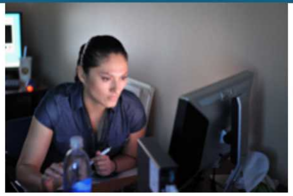
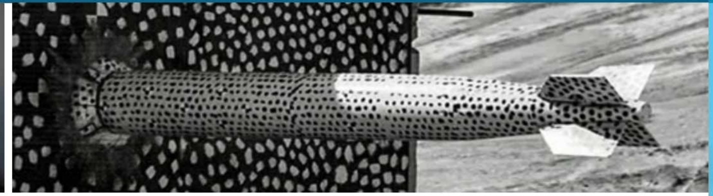
SAND2020-3025PE

Finite-Rate Modeling Updates





PRESENTED BY

Erin Mussoni

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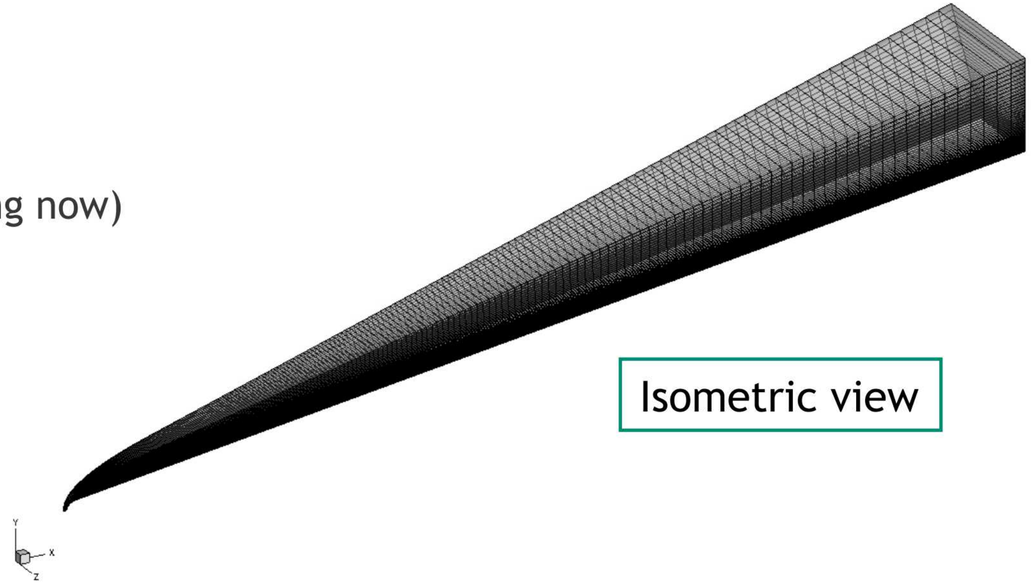
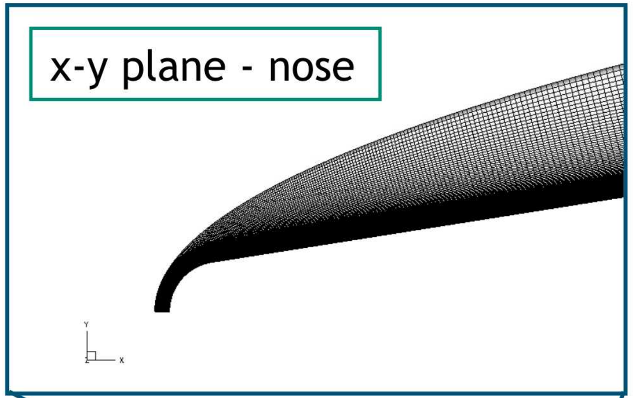
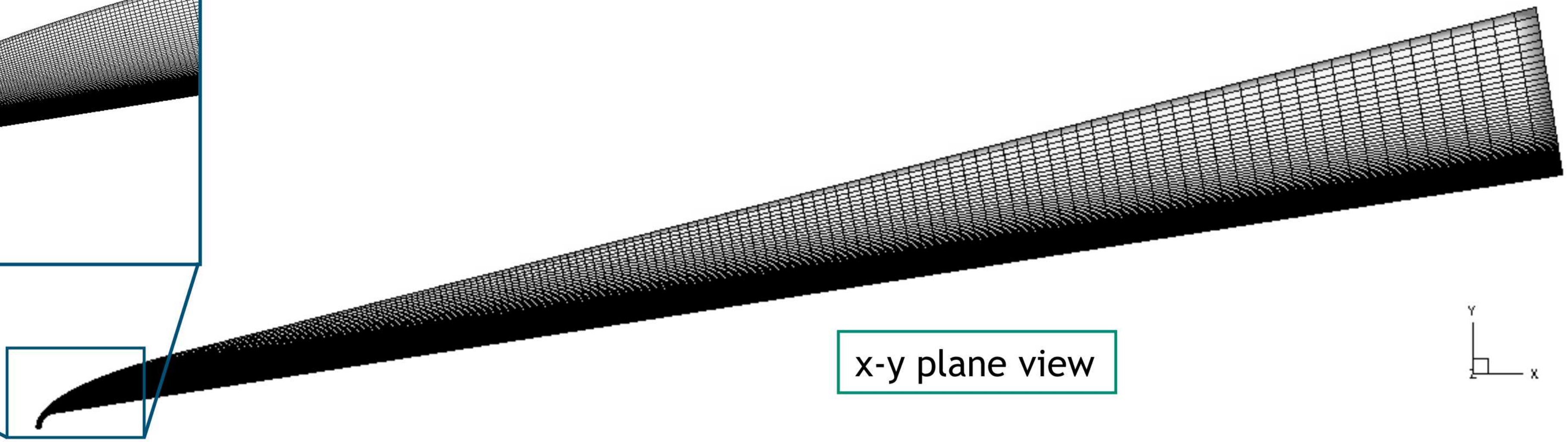
Problem Setup – Flowfield Geometry

- 3D structured mesh
- Geometry 1: radius = 0.5 inches, angle = 9 degrees
- Geometry 2: radius = 10 cm, angle = 8 degrees (using now)







Workflow (as of now)

Generate surface temperature boundary

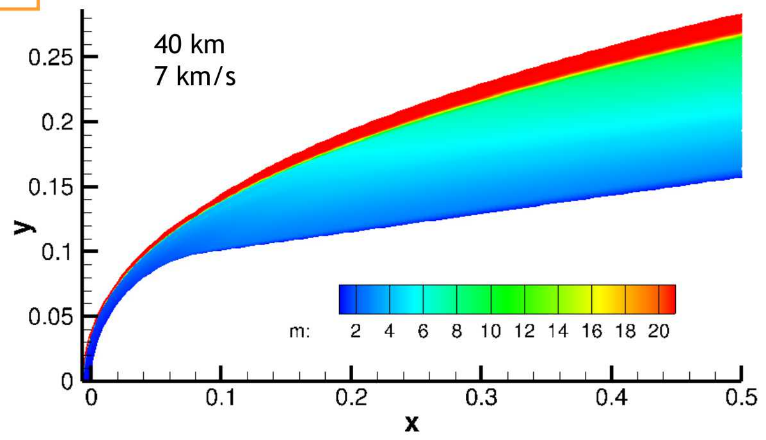
Velocity

Altitude

Air species composition

Trajectory-US3D
Using Non-catalytic non-ablating radiative equilibrium BC

Run laminar

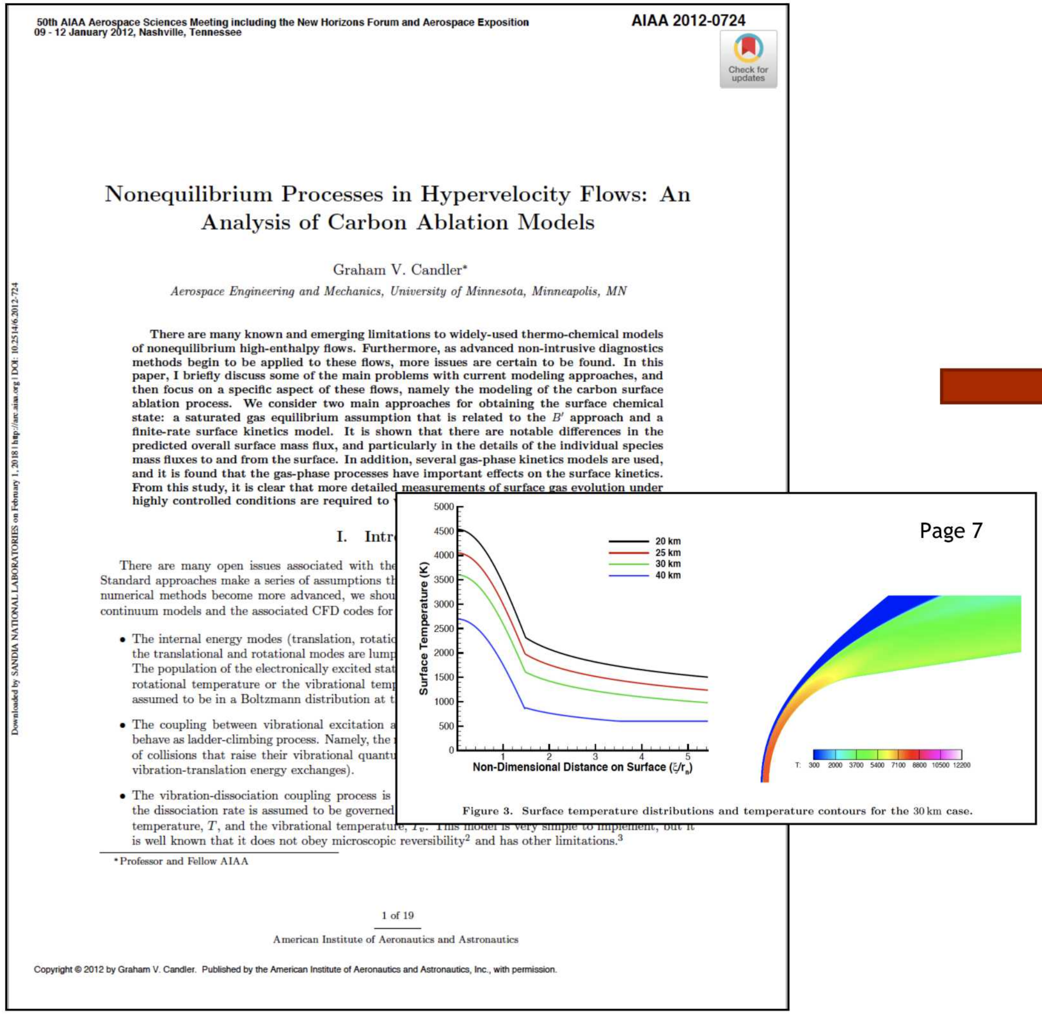


Surface temperature profile

Run finite-rate model

Trajectory-US3D Finite-rate model
adsorption, desorption, sublimation, coking, etc.
[assumes carbon surface]

- gas species mass flux
  can compute recession rates with this
- heat flux
- a bunch of other stuff



50th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition
09 - 12 January 2012, Nashville, Tennessee

AIAA 2012-0724

Check for updates

Nonequilibrium Processes in Hypervelocity Flows: An Analysis of Carbon Ablation Models

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There are many known and emerging limitations to widely-used thermo-chemical models of nonequilibrium high-enthalpy flows. Furthermore, as advanced non-intrusive diagnostics methods begin to be applied to these flows, more issues are certain to be found. In this paper, I briefly discuss some of the main problems with current modeling approaches, and then focus on a specific aspect of these flows, namely the modeling of the carbon surface ablation process. We consider two main approaches for obtaining the surface chemical state: a saturated gas equilibrium assumption that is related to the B' approach and a finite-rate surface kinetics model. It is shown that there are notable differences in the predicted overall surface mass flux, and particularly in the details of the individual species mass fluxes to and from the surface. In addition, several gas-phase kinetics models are used, and it is found that the gas-phase processes have important effects on the surface kinetics. From this study, it is clear that more detailed measurements of surface gas evolution under highly controlled conditions are required to

I. Intr

There are many open issues associated with the
Standard approaches make a series of assumptions th
numerical methods become more advanced, we shou
continuum models and the associated CFD codes for

- The internal energy modes (translation, rotatio the translational and rotational modes are lump The population of the electronically excited stat rotational temperature or the vibrational temp assumed to be in a Boltzmann distribution at t
- The coupling between vibrational excitation a behave as ladder-climbing process. Namely, the of collisions that raise their vibrational quantu vibration-translation energy exchanges).
- The vibration-dissociation coupling process is the dissociation rate is assumed to be governed temperature, T, and the vibrational temperature, T_v. This model is very simple to implement, but it is well known that it does not obey microscopic reversibility[2] and has other limitations.[3]

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1 of 19

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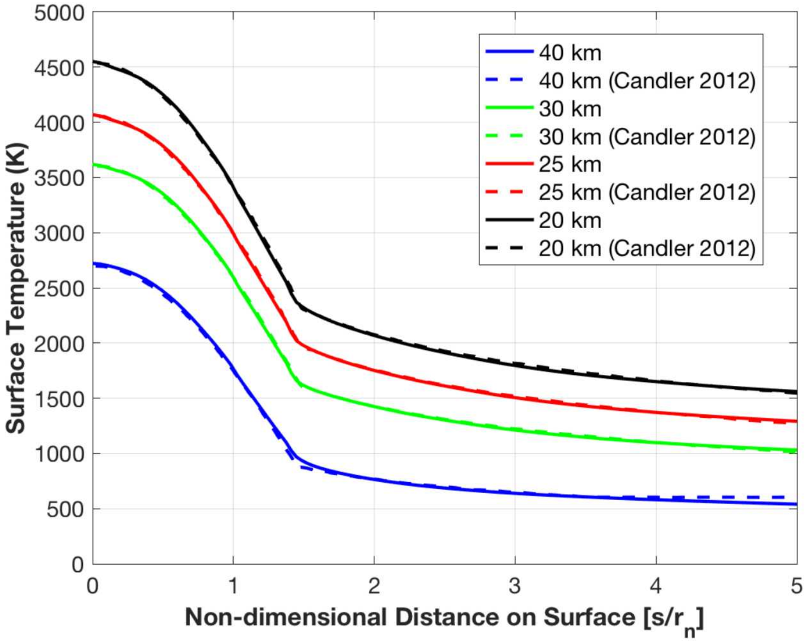
Page 7

Figure 3. Surface temperature distributions and temperature contours for the 30 km case.



Surface temperature comparison between model and Candler's results for freestream speed of 7 km/s. Temperature profile serves as boundary condition for finite-rate models. Results found by using a non-catalytic non-ablating radiative equilibrium surface BC and run with Trajectory-US3D. Geometry in both cases was a 10 cm radius sphere - 8 degree cone geometry. All cases run with laminar boundary layer.

Goals: Use this model comparison to 1) Verify that I'm able to produce the same surface temperature profiles that are applied to finite-rate models 2) Compare surface mass flux data from ZA and B' models at these conditions. This gives some confidence in the baseline models and workflow.