

MDO Problem Suite V3: We have the technology, we can rebuild it!

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Hello, I'm Justin Gray

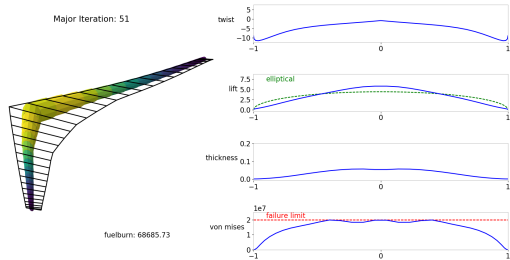


- I've lead NASA's OpenMDAO team since 2010
- PhD. In Aerospace Engineering from UofM
- MDO Interests:
gradient based optimization,
turbine engine design, optimal-control,
wind energy, electric aircraft design,
aeropropulsive optimization, structural-thermal
optimization, aircraft design, topology optimization



There is a need for good problems with ready to use implementations.

Example: OpenAeroStruct - VLM + Beam aerostructural problem



- Forked 71 times GitHub
- Cited roughly 43 times since Feb 2018
- Used in 5 different courses with hundreds of students
- Applications: applied mathematics, computer science, UQ, aircraft designers, MDO

Did you know that there are V1 & V2 MDO Problem Suites?

<https://www.aere.iastate.edu/bloebaum/mdo-test-suite/>

<https://doi.org/10.2514/6.1996-4028>

Goals

- Provide a set of problems to benchmark methods with
- Create a shared context to interpret MDO research results

Challenges

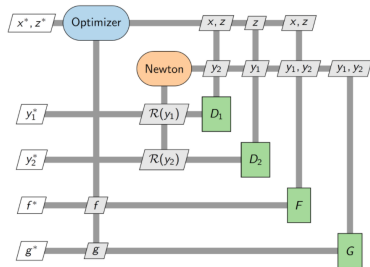
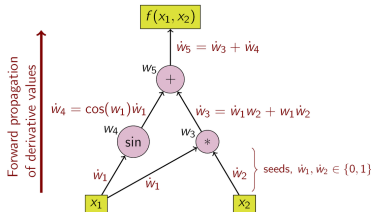
- Implementations were not provided
- Complexity of the problems was relatively low

The V3 MDO problems should be more useful, more challenging, and more relevant

Goals

- Create a shared context to interpret MDO research results
- Increase adoption of MDO tools and methods outside of our own community

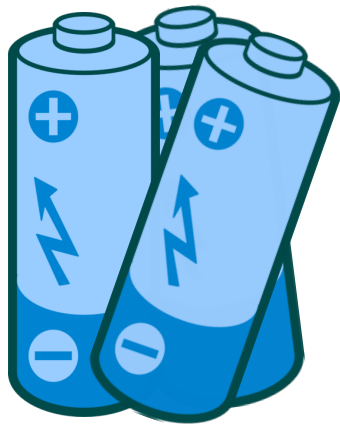
We have some new technology to help us



More useful: Batteries included

All problems will include a reference implementation!

- Rely on only open source codes
- Other implementations welcome, but should be verified against the reference
- Hackability should be a consideration



More challenging:

Consider adding easy/medium/hard versions of a problem

Easy

Computationally inexpensive, fairly well behaved, provides users with a way to get familiar with the basic physics

Medium

Introduces all key aspects of the problem but still uses computationally inexpensive models

Hard

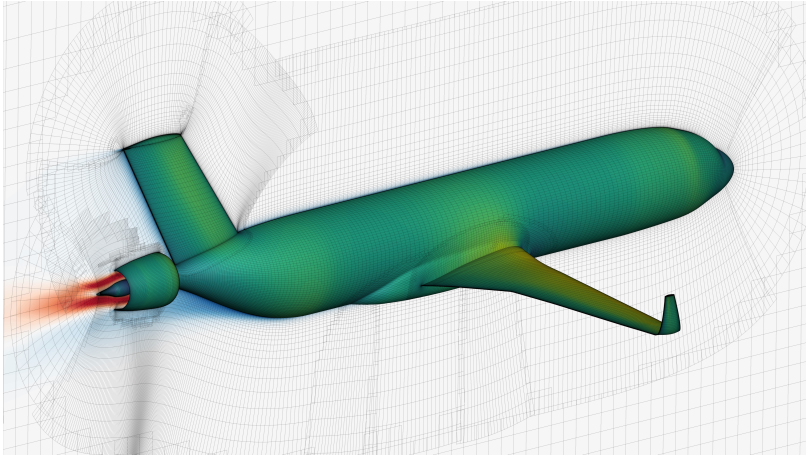
Good luck!

Easy mode is really important ...

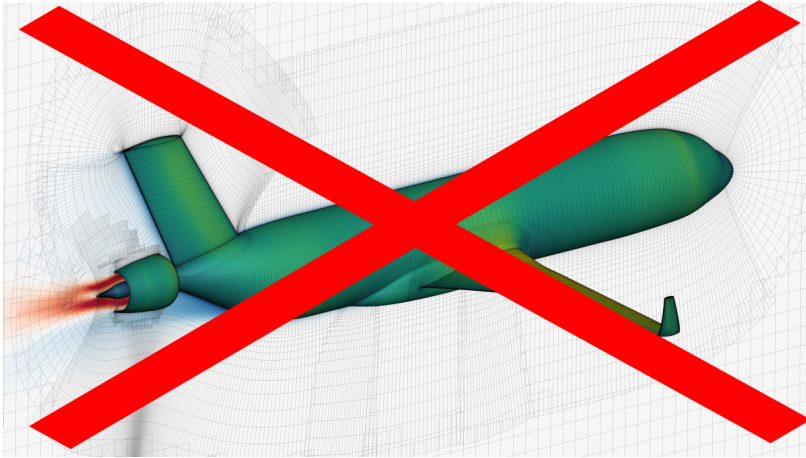
What is the first thing you do when you try out a CFD code?



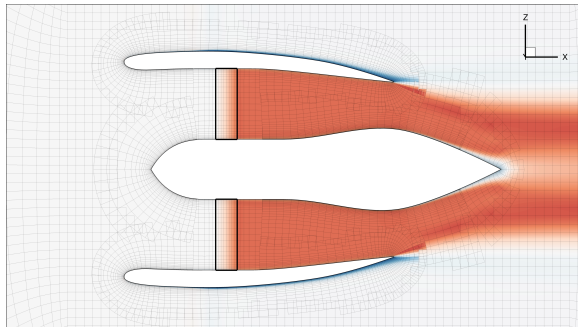
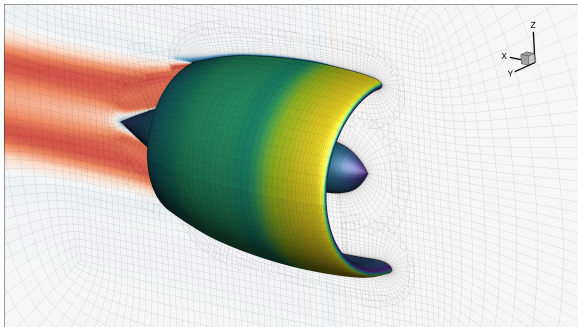
Easy mode for an aeropropulsive test problem: tail-cone-thruster?



Tail-cone-thruster is way too complex for easy mode!



Easy mode for an aeropropulsive test problem
should be the simplest podded nacelle possible



More useful:

The hard mode might not yet have a solution!

Easy

Medium

Hard

Good for benchmarking or for challenges to see who can get the best answer

More relevant: What makes a problem relevant?

Relevant To Who?

- Academics: The easiest hard-problem they can find
- Industry: Uses analyses that they would actually use

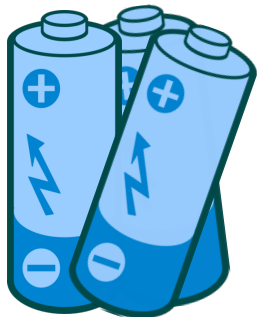
Some things needed for problems to represent reality

- Solvers that don't always converge
- Discrete variables
- Analyses with noisy outputs
- Finite-differences



MDO problem suite V3 should increase adoption of our tools and methods outside our own community

Useful



Challenging

Easy

Medium

Hard

Relevant



You have an idea? Here is what I think is needed in your implementation

- At least two difficulty levels (e.g. easy/hard)
- A set of regression tests that can be used to verify the functionality of any implementation of the analysis (just the analysis, not the optimization)
- Two applications in different contexts, developed by different groups (collaboration!)

Developing test problems is going to be a lot of work,
but we shouldn't use a traditional publication model for giving credit.



[image credit:

<https://distill.pub/2017/research-debt>]

- The “peer-reviewed publication” should be the code itself (not a paper about the code)
- The focus of the peer-review should be different than with a journal paper
- What about a prize pool?
(idea shamelessly stolen from distill.pub!)