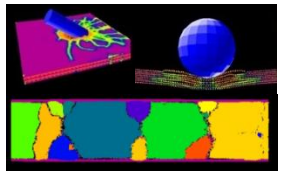
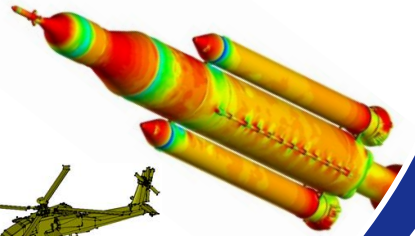
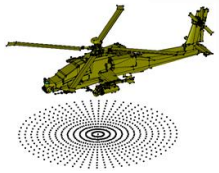
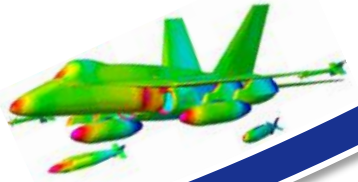


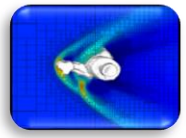




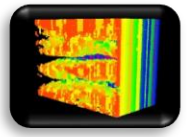
# Delivering Breakthrough Solutions

## CFD Research Company Overview

# Company Overview

## Who We Are





### Research and Development

- Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) Programs
- Critical technologies
  - Aerospace and propulsion
  - Energy and materials
  - Life sciences

Nunn-Perry Award Winner

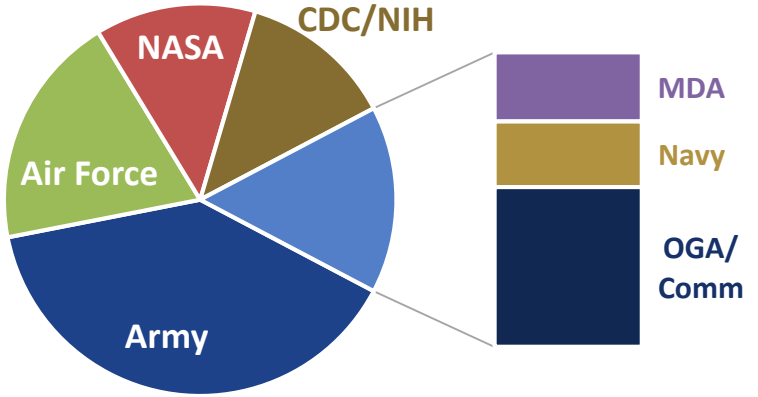
### Technology Services

- EXPRESS Blanket Purchase Agreement for Technical Services for Team Redstone (541330)
  - Missile and aviation systems support
  - Protective technologies and energy systems
- NASA MSFC (ESSCA) and NASA ARC (VLTD)
- Public Health
- Army and Air Force Medical

DEVCOM Aviation & Missile Center, CDC, NIH, DHA Defense Health Agency

## Footprint


## Customers




## Employee-Owned

**170 Employees**

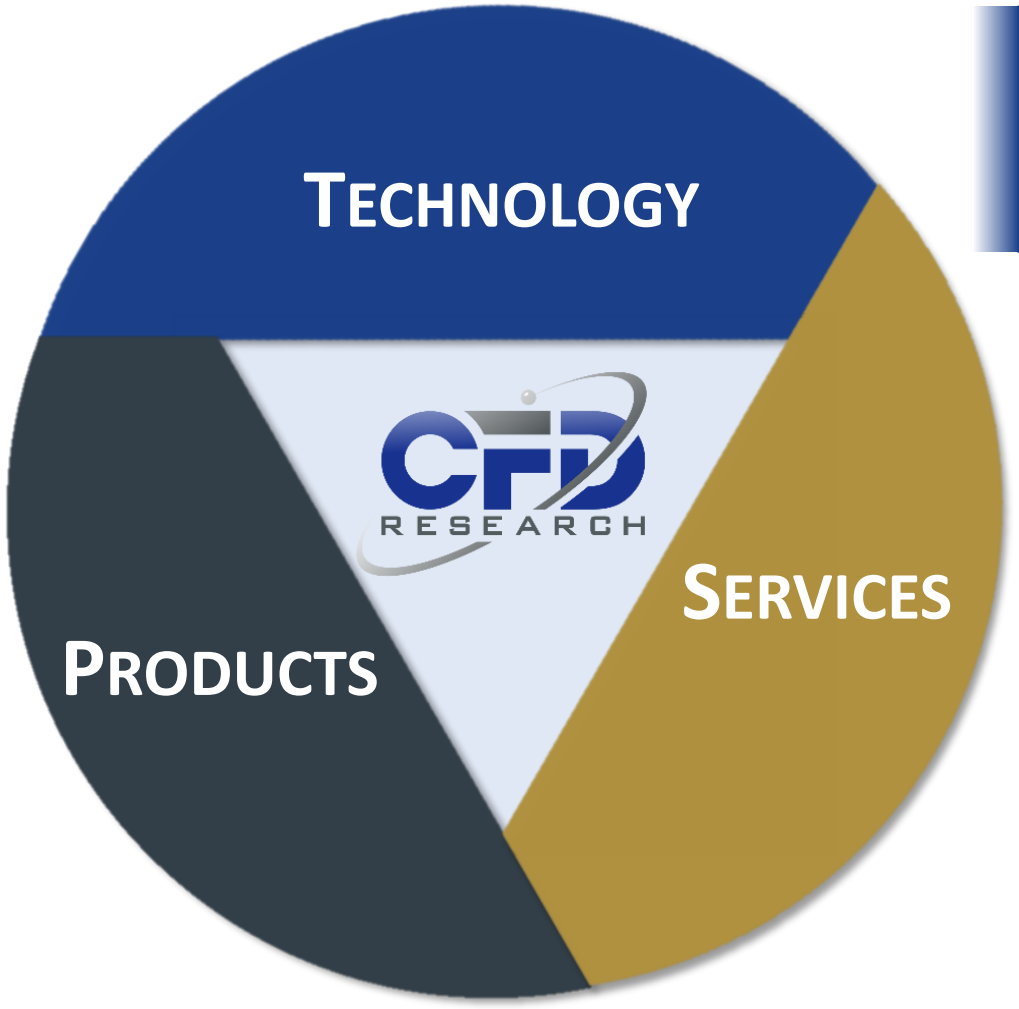
| | |
|---|---|
| *Cleared* | *40%* |
| *PhD* | *35%* |
| *Advanced Degrees* | *70%* |

## Mature Infrastructure

| | |
|---|---|
| 104 | Active Contracts |
| 80 | Deliverables per Month |
| 81 | Active Subcontracts |
| 55 | Active Subcontractors |
| 1,500 | Contracts in 33 Years |

ISO 9001 Certified, AS 9100, CMMI SVC /2 Exp. 2020-12-01/ Appraisal 830964

# Who We Are



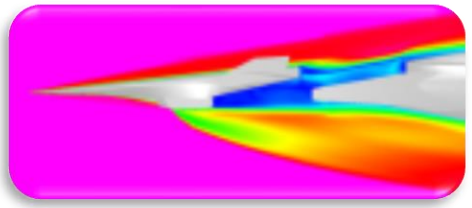

- Leverages insight gained from customer challenges to extend technologies
- Initial concept to prototype design and test
- DoD, civilian agencies, and commercial companies
- Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs

- Leverages technology expertise to provide value-added expert support
- On-site with customers to provide high level engineering and scientific problem-solving capabilities
- EXPRESS BPA Holder for US Army Redstone, Microbiology support for the Centers for Disease control, SLS and HLS support to NASA/MSFC and Vertical Lift Technology Development activities for NASA/ARC

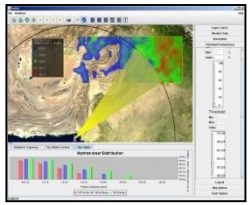
- Leverages technology capabilities and customer insight into products and solutions
- 75 patent awards with 35 licensed or sold to Partners
- Special purpose engineering software tools and consumer products
- Spin-off companies and products
- Maintains a top 20% rating in the DoD's Commercialization Achievement Index

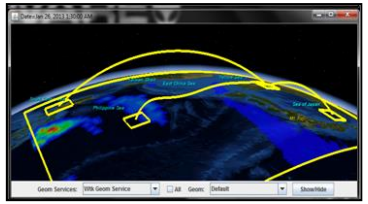
# Capabilities

## AEROSPACE



- **Aeromechanics**
  - Computational aerothermodynamics analysis and design support for Aircraft, rotorcraft, missile, launch vehicles and other aerospace systems
  - Coupled Aero-servo-thermo-elastic analysis
  - Flight dynamics, separation and abort dynamics
  - Plasma research and applications
  - Reduced Order Modeling for complex system simulations
- **Environmental Effects**
  - Flight simulation aeroheating and particulate erosion
  - Software subsystem built in SOA for C4I integration
  - Climatology, now-forecasting, satellite and radar data
  - Integration with fielded situational awareness software

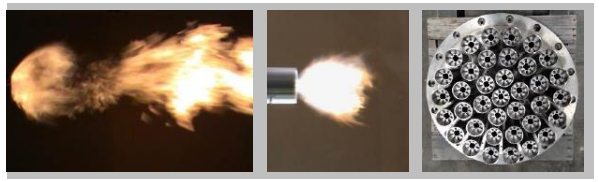




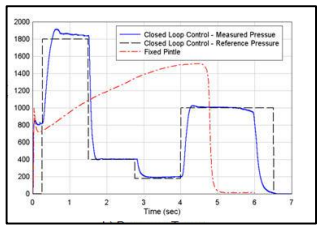
## PROPULSION

- Engineering **Test Facility** for prototype development
  - Air Turbine for Next Generation Jamming Pod
  - Helicopter inlet filter for sand ingestion protection
- **Combustion**, fuel injectors, fuel mixing

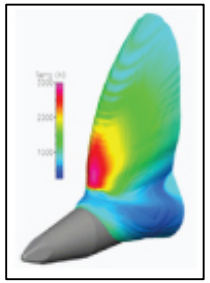
***APTU Injector Development***



- **Divert & Attitude Control Systems**
- **Gelled Propellant Systems**
- **Throttleable Propulsion**




***Thrust Profile***



***Thruster Modeling***

## ENERGY

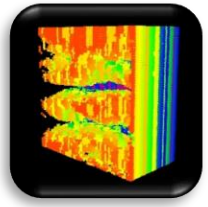
- **Energy Storage**
  - Next-generation thermal batteries
  - Solid-state batteries
  - Alternative fuel sources
  - Nanomaterial-based electrodes
  - Battery test and evaluation

***Bio-Battery***

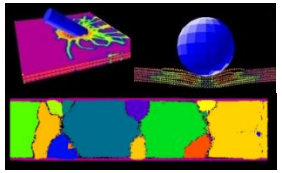
- **Smart Energy**
  - Advanced energy management
  - Battery modeling and simulation
  - Grid modernization
  - Power and energy analytics

# Capabilities

## Materials

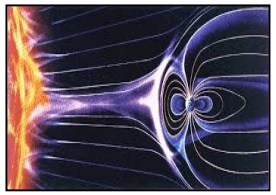


- **High Performance Materials**
  - Material property prediction
  - High-performance energetics
  - High-temp material & coatings



*Fracture Dynamics*

- **Radiation Effects**
  - Electronics and materials
  - Radiation environments
  - Application integration

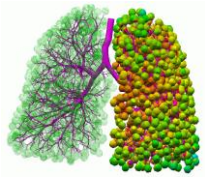


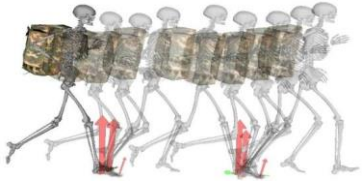
***Multi scale tools with links to macro scale platforms like CFD***

- **Additive Manufacturing**
  - Process optimization
  - Models linking build process to finished part properties
  - Applications related to certification & qualification

## Life Sciences

- **Warfighter Protection:** Traumatic Brain Injury, Improved Helmets/Pads/PPE, Vehicle Crew Injury
- **Warfighter Performance:** Lightening the Load, Spinal/Shoulder/Neck injury, Pain & Fatigue
- **Personalized Health Apps & Portal:** Asthma, Burn Injury, Opioids, Warrior Health, Vestibular Rehabilitation
- **Drug Delivery, PK/PD, Toxicity Modeling**





- **Microfluidic biochips** for sample preparation and environmental, biological and clinical diagnostics
- **SynVivo** for Drug Discovery

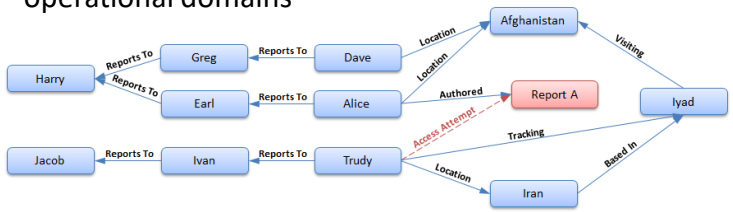
SYNVIVO

REALISTIC. DYNAMIC. CELL-BASED ASSAYS.

www.synvivobio.com

## Cyber Security

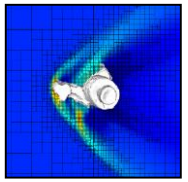

- **Protective Technologies**
  - Verification, validation, and accreditation of critical information
  - Electronic component evaluation for weapons systems
  - Security of FPGAs, ASICs, and components
  - Modeling of mitigation approaches
- **Trust and Access**
  - Efficient methods of establishing trust in information from Service-Oriented Architectures & Big Data
  - Access control and awareness via logical proximity
  - True assessment of "need-to-know"
  - Beyond spatial, temporal, organizational, and operational domains

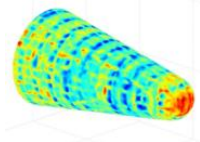


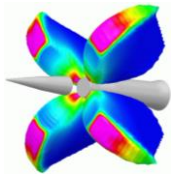
# Aerospace Systems Computational Modeling Capabilities

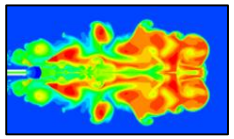
## High-Speed Systems

- Aero-thermal-dynamics analysis & design
- Coupled continuum & rarefied flows
- Re-entry plasma physics & black-out
- Debris & fragment aerodynamics
- Plume signature modeling
- Stage separation


Debris Aerodynamics

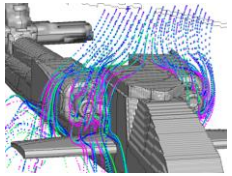

Plasma Effects

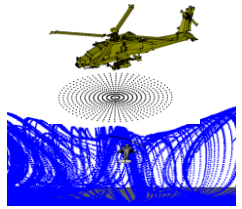

Plume Effects

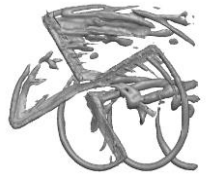

Muzzle Flash Plume Signature

## Rotorcraft Systems

- Engine Sand Ingestion
- Aerodynamics & drag reduction
- Vortex dynamics
- Particles dynamics & brownout
- Aero-acoustics


Engine Sand Ingestion

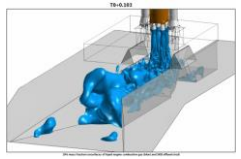

Brownout

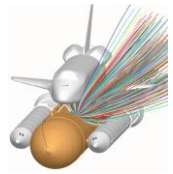

Vortex Dynamics

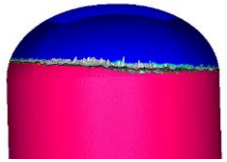
## Launch Systems

- Lift-off plume environments
- Ignition over pressure effects
- Propellant tanks sloshing dynamics
- Launch acoustics suppression
- Launch debris


Acoustic Loads

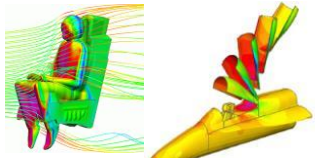

Plume Impingement

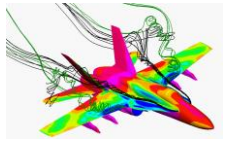

Launch Debris

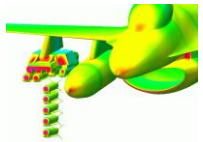

Propellant tank sloshing

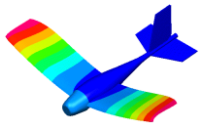
## Aircraft Systems

- Aerodynamics
- Store separation (CFD+6-DOF)
- Aero-servo-elasticity; buffet, flutter, LCO
- Aero-acoustics
- Crew Escape systems


Crew Escape Systems

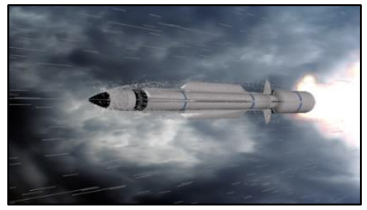

Aero-servo-elasticity

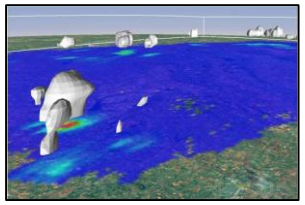

Store separation


Flexible Micro Air Vehicle Analysis

## Weather Effects

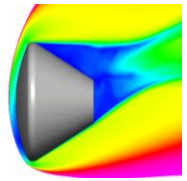
- Flight simulation aeroheating & particulate erosion
- Climatology, now-forecasting, satellite & radar data
- Integration with fielded situational awareness software

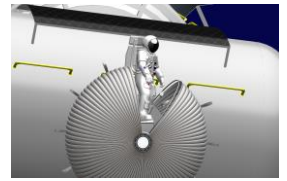

Effects Predictions

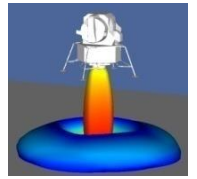

Impact Zone Forecasting

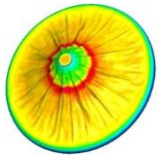
## Space Systems

- Entry Aerothermodynamics
- Aerodynamic decelerators analysis
- Inflatable Systems design & analysis
- Lander plume/regolith interaction


Entry Analysis


Inflatable Air Lock


Lander Plume Debris

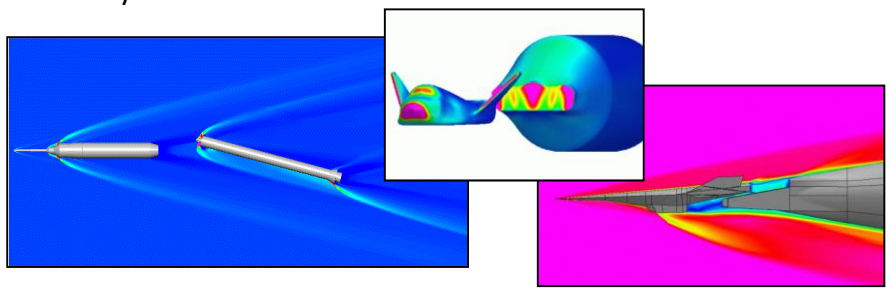

Inflatable Aero Decelerators

**Past Performance Supporting DoD & NASA**

# Vehicle Design & Analysis

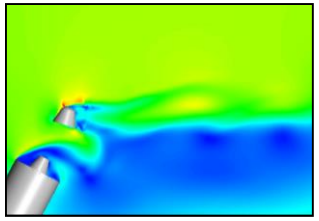
## Stage Dynamic Separation

- Studied effects of residual thrust on first stage separation
- Provided induced body rates and loads for second stage capture
- Assessed stage separation dynamics and post separation trim, stability and control.

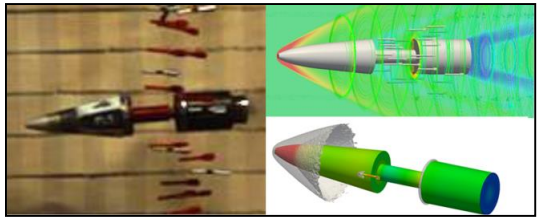


## Nose Shroud Separation Dynamics

- Estimated motor thrust needed for clean separation
- Provided induced body rates, loads, and nose shroud trajectories
- Provided aerodynamic loads impacting trajectory post dispensing and potential impact between multiple objects



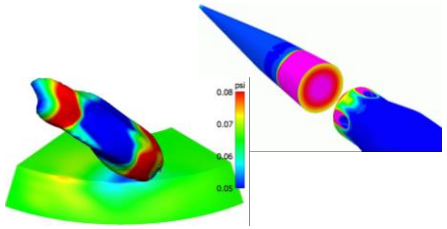
Booster Parachute Cover Separation



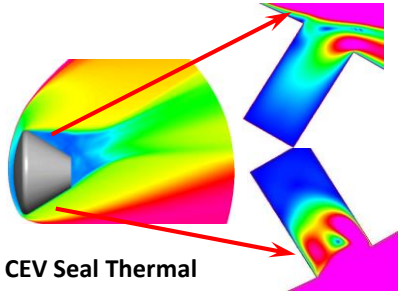
Mine Field Detonators

## Thermal Loads Analysis

- Performed aero-thermal analysis to estimate thermal loads
- Used finite rate chemistry with radiative equilibrium walls
- Performed entry thermal analysis to assess seal thermal leaks



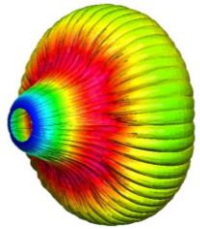
Thruster Plumes

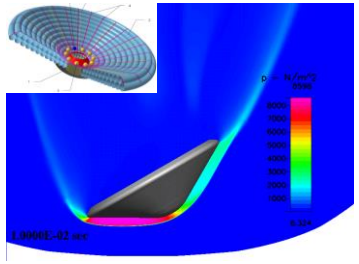


CEV Seal Thermal

## Stability Analysis

- Assessment of stability and static margin of different designs
- Performed stability analysis on hypersonic entry inflatable systems using coupled fluid-structure-thermal analysis

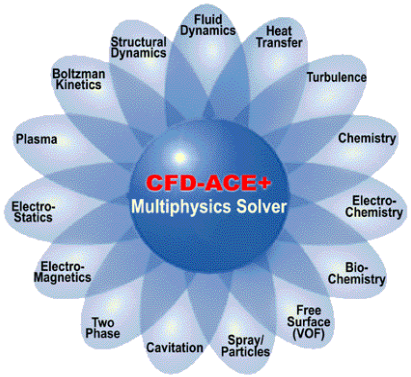




Inflatable Aerodynamic Decelerators Concept Studies

**Experience using CFD codes DPLR, US3D, AVUS, FUN3D, Overflow, CFD-FASTRAN, Loci/CHEM**

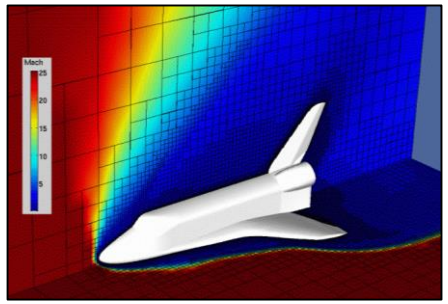
# CFD Research Computational M&S Tools




Enables Coupled Simulations of Fluid, Thermal, Chemical, Biological, Electrical and Mechanical Phenomena

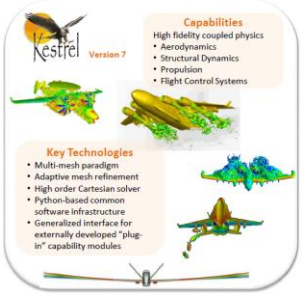

Density-based Compressible Flow Solver with Moving Multi-body Dynamics, Finite Rate Chemistry, and Thermal Modules

## Unified Flow Solver



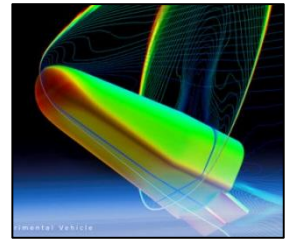
Coupled Continuum and Rarefied Solver with Automatic Solver Selection, Mesh Generation and Mesh Adaptation

## CREATE-AV™



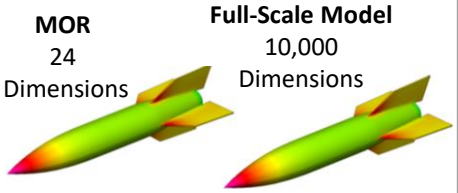

Air Vehicles version of the DoD CREATE (Computational Research and Engineering Acquisition Tools and Environments ) program

## Data-Parallel Line Relaxation Code (DPLR)

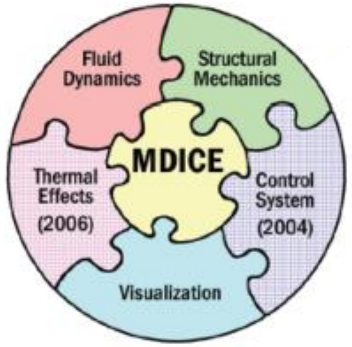


Full 3-D Navier-Stokes Solver for Hypersonic Flow with Generalized Models for Reaction Kinetics and Ionized Flow Physics

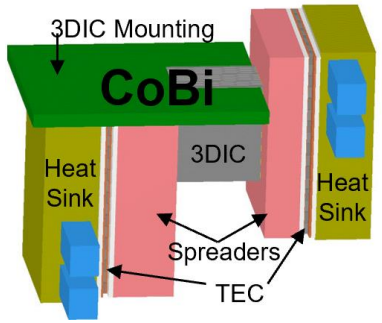
## Model Order Reduction




Multi-physics M&S tool that uses Low-dimensional models extracted from full models for real-time systems analyses (can be trained on flight, experiments, & computational data)

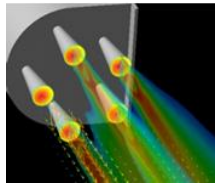



Multi-Disciplinary Computing Environment For Coupling Legacy Codes for Aero-Thermo-Servo-Elastic Applications



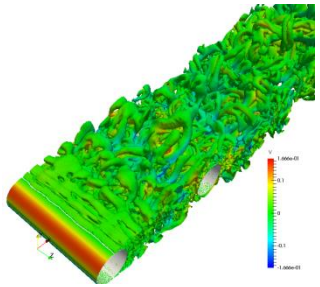

Coupled Multi-Physics Fluids and Structures Modeling Enabling Solutions to Complex Multidisciplinary Problems

## Loci/CHEM



Full Featured Navier-Stokes Solver for Non-Equilibrium Flows Involving Chemical Reactions Using Advanced Generalized Grid Algorithms

## Fun3D



NASA Fully Unstructured 3-Dimensional Production CFD Code for Subsonic to Hypersonic Applications

**Extensive Experience Using and Developing Computational Tools**