Efficient Multidisciplinary System Design Optimization at the Mission Level

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Research Overview

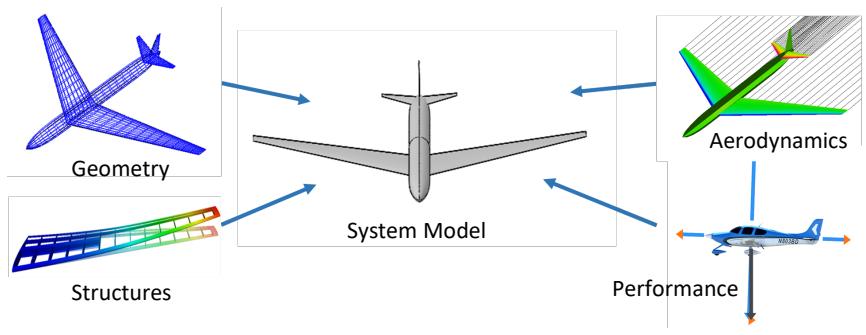
Optimizing complex models can be computationally expensive.

At the system level, multifidelity optimization (MFO) techniques coupled with an appropriate multidisciplinary design optimization (MDO) architecture can reduce the required computing resources.

Efficient multidisciplinary system models can be leveraged to make mission-level optimization (MLO) more feasible

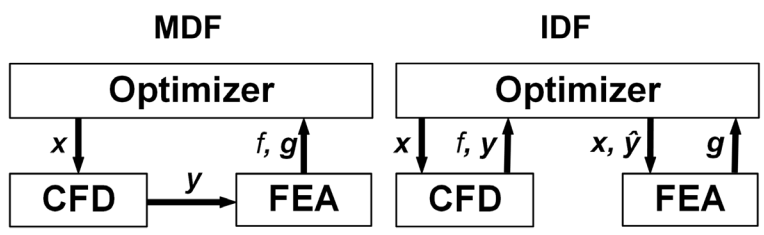
Goals & Objectives

- Examine the performance of different MDO architectures on an aircraft case study
- Utilize MFO within these architectures to find optimal designs while conserving resources
- Apply these techniques and find new best practices for the unique challenges of MLO



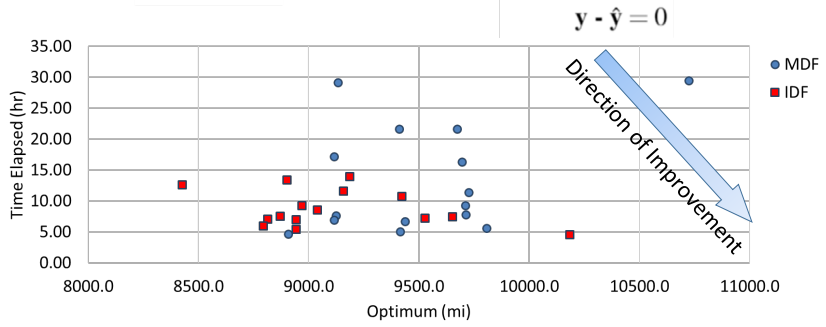
Data & Analysis

MDO Architectures[1]



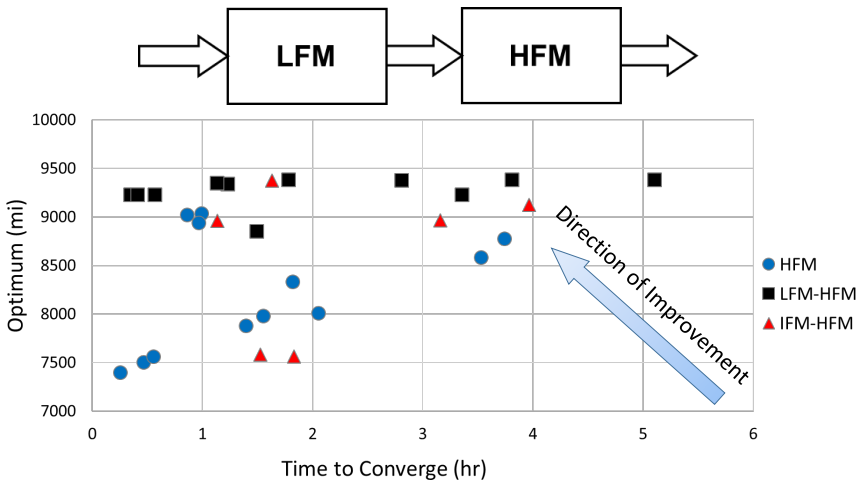
$$\min_x \; f \quad \text{s.t.} \quad \mathbf{g} \leq 0$$

$$\min_x \; f \quad \text{s.t.} \quad \mathbf{g} \quad \mathbf{y} - \hat{\mathbf{y}} = 0$$



MDF generally finds a **better optimum** but takes **more time**

Multifidelity Optimization[2]



Starting HFM at solutions from lower-fidelity models using a gradient-based algorithm can **save time** and **improve optimality**

Mission-level Optimization[3]

Optimal solution took had **no failures**, took **less time** to find the target, and was **more consistent**

Methodology

MDO Architectures

- Conducted a comparison study on two MDO architectures
  - MDF – Multidiscliplinary Feasible
  - IDF – Individual Discipline Feasible
- Used a simulation-based aircraft model developed for MDO research
- Reduced required "coupling constraints" between disciplinary models by using proper orthogonal decomposition

Multifidelity Optimization

- Tested a multifidelity model management system (MMS) where the optimizer from a lower-fidelity model is passed to the higher-fidelity model as a starting point
- Tested two MFO MMS's (coarsened mesh/surrogate model) and compared to original high-fidelity model using a gradient-based algorithm

Mission-level Optimization

- Sampled mission-level UAV/counter-UAV graphical CONOPS scenario using definitive screening design
- Created surrogate models for success/failure ratio and two intermediate objectives
- Combined surrogates to find optimal design inputs

Future Research

- Extend and validate MDO architecture and MFO work with new models currently under development
- Conduct an in-depth literature review of mission-level modeling and MLO
- Combine all previous work to efficiently optimize a more complex mission scenario

Contact/References

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1. Chell, B., Hoffenson, S., and Blackburn, M.R. (2019) "A comparison of multidisciplinary design optimization architectures with an aircraft case study," *AIAA Scitech 2019 Forum,* San Diego, California, January 7-11.
2. Chell, B., Hoffenson, S., and Blackburn, M.R. (2019) "Comparing multifidelity model management strategies for multidisciplinary design optimization," ASME 2019 International Design Engineering Technical Conferences, Anaheim, California, August 18-21.
3. Chell, B., Hoffenson, S., Ray, D., Jones,. R.D., and Blackburn, M.R. (*in press*) "Optimizing for mission success using a stochastic gaming simulation," *The Journal of Cyber Security and Information Systems: Modeling and Simulation Special Edition.*