General Rocket Analysis

Examples of a "Full Pre-Flight Analysis" on a Rocket

QUESTION: If someone gave you 1-million-dollars, and a YEAR, to make ONE rocket launch – but the launch had to be "fully analyzed"… what would you do?

ANSWER: Trajectory, Structures, Thermal, Fluid, Internal Ballistic, Manufacturing, Design, and Statistical Analysis

1 Mar 2014

(Cool graphic goes here)

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The Problem:

Even "professional" rockets can go wrong…

Pair-fired Mk66 rockets from side-mounted launchpods on an Apache AH-64: These two rockets should have landed "in the same place" (~40ft apart)… but instead: One arced down to the dirt…

So, what went wrong?

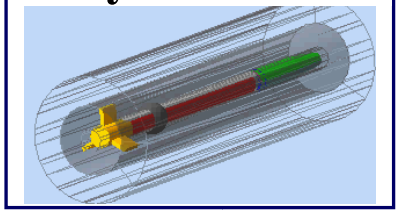
The torsion-fluted expansion cone?
The spring-loaded wrap-around fins?
The graphite nozzle throat insert?
The nozzle-to-case lockwire?
Motorcase burn-thru?
Thrust misalignment?
Warhead loosening?
Burn instability?
Launcher?
Downwash?
Winds?
The Fault-Tree is large…

APPLICATIONS

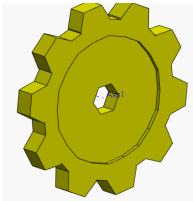
What can you analyze?

Structures...

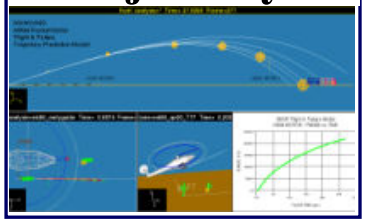
Dynamics...



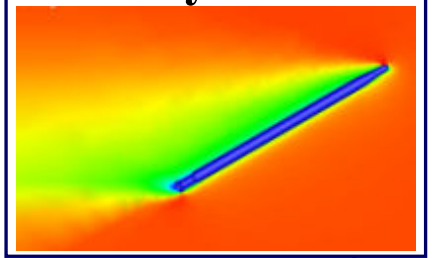
Mechanics...



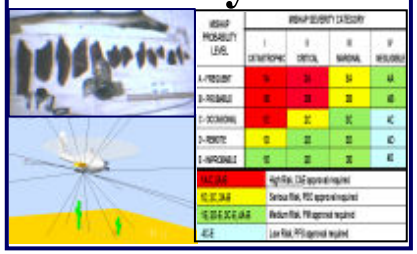
Trajectory...



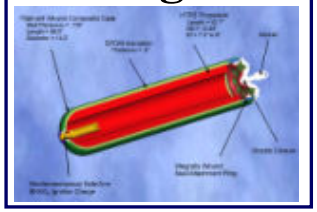
Fluid Dynamics...

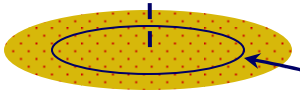


Safety...

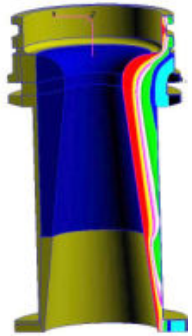


Design...

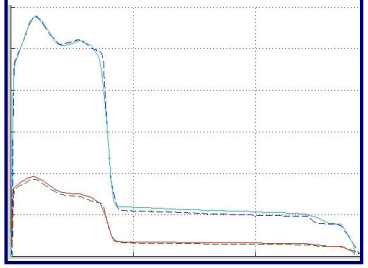




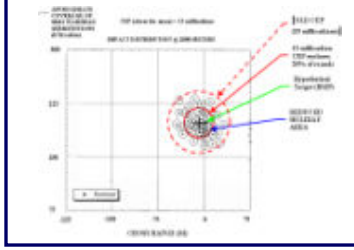
Thermal...



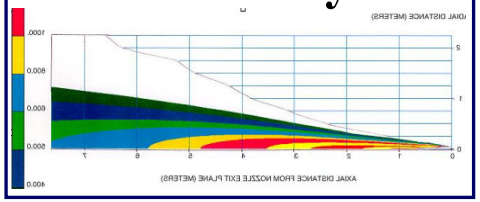
Internal Ballistics...



Statistics...



Plume Analysis...



DYNAMICS

Things can rattle around…

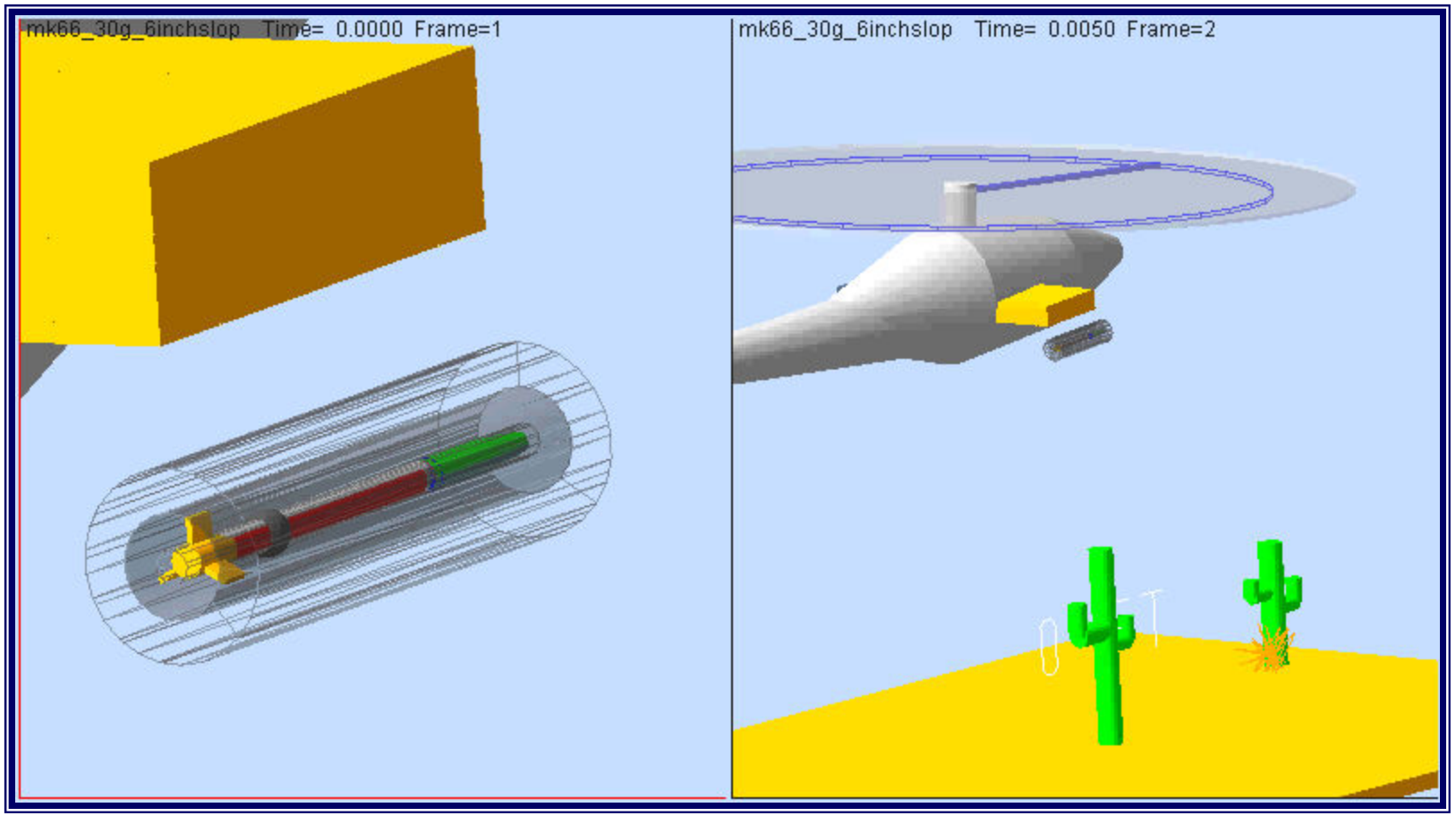
Sometimes a complex model is required, like: A moving, vibrating, flexible launch platform (helicopter), with toleranced dimensional "slop" between the rocket and its launch tube…

MSC Software

Automatic Dynamic Analysis of Mechanical Systems…

ADAMS

* **6-DOF**
* **The world leader; the international industry standard in 6-DOF Mechanical, Trajectory, and Dynamics Software**



TRAJECTORY

Multi-staged, misaligned thrust, with possibly catastrophic explosions
(A way to spend $50,000 to calculate F = ma)

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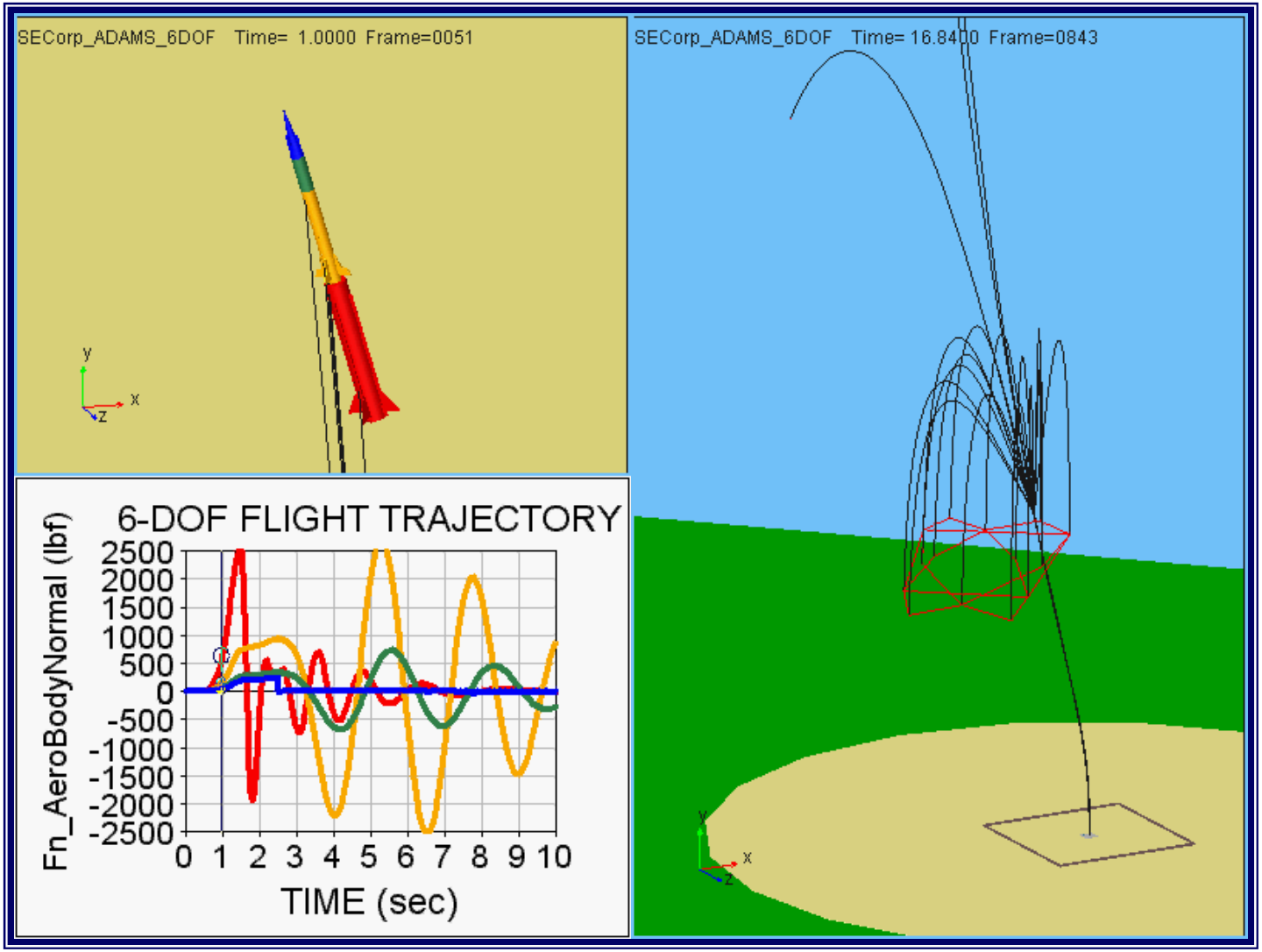


* **Up to 200 Components**
* **All Solved Simultaneously**
* **Micro-Mechanical Interactions Modeled…**
* **Macro Trajectories Predicted…**
* **Classical Accelerations, Velocities, Displacements..**
* **Scope Ranging from Bracket-to-Bolt Interactions, up to Global Orbits of the Earth…**
* **Interactive Loads Reported Throughout**
* **Software Professionally Verified and Maintained since 1986**

*** ADAMS is used by the world's leading Aerospace, Defense, Automotive, Marine, Manufacturing, and Aviation industry dynamics modeling specialists, such as NASA, US Air Force, US Navy, FAA, Boeing, etc.**

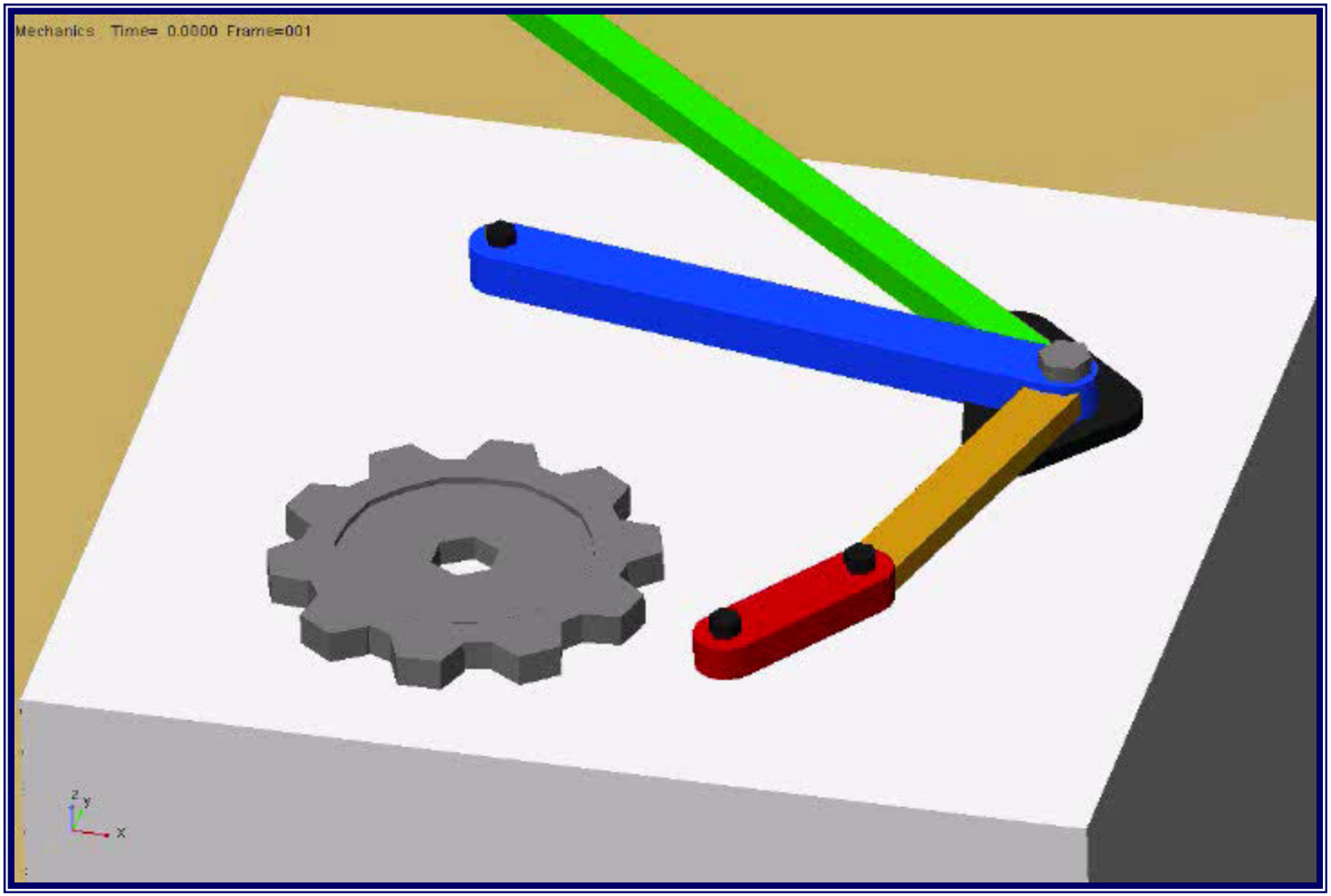
MECHANICS

Things can move around…

Interaction of parts, including micro- and macro- systems, and flexible bodies

In both ADAMS and SolidWorks, virtually any mechanism can be analyzed for both "kinematics" (moving parts; without regard to their mass) and "dynamics" (the mechanism in full analysis of inertial reaction loads, accelerations, etc.).

Additionally, ADAMS can incorporate intrinsic flexibility in parts.

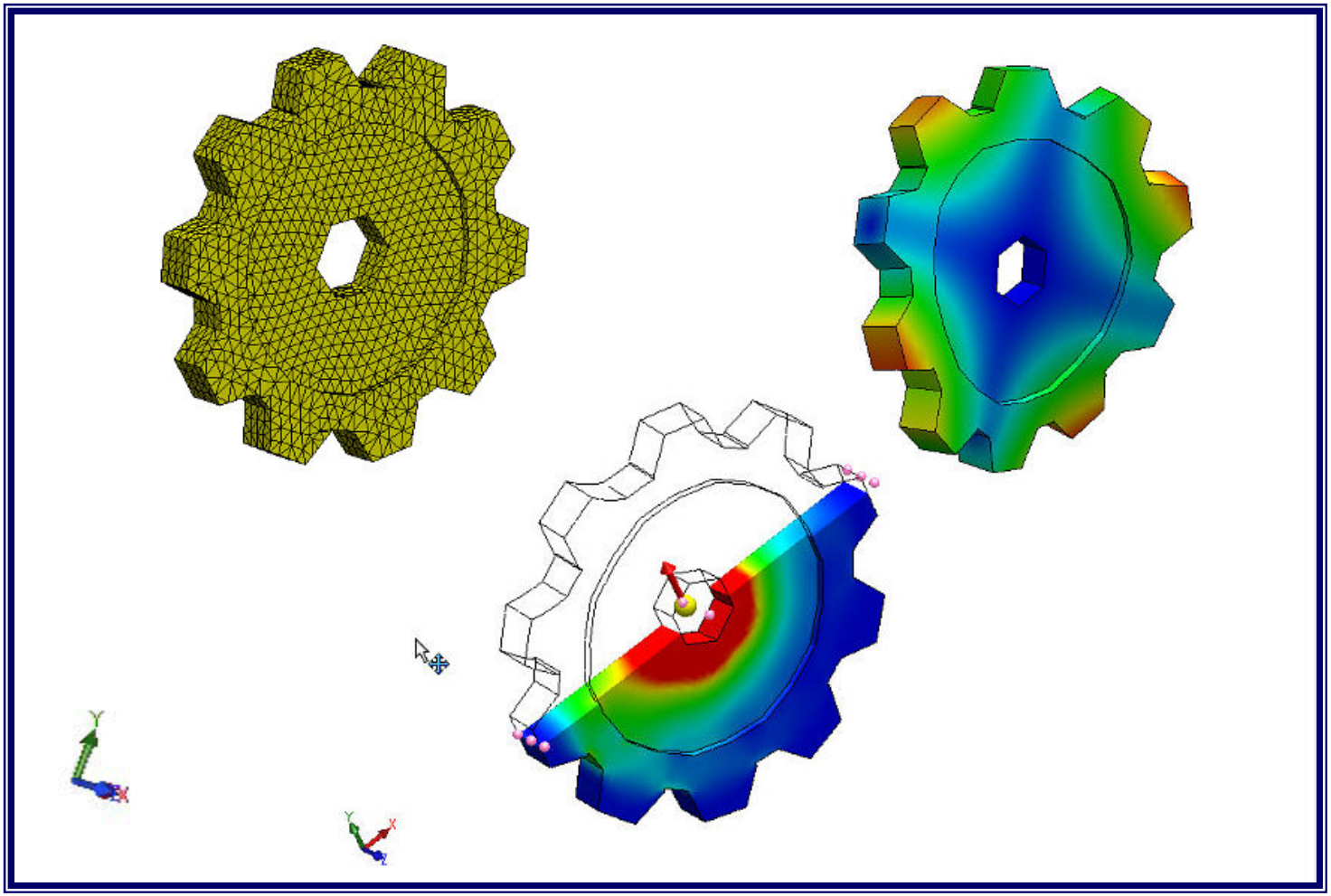


STRUCTURES

Things can break, bend, or oscillate…

3-D CAD Solid Modeling, w/ Parametric Dimensioning, and Finite Element Analysis - FEA – to identify both the natural frequency structural modes and a part's response to external loads, with sectioning tools to identify Safety Factor, deflections, and potential weight reduction

Virtually any object – or assembly of objects - can be evaluated for stress and strain responses using professional Finite Element Analysis (FEA) software – if it includes 3-D non-linear transient dynamic anisotropic conjugate thermal and structural capability.

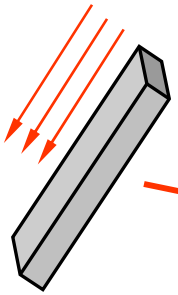


THERMAL

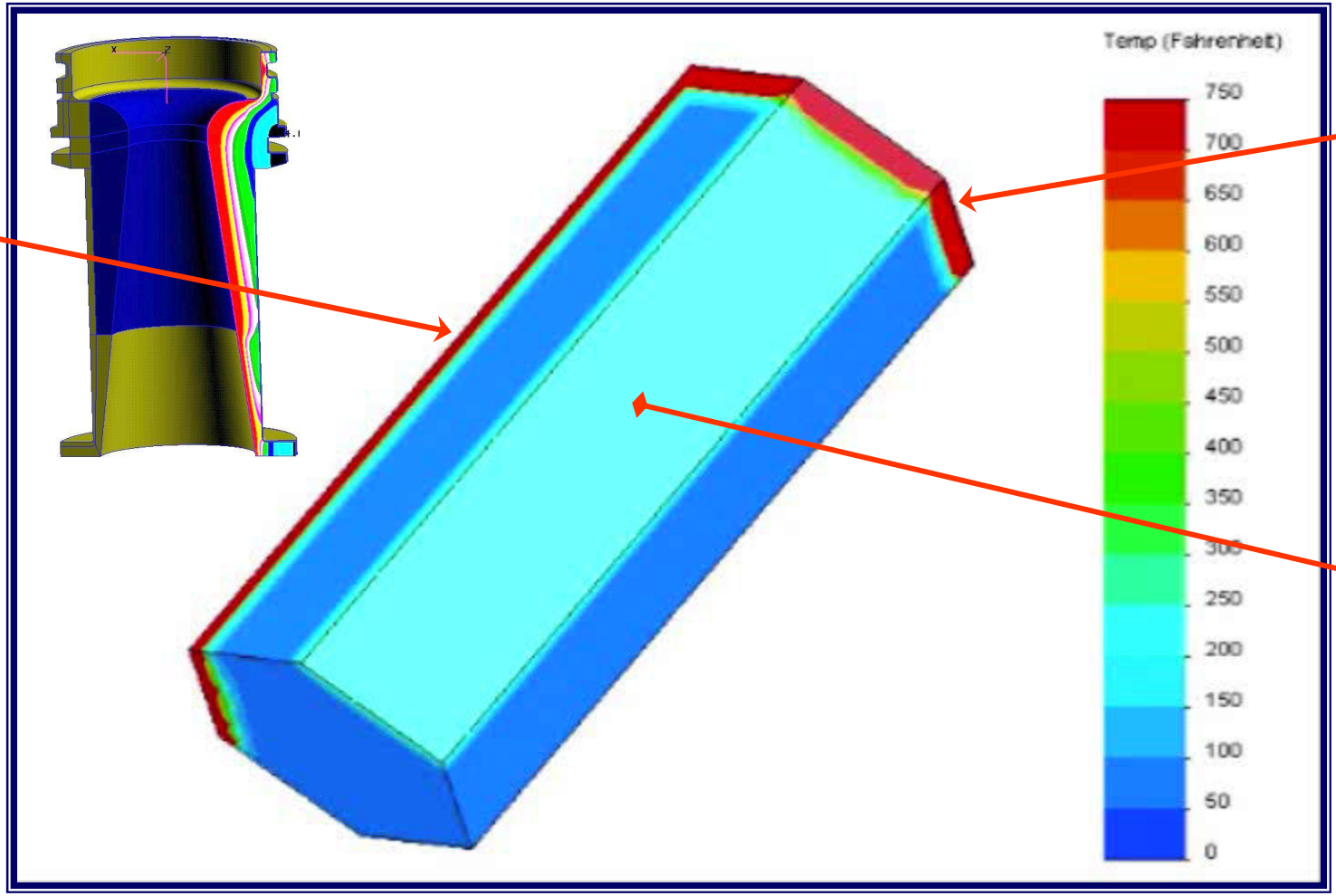
Things can burn, melt, or weaken…

3-D Finite Element Analysis to identify temperature from Conduction, Convection, and Radiation

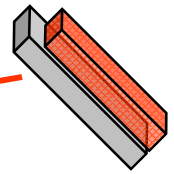
Convection



(Shown: 4800F gas flow at 3300 fps over a graphite blank with a heat transfer coefficient of 0.01 BTU/sec /sq.in/F - comparable to the flow of solid propellant rocket gas over a graphite nozzle throat)



Conduction



(Shown: 4800F temperature heat source, in direct contact)

Radiation

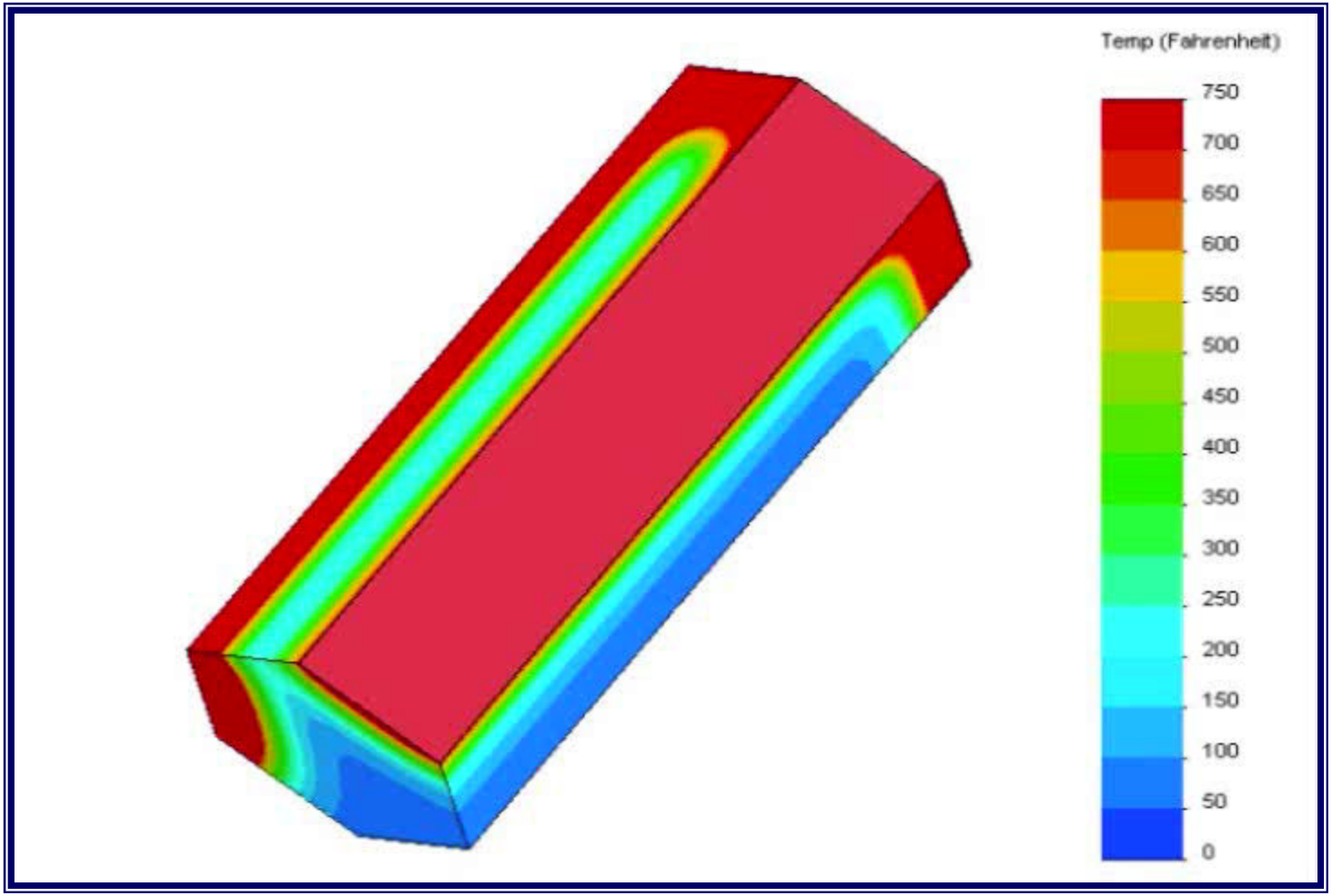
(Shown: 4800F heat source, w/ View Factor and Emissivity of 1.0)

THERMAL-STRUCTURAL

Things can warp…

3-D Finite FEA to identify Structural Response from Temperature Effects

Virtually any object – or assembly of objects - can be evaluated for thermal stresses and deflections by using professional Finite Element Analysis (FEA) software - if it includes 3-D anisotropic conjugate thermal and structural capability.

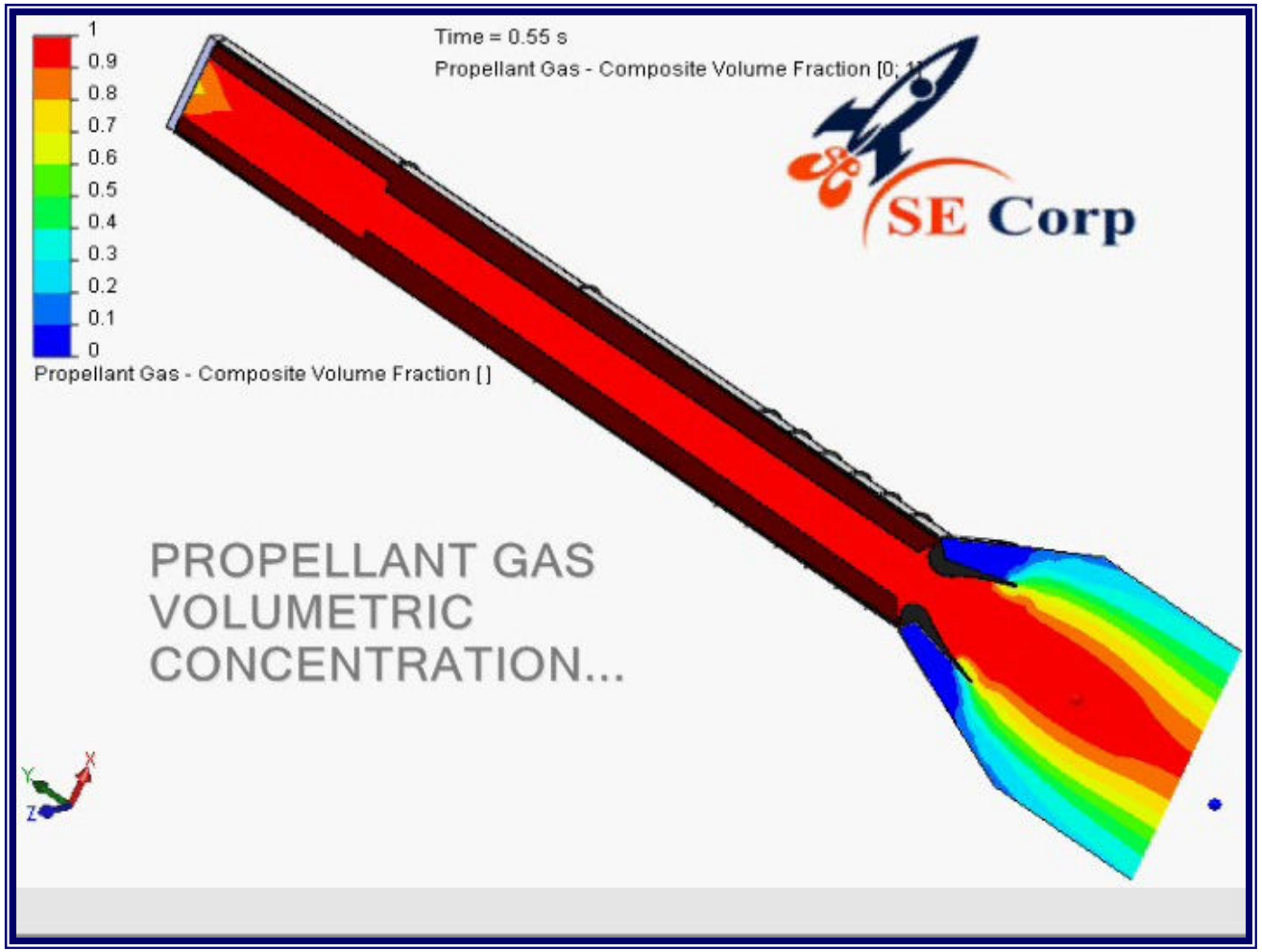


CFD ("Internal")

Things can swirl around inside your space…

Computational Fluid Dynamics – CFD – can be used to calculate flowpaths within structures

For "Internal" CFD runs, a fluid source can be calculated for its driving flowpaths, pressures, temperature gradients, heat transfer coefficients, etc…



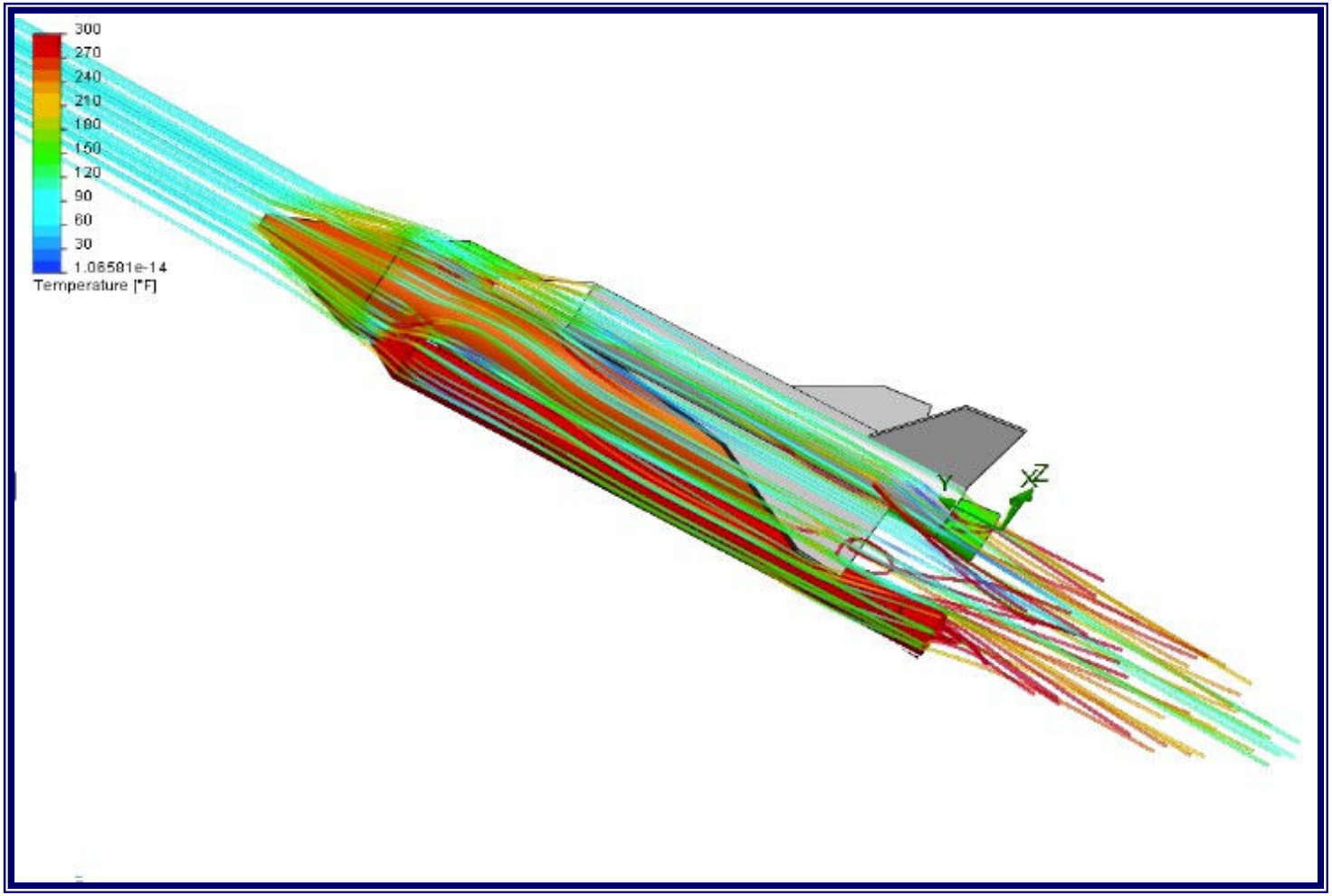
CFD ("External")

Things can be blown around by the airstream…

Computational Fluid Dynamics – CFD – can be used to calculate flow over objects, assisting in calculation of Drag Coefficients – Cd, Lift Coefficients - Cl, Heat Transfer regions, Local Pressure Loads, etc.

For "External" CFD runs, a fluid can be passed over an object at various speeds and directions to perform a "Virtual Windtunnel Test".

These tests can help predict an object's Cd, aerodynamic lift, aerodynamic heated areas, pressure contours, etc… all at various "Angles of Attack" (AoA) and fluid conditions.



CONCLUSION

Thank you, and…

There is a lot to be calculated out there.

Any Questions? Please contact…

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