Why Focus on Conceptual-Stage Optimization?

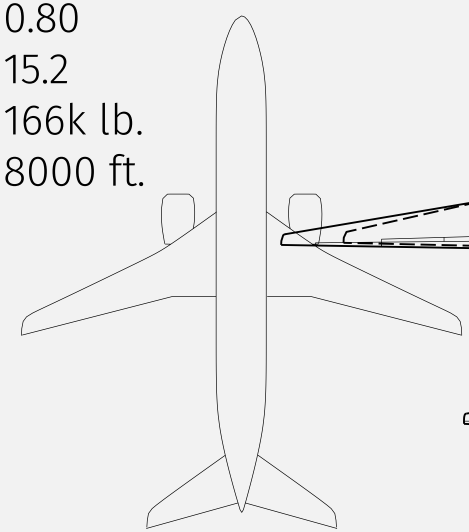
Reason 1: >80% of the performance of the final design is determined by early-stage design decisions

Example: Transport Aircraft Fuel Burn

- Most design opportunities can't be captured later
- Passenger loading: one of many disciplines not typically considered during conceptual design

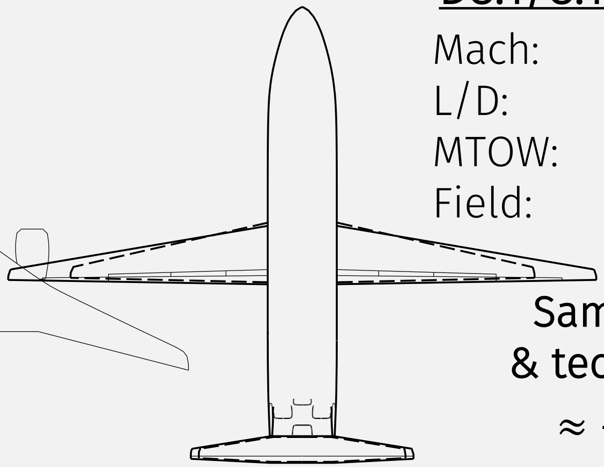
B737-800

Mach:	0.80
L/D:	15.2
MTOW:	166k lb.
Field:	8000 ft.

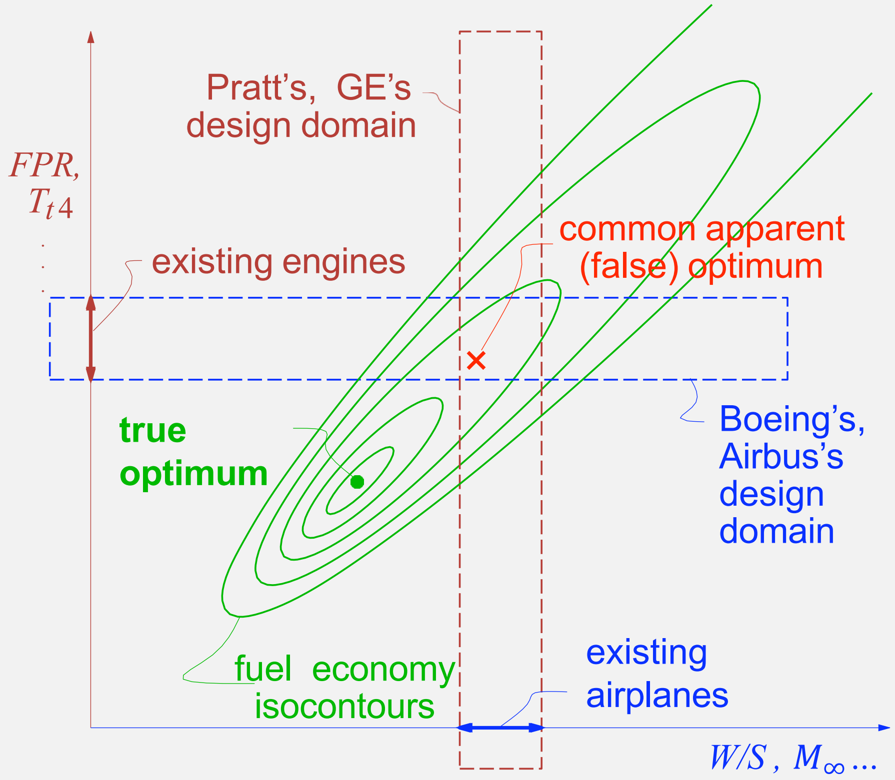


D8.1/8.1b

Mach:	0.72
L/D:	19.5 – 22.0
MTOW:	120 – 130k lb.
Field:	5000 ft.



Same requirements & tech. assumptions, ≈ −**49**% fuel burn



Both figures adapted from **Drela**, "Simultaneous Optimization of the Airframe, Powerplant, and Operation of Transport Aircraft". RAeS Conf., 2010

Why Focus on Conceptual-Stage Optimization?

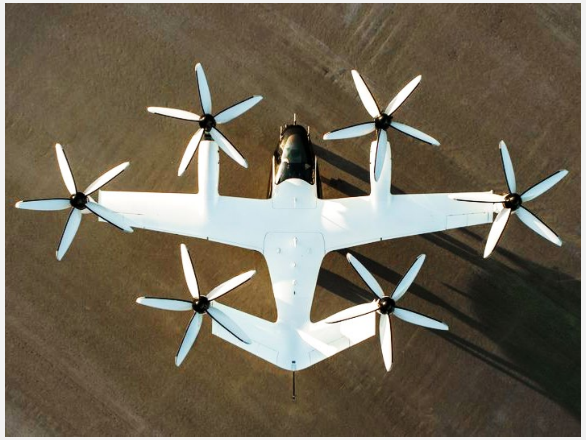
Reason 1: >80% of the performance of the final design is determined by early-stage design decisions

Example: eVTOL Noise

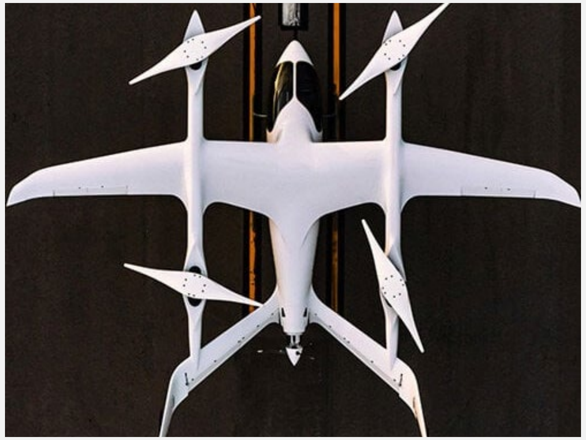
- Most design regrets can't be fixed later
- Noise: one of many disciplines not typically considered during conceptual design

> "The very next design principle, behind safety, was noise."
>
> -Joby Aviation, on conceptual design
>
> SEC 001-39524: "Virtual Fireside Chat with Joby…"

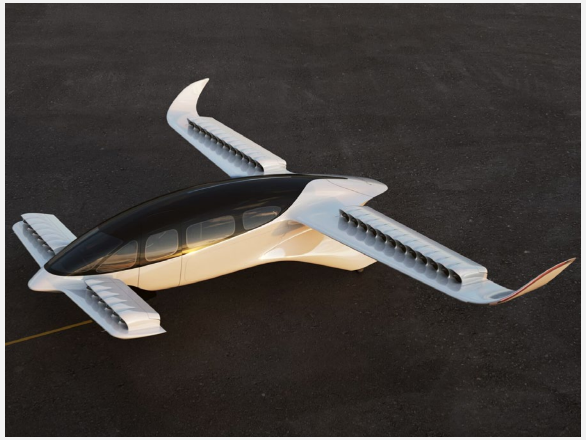
Joby Aviation S4



BETA Alia-250



Lilium Jet



Less noise ⟷ More noise

All images reproduced from their respective manufacturers

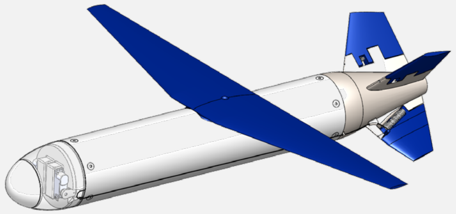
[1] SEC 001-39524: "Virtual Fireside with Joby"…

Why Focus on Conceptual-Stage Optimization?

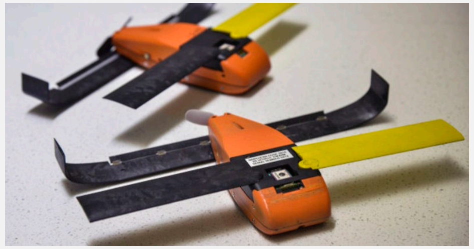
Reason 2: These days, new technologies are enabling more early-stage aircraft design space exploration than ever before

Example: Drones / UAVs

- Able to take more risks with exotic designs:
    - Shorter design cycles, lower cost
    - Minimal certification and safety risks
- New trade spaces to explore
    - Packaging/folding – every mm^3 counts!
    - Autonomy & computing SWaP
    - Payload miniaturization
    - New missions: dull, dirty, and dangerous
        - Attritable design and cost optimization
    - Physics: scaling laws
        - Square-cube
        - Reynolds numbers



MIT Firefly (Mach 0.8, rocket-propelled micro-UAV)



MIT Perdix (Air-launched ALE-55-class ISR UAV)

Transonic DP
545 mph dynamic-soaring glider
100 G sustained turn capability
(Photo: Spencer Lisenby)

Black Hornet Nano
18-gram ISR helicopter
(Photo: Richard Watt/MOD)

Why Focus on Conceptual-Stage Optimization?

Reason 2: These days, new technologies are enabling more early-stage aircraft design space exploration than ever before

Example: Urban Air Mobility / eVTOLs

- After a decade, still no clear consensus on the "right" way to use electric propulsion.
- Electric propulsion is fundamentally different:

	Conventional	Electric
Energy Storage	Kerosene	Batteries
Energy Transmission	Combustion engines	Electric motors

Figure adapted from SMG Consulting, "AAM Reality Index"

Why Focus on Conceptual-Stage Optimization?

Reason 3: The true value of conceptual MDO isn't only in answering questions ("the point design") – it's in determining which questions we should be asking

Requirements Feedback

- Which requirements are driving, and which are unimportant?
- How should we negotiate requirements?
    - Where can we give margin, and where do we need margin?

Market Identification & Competitive Analysis

- Given our technologies and capabilities, which customers should we be pitching to?
- Where are the market gaps in competitor offerings?

Risk Reduction

- How much margin do we have to various constraints?
- Which key model assumptions are we sensitive to?
- What's the most cost-effective way to reduce uncertainty in our ability to deliver?