National Aeronautics and
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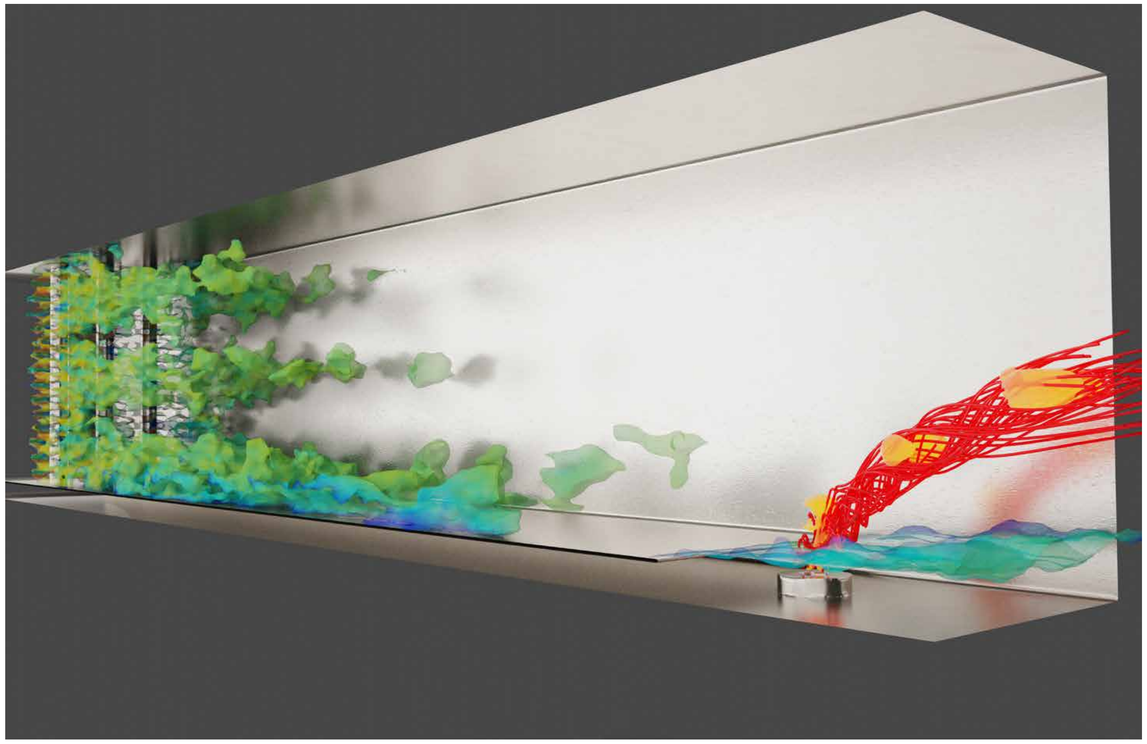

A large-eddy simulation of a model aircraft engine combustor that represents high-altitude relight. Shown are upstream fuel mixing (isosurface of mixture fraction colored by velocity magnitude) and downstream non-premixed spark ignition (red lines tracing a spark-induced ignition kernel). Ignition will succeed or fail depending on the initial states of the kernel and the turbulent flow conditions. Here, it succeeds, as shown by the isosurface of reaction progress variable (yellow). *Yihao Tang, Venkat Raman, University of Michigan*

HPC Framework for Predicting High-Altitude Relight in Aircraft Engines

In high-altitude relight after an aircraft engine flameout, one or more ignition kernels (pockets of high-energy flow and free radicals) are introduced into the engine combustor by firing the ignitor. There are two main modeling challenges for predicting this event: conflicts between simulation fidelity and computational capacity, and the stochastic nature of turbulence and spark discharge. To address these, we developed a tabulation model for non-premixed forced ignition of realistic jet fuels; an uncertainty quantification approach, based on Monte Carlo simulations, is used to estimate the ignition probability. Results show that the developed framework can both qualitatively and quantitatively predict the forced ignition process under different operating conditions.

Yihao Tang, Venkat Raman, University of Michigan

The pulse-jet-in-crossflow effect of the ignition kernel is visualized from a cross-section of the combustor. From this view, the counter-rotating vortex pair can be better visualized. The shape of the flame front (yellow) follows those flow streak lines (red) integrated from the initial kernel ejection boundary. To capture such complex flow dynamics requires high-fidelity simulation of the turbulent flow field, which is indispensable to accurately predict the ignition process. *Yihao Tang, University of Michigan; Malik Hassanaly, National Renewable Energy Laboratory*

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