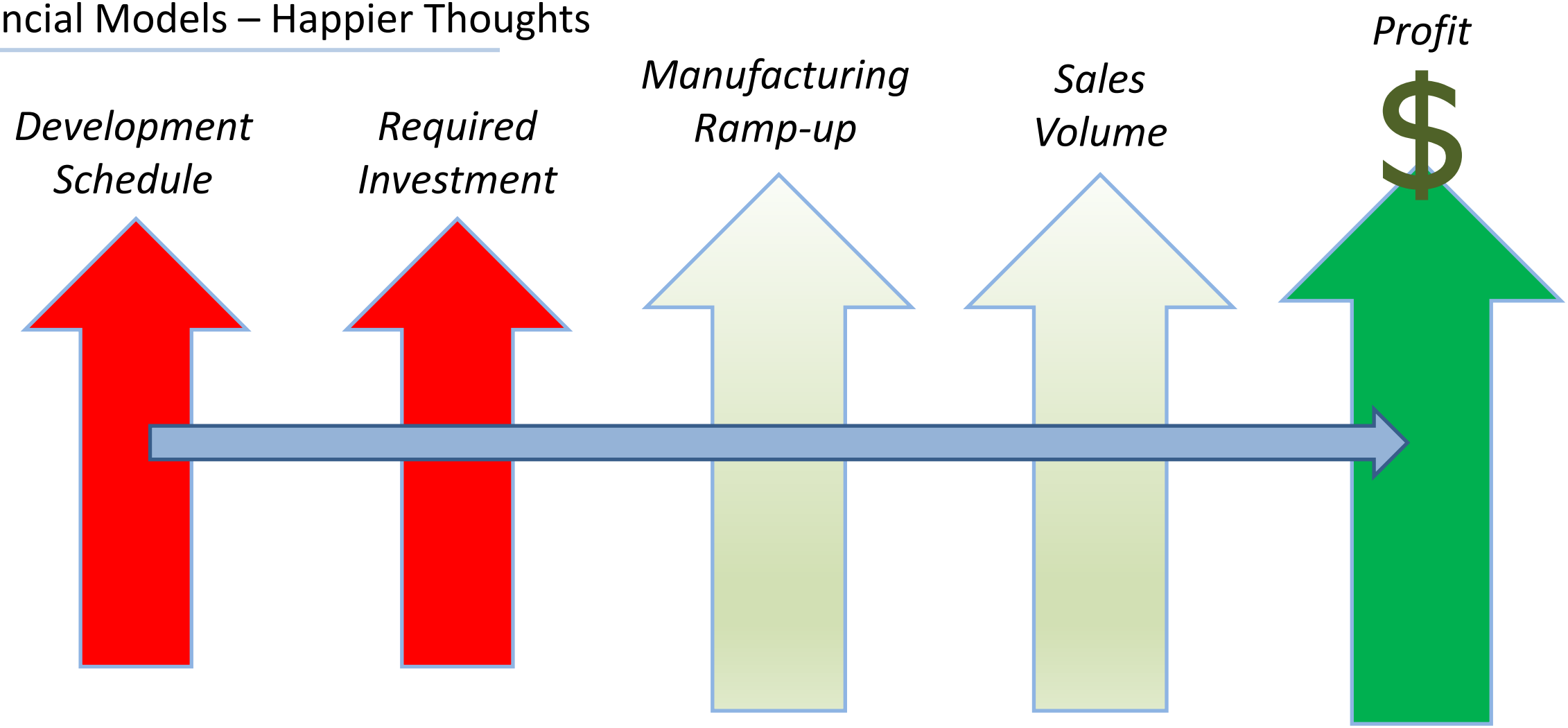
Financial Models – Happier Thoughts



Sales! – The projections

https://www.researchdive.com/166/evtol-aircraft-market

"The global eVTOL aircraft market forecast shall be $4,222.4 million by 2033, increasing from $458.0 million in 2025 at a healthy rate of 29.6%. The North America eVTOL aircraft market is estimated to grow at a CAGR of 31.1% by registering a revenue of $1,283.6 million, throughout the analysis period. Strategic collaborations among the market players along with the launching of advanced eVTOL aircraft services are expected to accelerate the North America eVTOL aircraft market growth."

https://www.persistencemarketresearch.com/market-research/evtol-aircraft-market.asp

"According to Persistence Market Research's analysis, the eVTOL aircraft market is projected to expand at more than 21% CAGR from 2021 to 2031."

https://www.rfdtv.com/story/45093116/eVTOL-Aircraft-Market

"The global eVTOL Aircraft market was valued at 9221.32 Million USD in 2020 and will grow with a CAGR of 8.79% from 2020 to 2027, based on Researcher newly published report."

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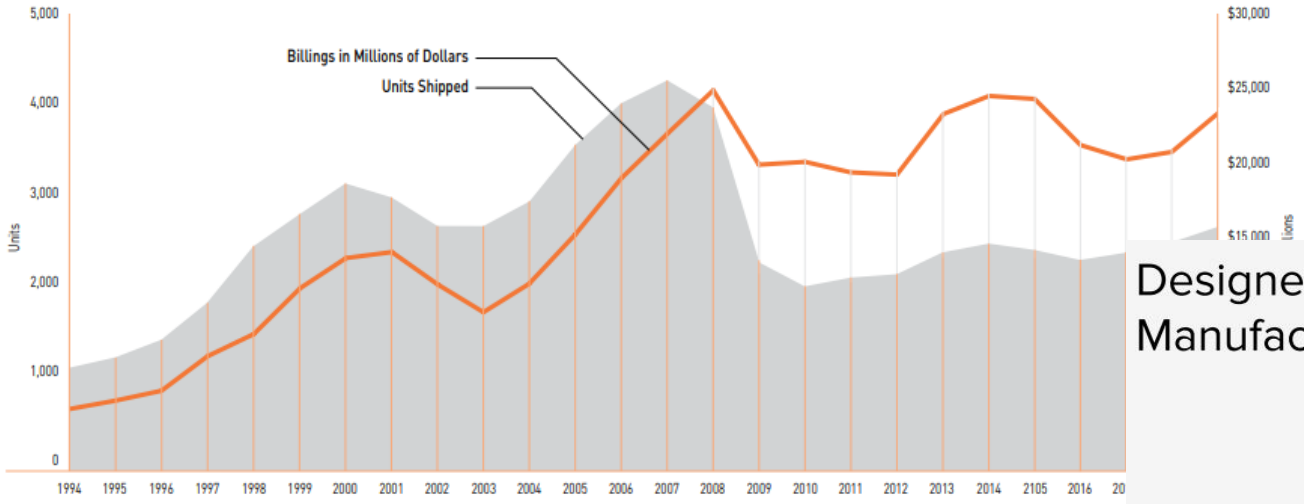
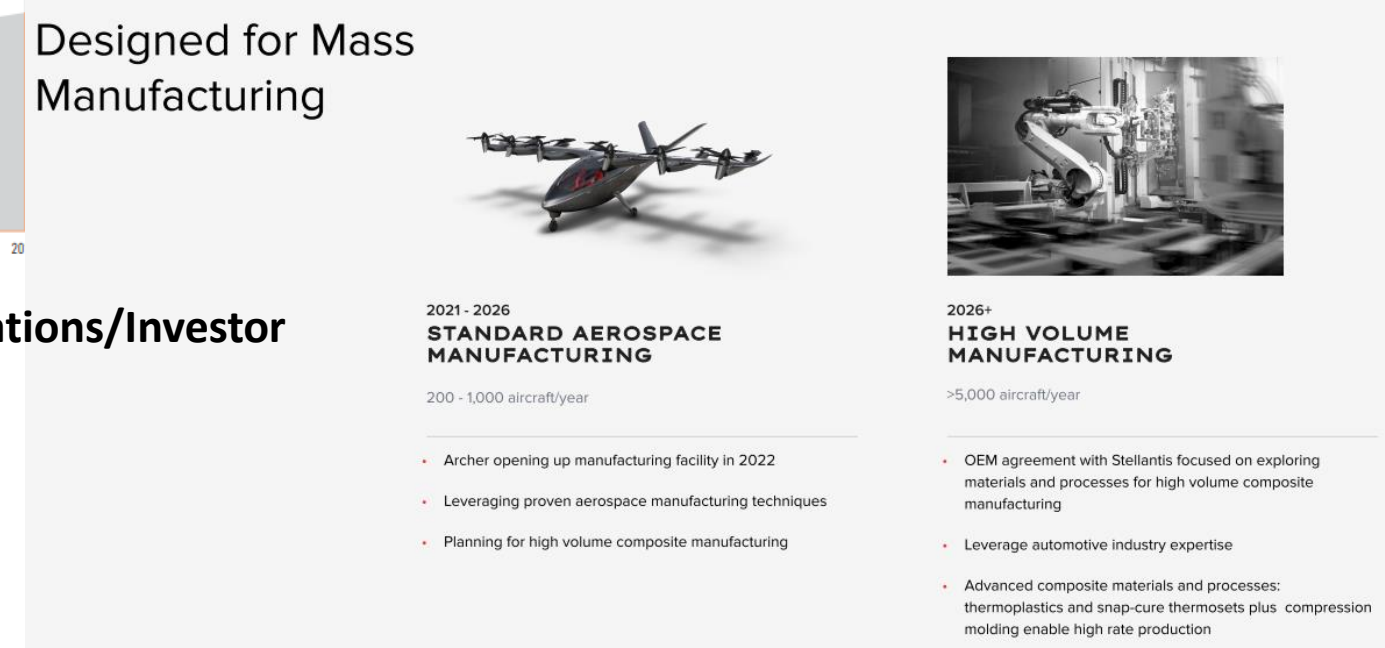
How large is the Market?

https://gama.aero/wp-content/uploads/GAMA_2019Databook_Final-2020-03-20.pdf



https://s27.q4cdn.com/936913558/files/doc_presentations/Investor-Presentation.pdf



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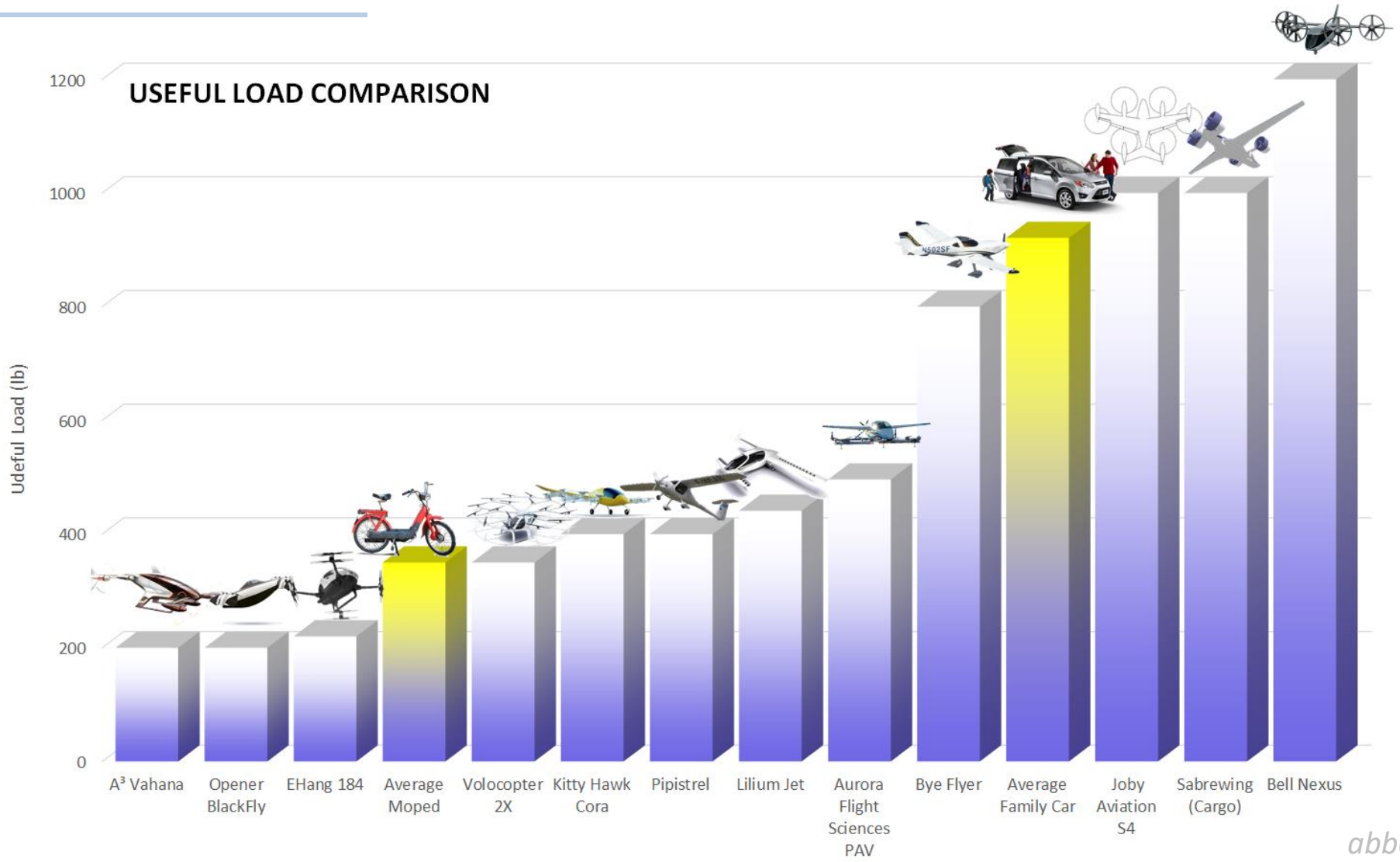
Comparison to Alternatives



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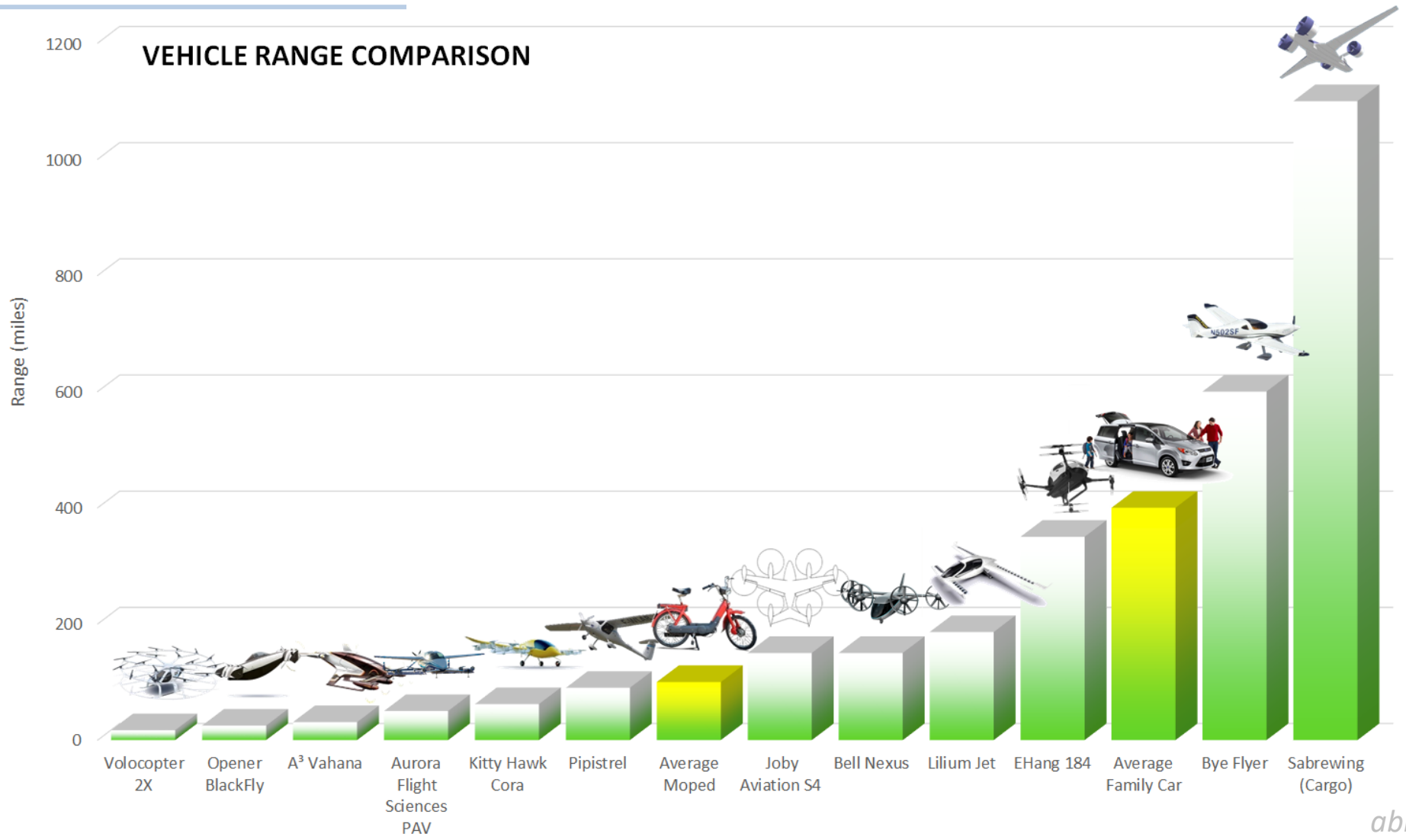

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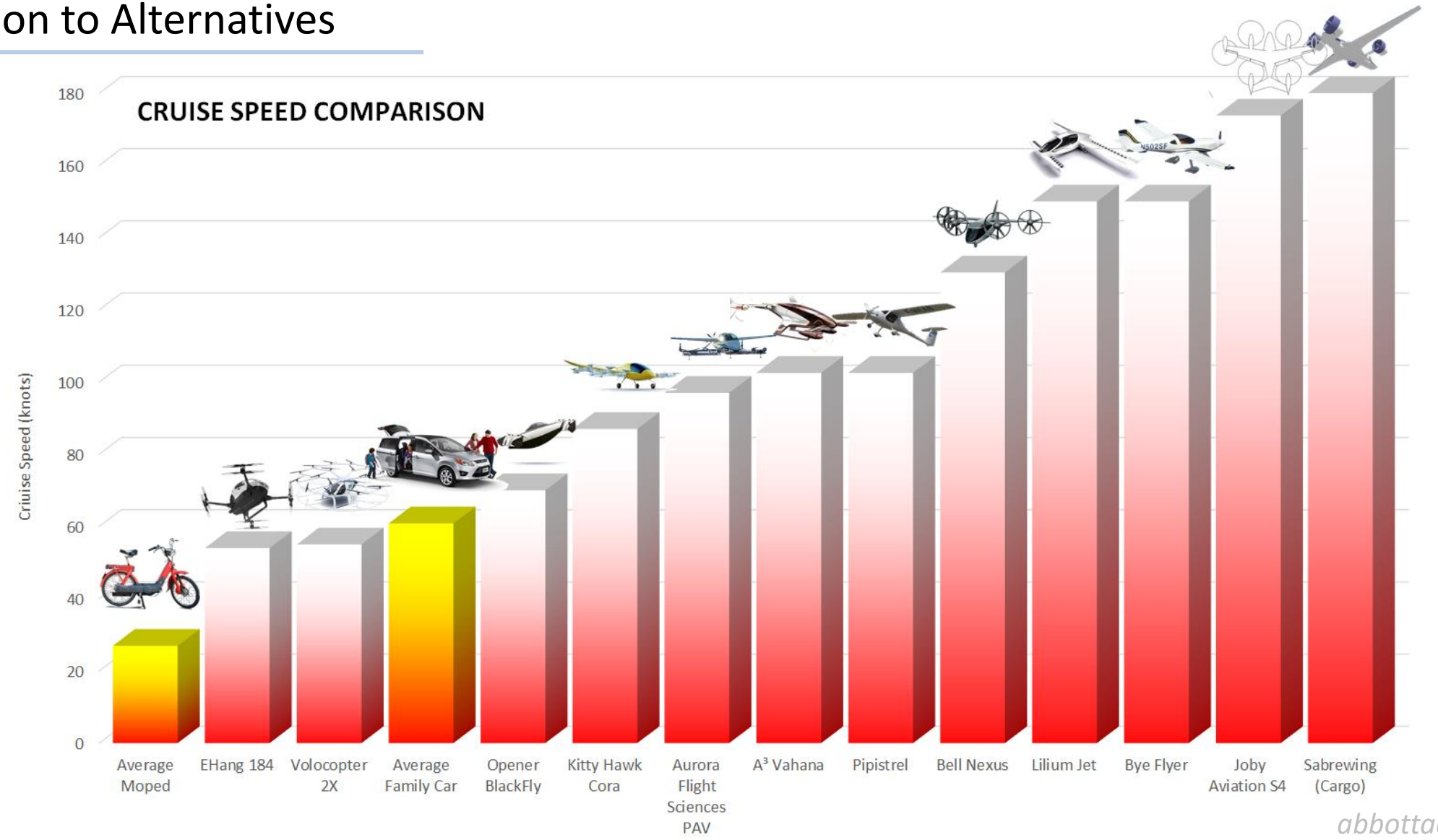

Urban Mobility Procurement & Energy Cost.

Type	Specific	Procurement Cost	Cost Factor	Power	Power Factor
One Person	Blackfly Opener	$60,000	30	15,000W (Cruise)	15
	Moped	$2,000		1,000W (Cruise)	
Two People	Archer Maker	$4,000,000	133	672,000W (Max)	17
	Smart Car	$30,000		40,000W (Max)	

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What is an engineer to do?

Acknowledge commercial Reality:

- Risk = development cost & development time
- Innovation = risk
- Innovation = development cost & development time

Increases in development cost and time to market will harm the commercial potential of the product.

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What is an engineer to do?

Do not be optimistic. Never ignore risk.

- Always Reduce Risk
- Always Reduce Innovation - *to the minimum necessary to meet the mission*

Do not trust that your managers understand the technical risk.
Do not trust that the regulator understands the technical risk.

- You may be the only person that understands the technical risk

What is an engineer to do?

Unmitigated Risk turns Good Ideas into a Bad Ideas

Optimism Ruins Programs

Raising Capital does not Mitigate Risk. It Heightens Risk.

Making the impossible happen is possible, but people may not want to buy it.
In the end the Market will decide.

"Der mentsh trakht un got lakht”
(*Man Plans, and God Laughs*)

Plans are useless, but planning is indispensable. – Eisenhower