High-Resolution
Launch Environment Simulations

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Recent Flame Trench Redesign at Kennedy Space Center's Pad 39B

https://www.youtube.com/watch?v=9matDigB2w4

After many years of harsh rocket launches, the Main Flame Deflector (MFD) at Kennedy Space Center has been upgraded in anticipation of flights of NASA's next generation Space Launch System.

The new MFD has a much easier to maintain shingled steel surface.

Recent Flame Trench Redesign at Kennedy Space Center's Pad 39B

Gaps between the MFD and the trench wall, and the gaps between the steel plates of the MFD itself could allow hot plume gases and strong acoustic waves to affect structures under the MFD.

A team of experts from the NASA Advanced Supercomputing (NAS) Division was called in to apply high-resolution computational fluid dynamics (CFD) to help identify thermal, pressure, and flow environments on and around the geometrically complex MFD.

LAVA Cartesian Grid Simulations

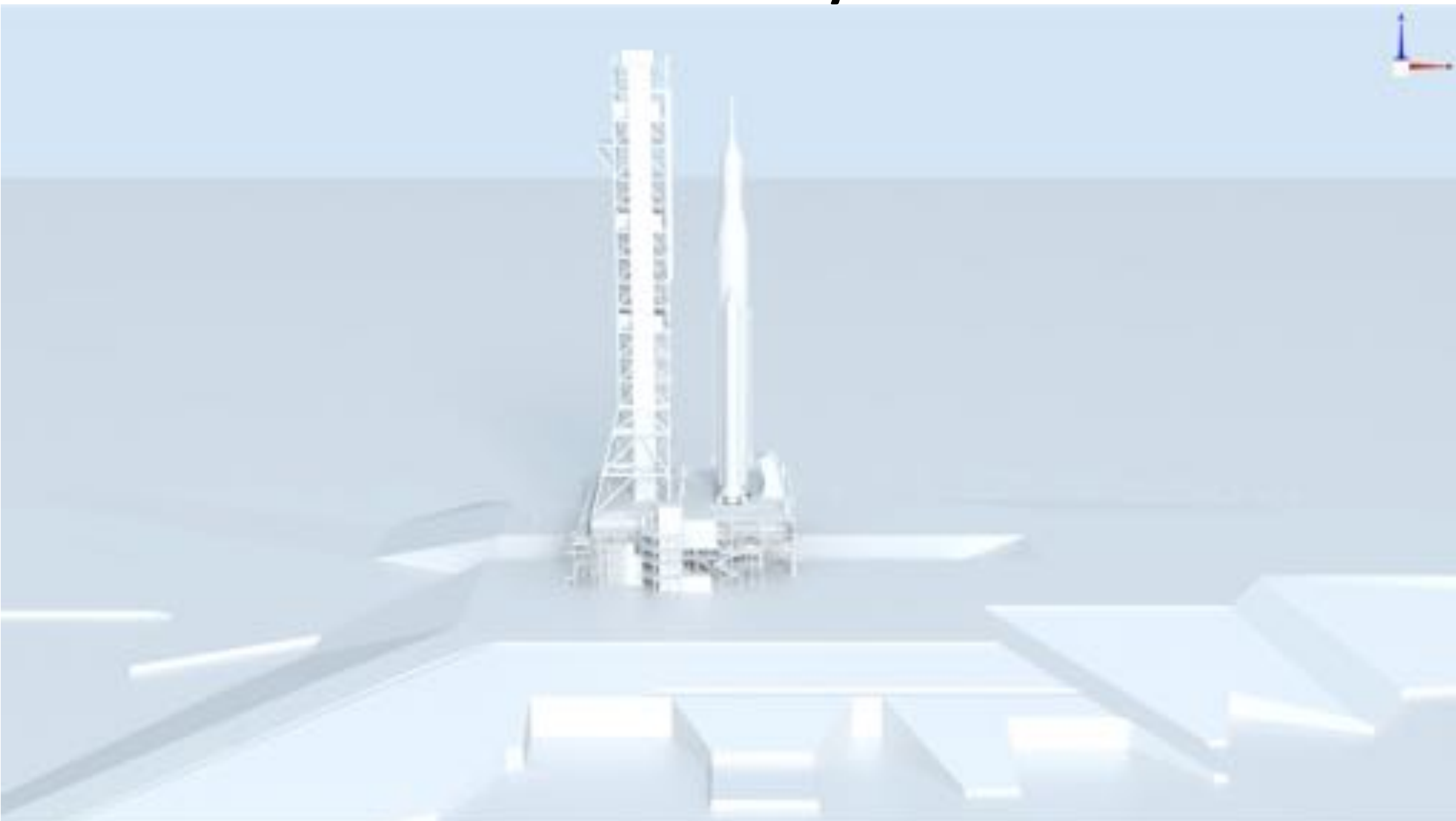
- Significant CAD cleanup and surface mesh generation.
  Kept most detail from as-built CAD.

- LAVA Cartesian computational fluid dynamics:
  - Immersed boundary representation for complex geom.
  - WENO5 high-order space discretization
  - RK4 high-order time discretization
  - Homogeneous mixture model with 3 species: air, SRB, RS-25D (no water)
  - Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation. Temperatures are shown to indicate trends. Thermal analysis conducted separately.

- Engine sequence:
  - RS25D Liquide Engines: Steady, radially varying bc is started at T-0.35
  - Solid Rocket Boosters (SRB): Unsteady, radially varying bc is started at T+0

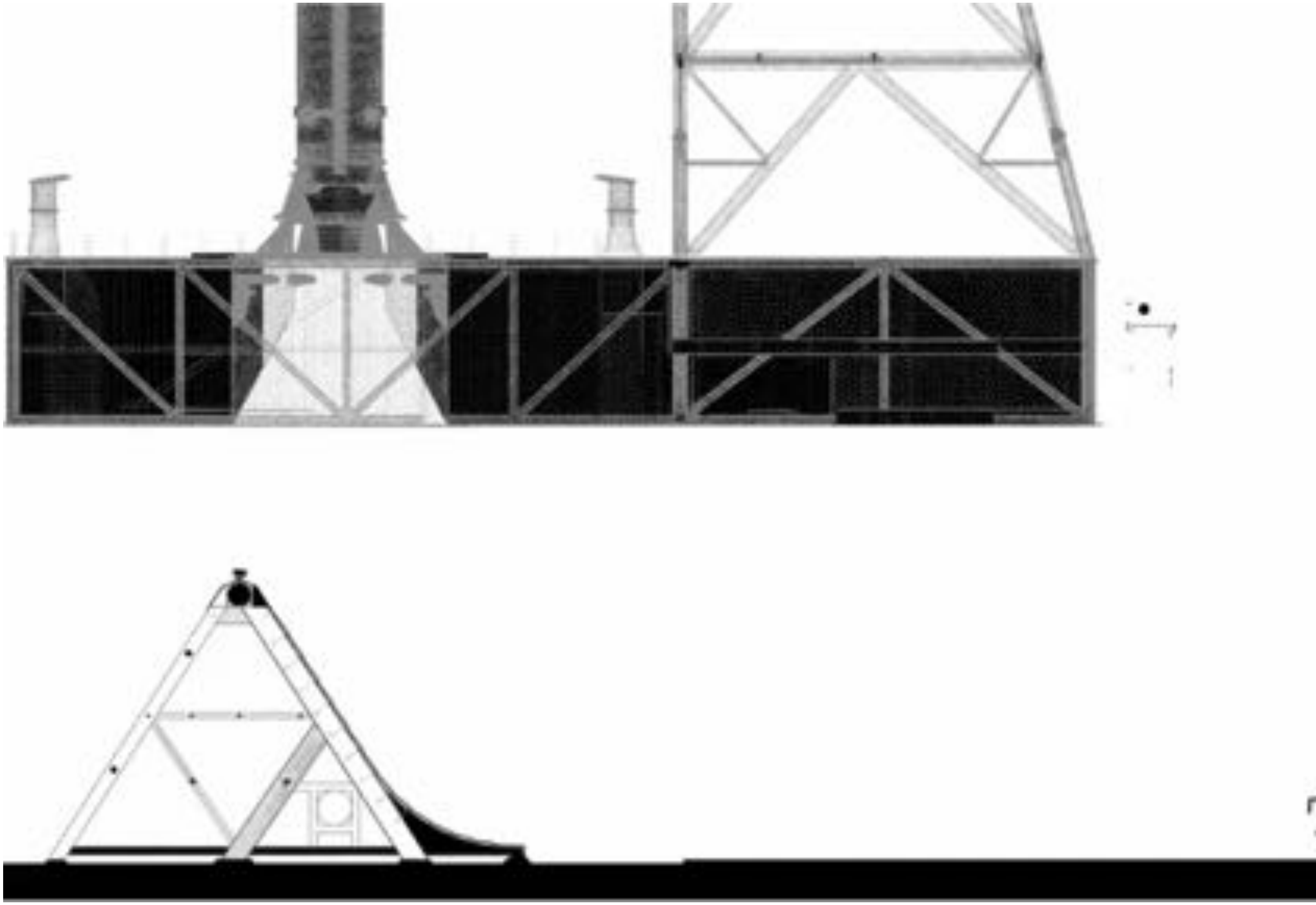
- Simulation is much more complex than our previous Main Flame Deflector (MFD) analysis:
  - Geometric detail is significantly higher, focused on gaps adjoining the MFD
  - Mesh is now 555 million cells vs 200 million previously
  - Timestep is much smaller, due to CFL constraint

Cartesian Grid IOP Simulations: Geometry



Visualization of geometry used in LAVA Cartesian simulation

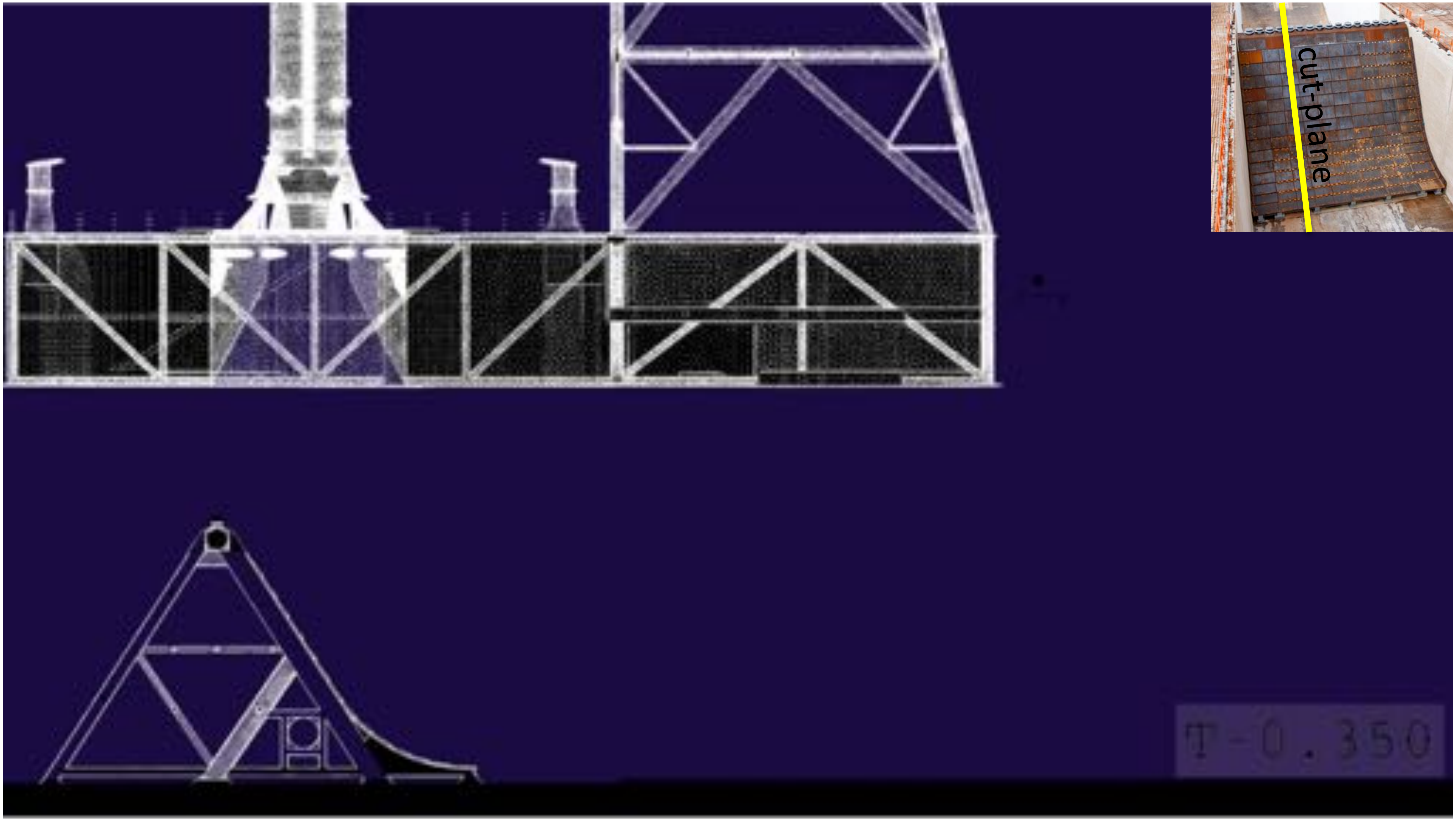
Cartesian Grid IOP Simulations: Flow Visualizations



Pressure cutting plane passing through an SRB centerline

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation.

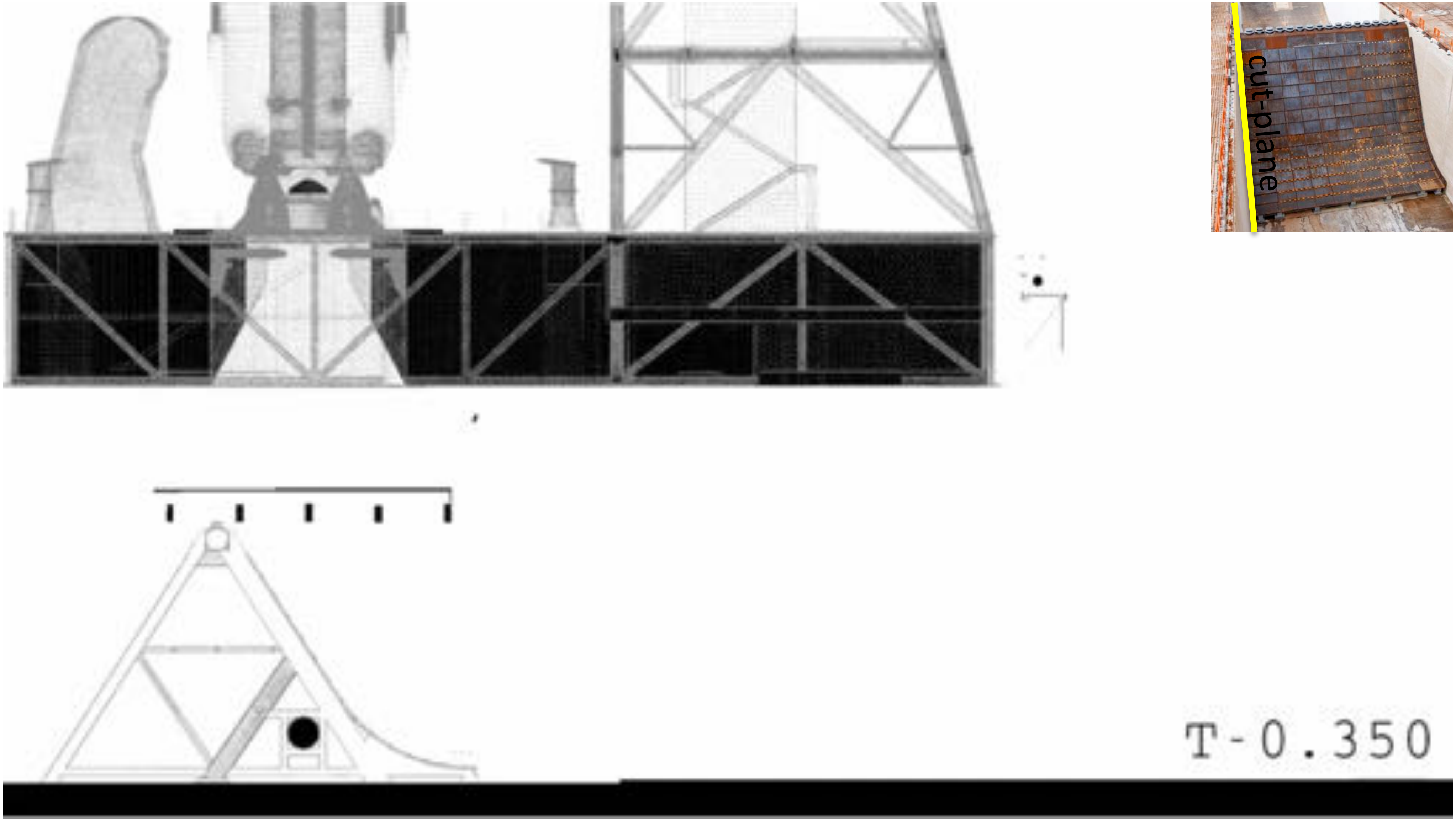
Cartesian Grid IOP Simulations: Flow Visualizations



Temperature cutting plane passing through an SRB centerline

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation. Temperatures are shown to indicate trends.

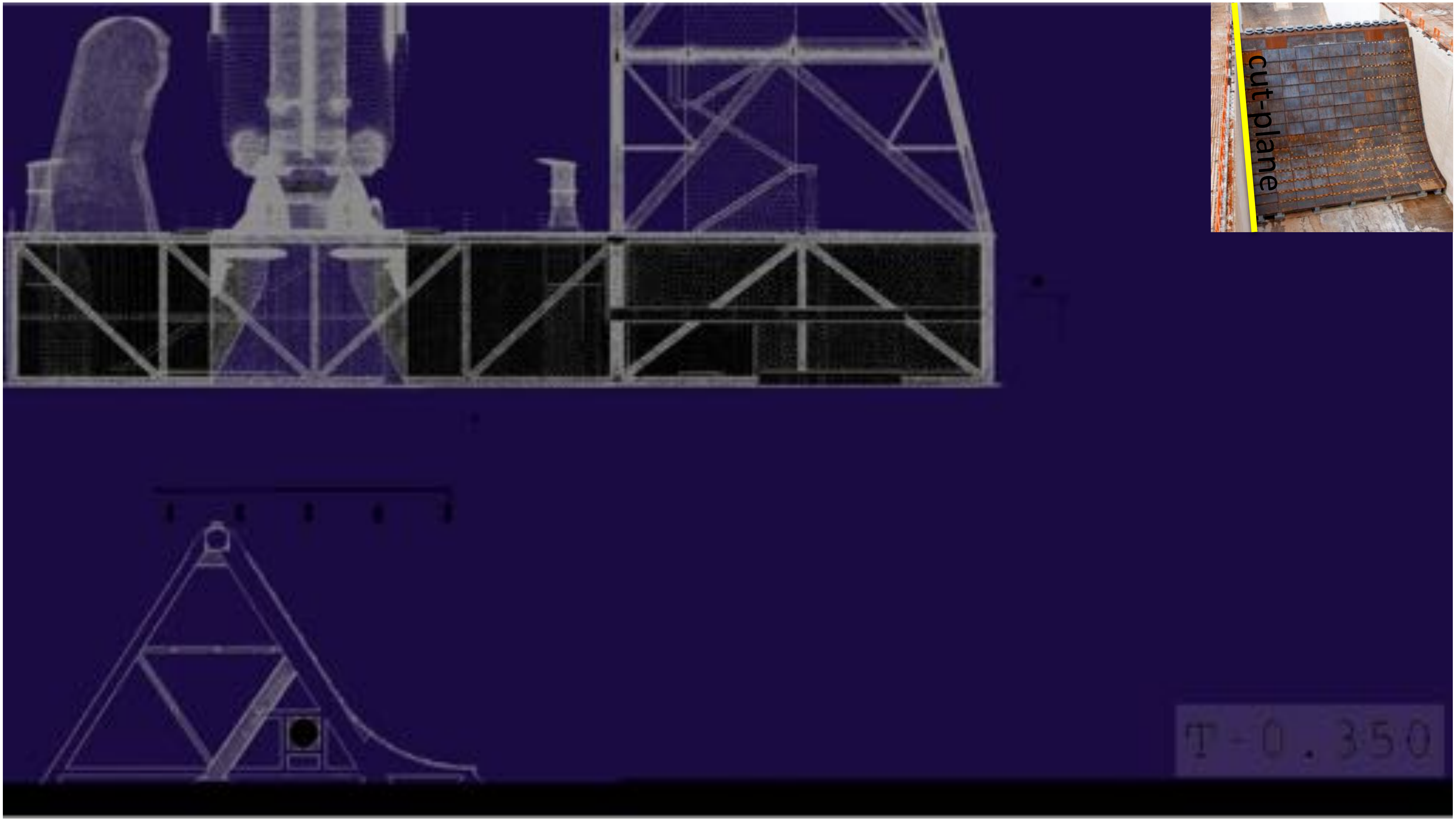
Cartesian Grid IOP Simulations: Flow Visualizations



Pressure cutting plane passing through the MFD/Wall gap

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation.

Cartesian Grid IOP Simulations: Flow Visualizations



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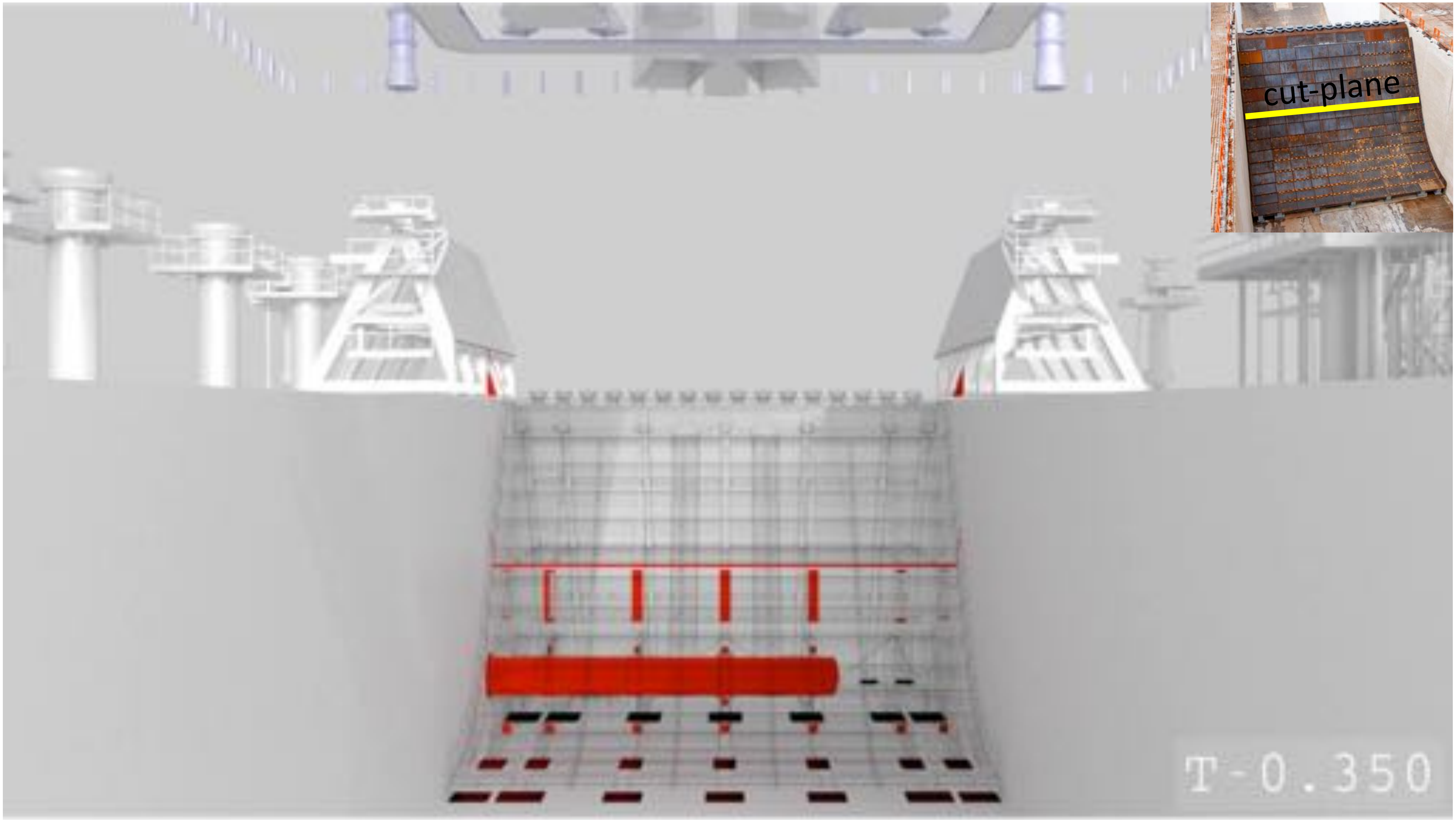
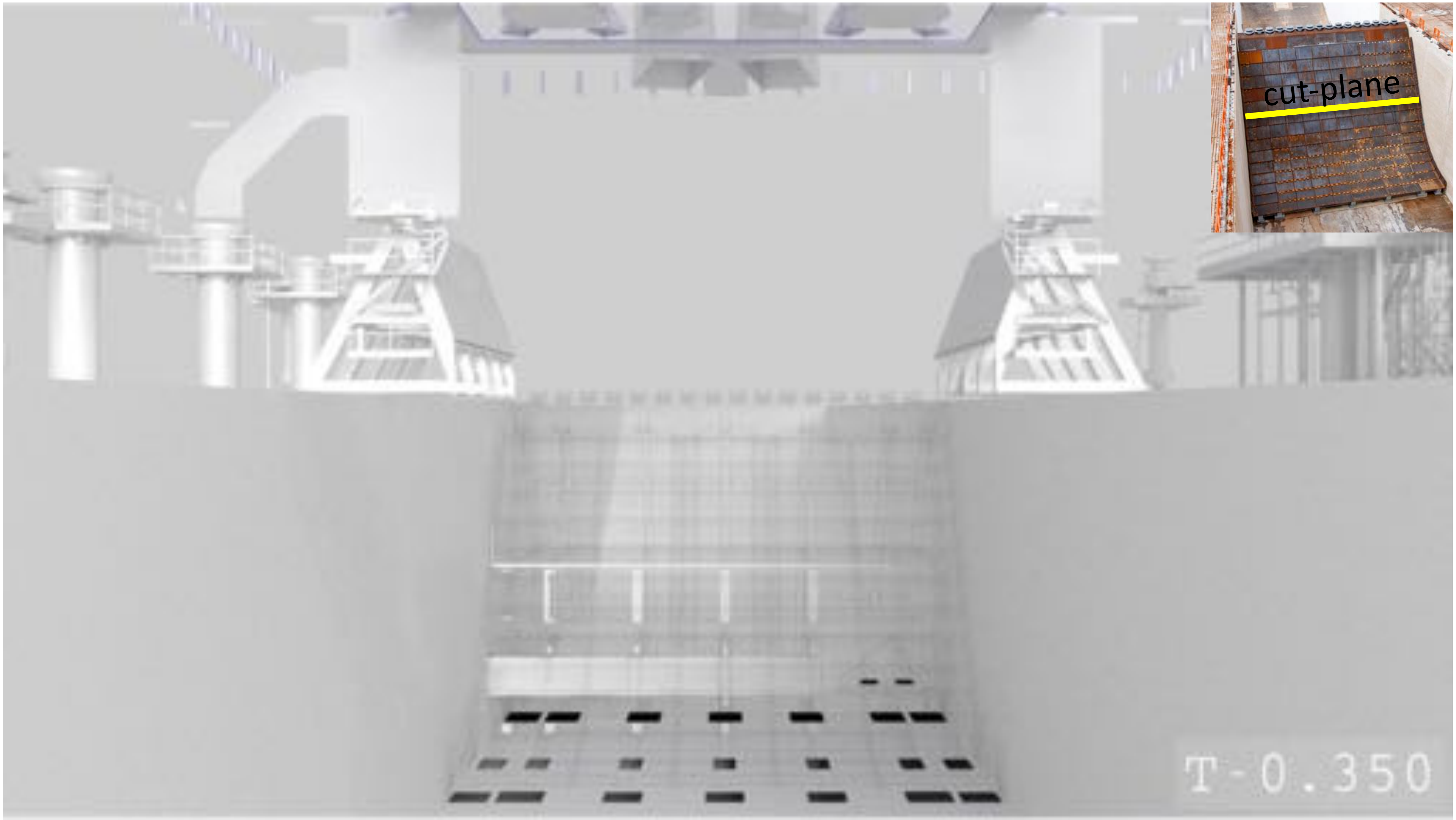
Cartesian Grid IOP Simulations: Flow Visualizations



Pressure cutting plane passing through the SRB centerlines. Plume is clipped.

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation.

Cartesian Grid IOP Simulations: Flow Visualizations



Temperature cutting plane passing through the SRB centerlines. Plume is clipped.

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation. Temperatures are shown to indicate trends.

Cartesian Grid IOP Simulations: Flow Visualizations

Temperature cutting plane passing through an SRB centerline. Plume is clipped. Green people shown for scale.

Note: Viscous/thermal boundary layers, combustion, conjugate heat transfer, water, and other effects are not included for the Cartesian simulation. Temperatures are shown to indicate trends.