EXPEDITE: MEETING THE ENGINEERING CHALLENGES OF HYPERSONIC DESIGN

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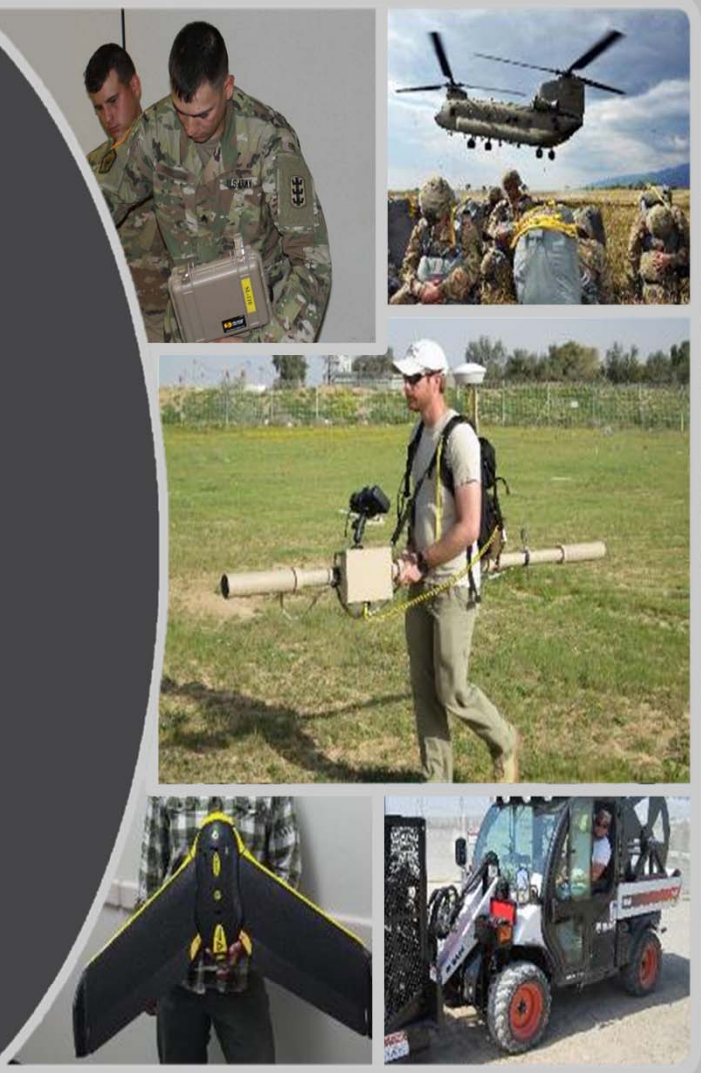
DISTRIBUTION A



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OUTLINE

- Team Overview
- Problem Introduction
- Aero Domain
- Thermal Domain
- Structures Domain
- Orchestration Domain
- Summary
- Collaborative Reach

TEAM OVERVIEW

Leverage a large, diverse team.

- **Expertise in:**
  - **Applied Mathematics**
  - **Physics**
  - **Mechanical/Aerospace engineering**
  - **Computer Science**

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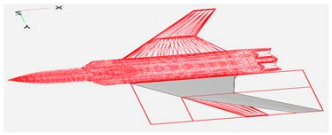
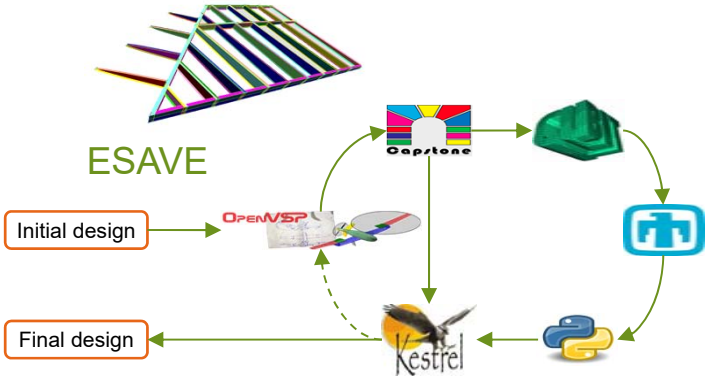
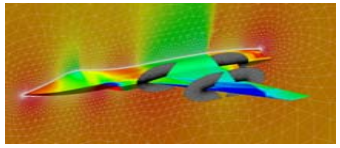
Prior Work

- **Aerostructural Defeat – CCDC AvMC collaboration**
  - **Improved efficiency of UAV blast simulations for lethality**
- **ESAVE – AFRL and Lockheed Martin collaboration**
  - **Automated workflow for supersonic vehicle design**







PROBLEM INTRODUCTION

The ability to efficiently and effectively model the coupled physics associated with hypersonic vehicles has not been sufficiently addressed

- **Limits our ability to set realistic performance requirements**
- **Reduces the set of conceptual designs that can be considered**
- **Compromises our overall ability to effectively analyze designs**

Key Technology Gaps

Code integration

- Limited formal communication among tools
- Few established frameworks for integrating single-discipline codes

Effective Computing Resources

- Scalability of trusted toolsets is not a given
- Lack of computing resources at appropriate classification

Convergence of Coupled-Physics

- Unknown order-of-execution, time-dependence, and required fidelities of single-discipline analysis

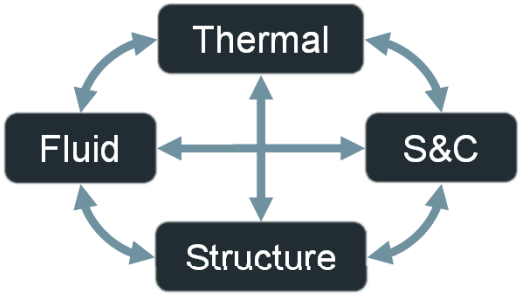
PROBLEM INTRODUCTION

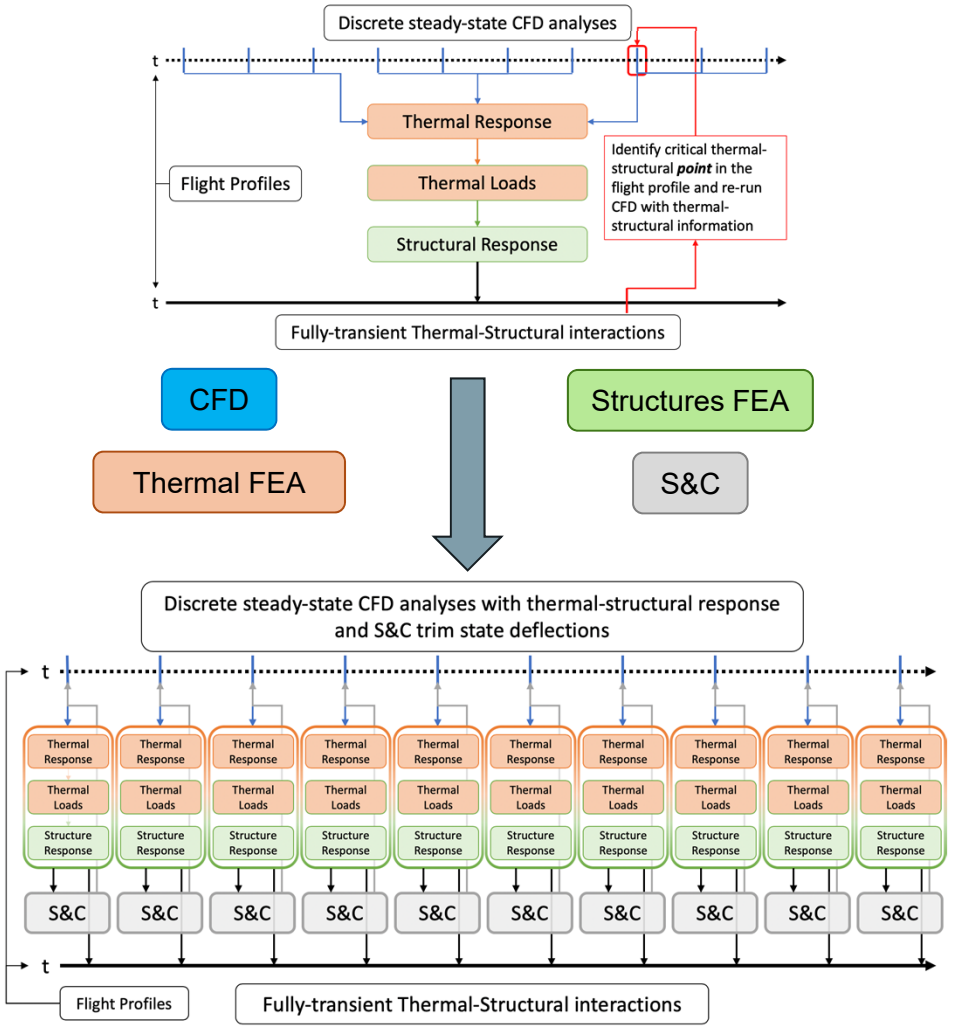
Current Status

- Flight profile defined by single-discipline CFD analyses
- Thermal-structural response only considered at critical point
- No in-the-loop stability and controls consideration

Goals

- Coupled-physics analyses
- Integrated stability and controls
- Automated workflow





AERO DOMAIN

Objective

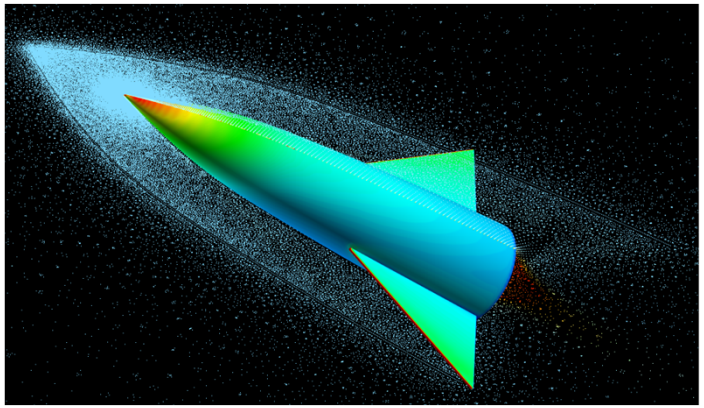
- Validate, develop, and integrate government tools for current and future hypersonic vehicle design (HVD) workflows

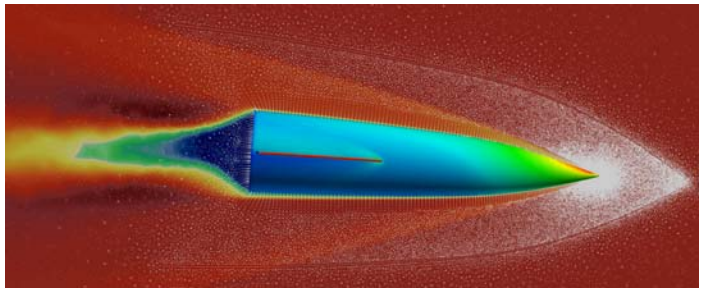
Approach

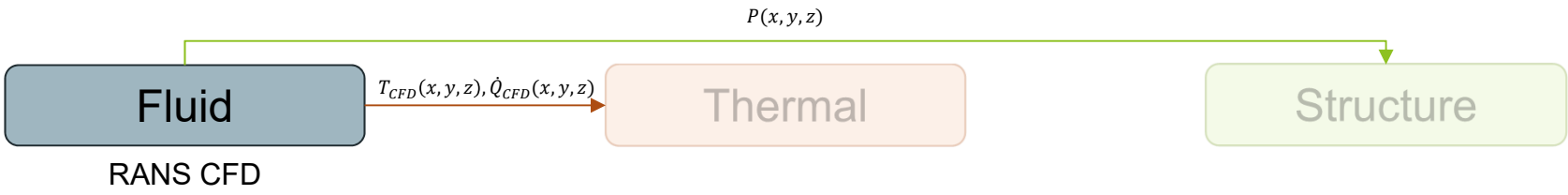
- Compare government and industry tools to validate hypersonic analysis
- Develop capabilities to fill technology gaps and integrate tools within the HVD workflow

Impact

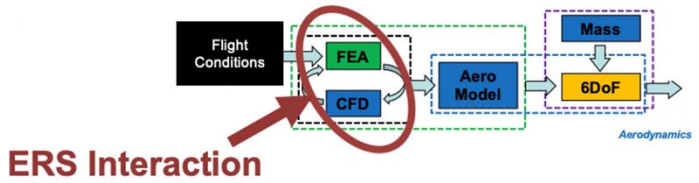
- Reduce or eliminate dependence on licensed software
- Introduce capability for S&C analysis of a hypersonic vehicle







THERMAL DOMAIN



Objective

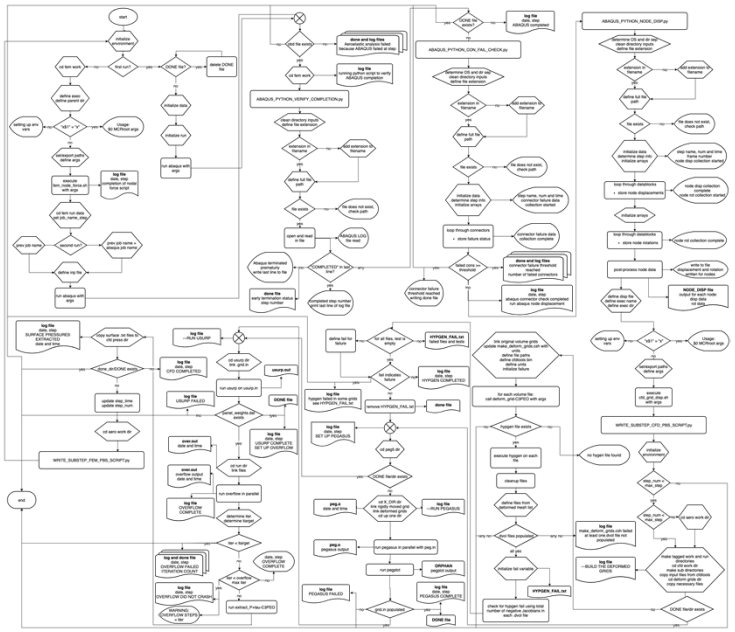
- Establish the usability of government tools for current and future HVD workflows

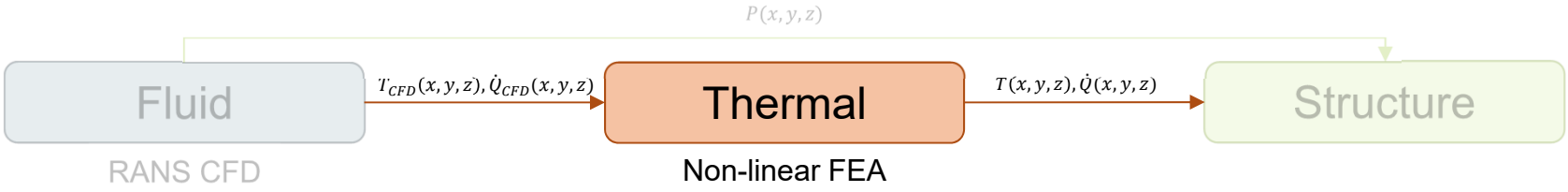
Approach

- Validate government tools for thermal analysis
- Develop better physics-based models for thermal analysis
- Automate code execution

Impact

- Improved physics-capture of thermal effects
  Scalable solution for thermal analysis





STRUCTURES DOMAIN

Objective

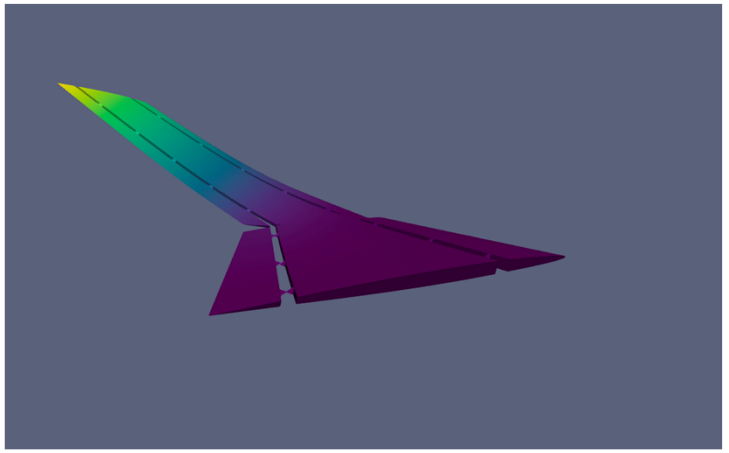
- **Establish the usability of government tools in current and future HVD workflows**

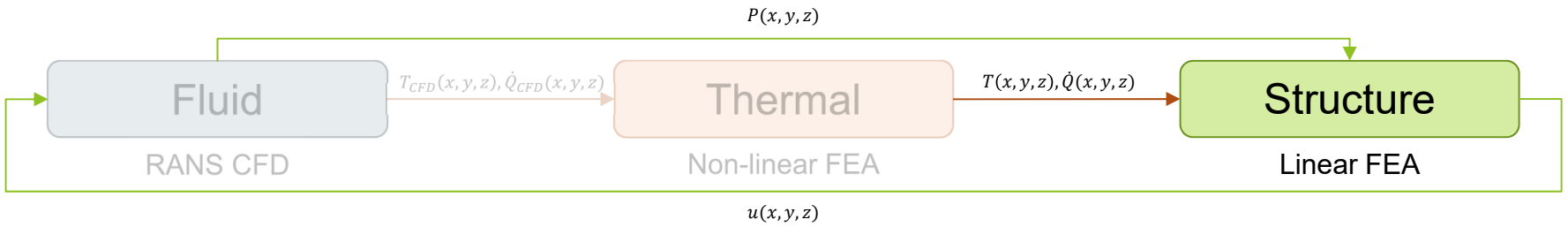
Approach

- **Validate government tools for combined thermal and aero loading**

Impact

- **Increased fidelity for structures analysis**
- **Reduced dependency on licensed software**

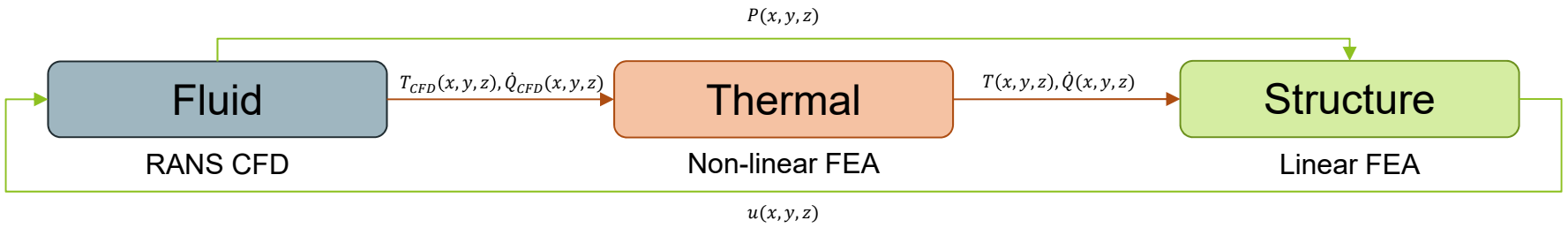




ORCHESTRATION DOMAIN

Code Coupling

- **Objective**
  - Couple government toolset to facilitate data transfers and coordinate parallel execution
- **Approach**
  - Identify the physics needed by each discipline from each other discipline and any software gaps preventing transition of that data to other codes
  - Develop capabilities to facilitate execution of domain codes and their coordination.
- **Impact**
  - Drastic reduction in solution cost and time for HVD
  - Significant increase in accuracy of hypersonic vehicle analysis



SUMMARY

Objective: Quantify the coupled-physics on hypersonic vehicle design and automate the analysis process to improve efficiency.

Status

- **Investigating the current hypersonic analysis capabilities of government tools**
- **Comparing government and industry toolsets**
- **Developing APIs for automated execution of software**

Impact

- **Reduce or eliminate dependence on licensed software**
- **Expand capabilities for S&C analysis of a hypersonic vehicle**
- **Increase fidelity for structures analysis**
- **Improved physics-capture for thermal effects**
- **Scalable solution for thermal analysis**
- **Drastic reduction in solution cost and time for hypersonic vehicle analysis**
- **Enormous advance of the state-of-the art in hypersonic vehicle analysis quality**

COLLABORATIVE EFFORT

Domain Expertise
- Thermal modeling
- Structural modeling
- CFD modeling
- S&C modeling

Tool Access
- High-fidelity analysis software
- No license restrictions
- Software trial flexibility

HPC Access
- Allocation
- Experience

Workflow Experience
- Automated code communication
- Improved solution efficiency

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QUESTIONS?