A High-Quality Physically-Accurate Visualization of the September 11 Attack on the World Trade Center

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Video

- Google Earth Integration Video

Motivation

- Produce a high fidelity visualization of the attack on WTC-I (North Tower)
- Visualization is intended primarily for the benefit of non-expert users
- Post processors exist which are useful for experts

Previous Work

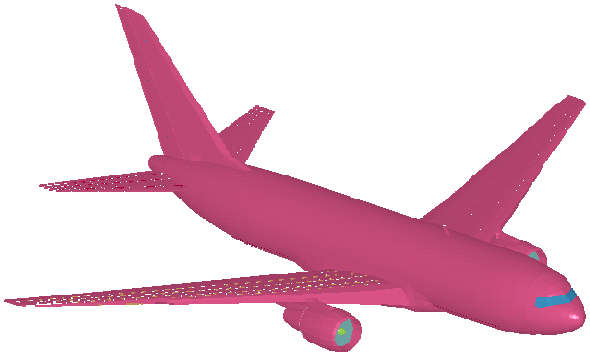
- Our work with the Pentagon simulation is the most similar previous work
- Large extension to the importer that was used previously

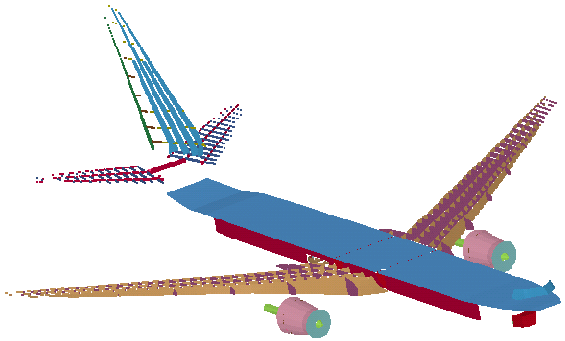
Our Extensions

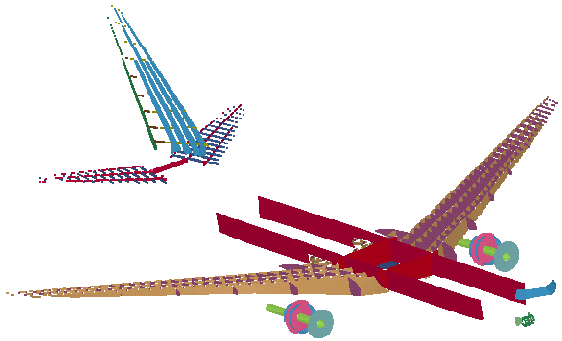
- Complex beam element profiles
- SPH liquid simulation
- Automatic fire visualization controlled by SPH elements
- Automatic dust and debris visualization controlled by eroding elements
- Out-of-core simulation visualization

FEA Simulation

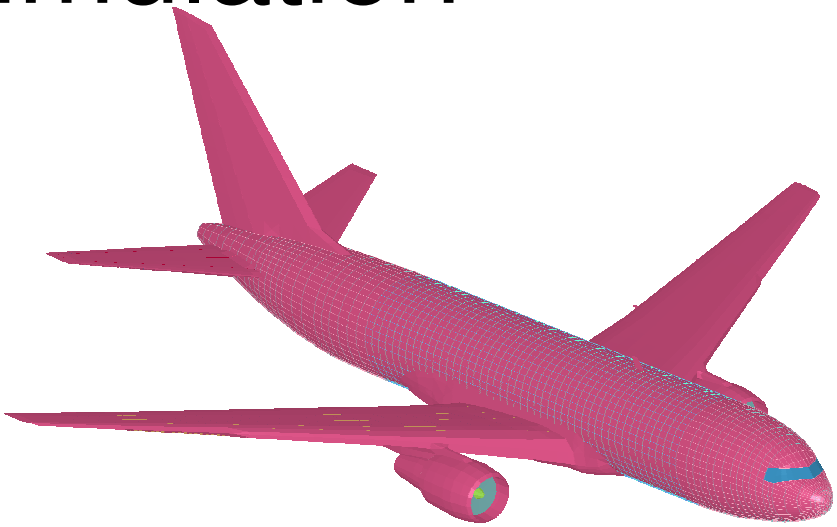
- Boeing 767-200ER modeled using graphics models and published literature about the aircraft
  - Model calibrated using Riera approach as well as weight distribution

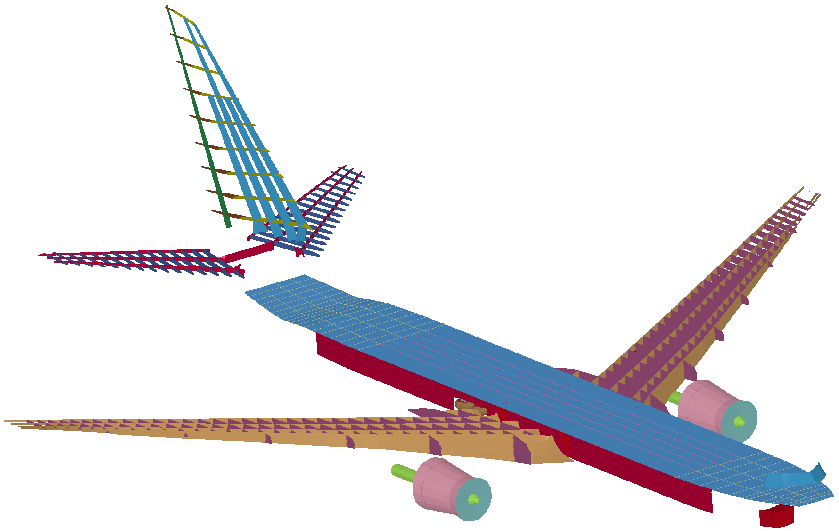


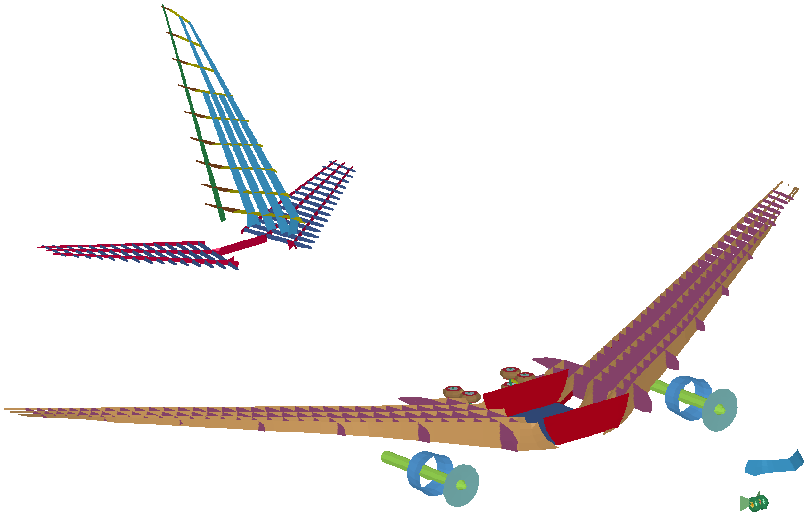




FEA Simulation

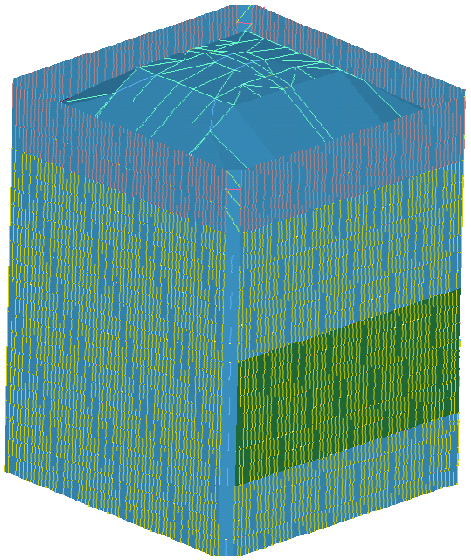


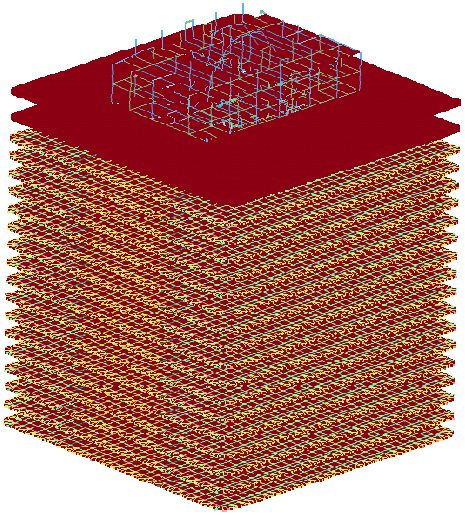


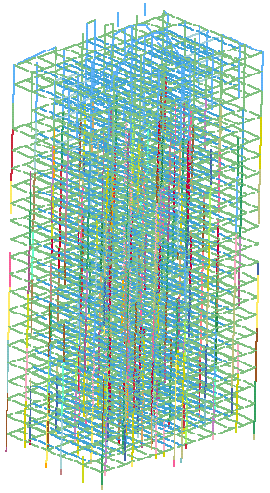


FEA Simulation

- WTC-I (North Tower) modeled by civil engineering team
  - Entire building modeled, top 20 floors used in the simulated







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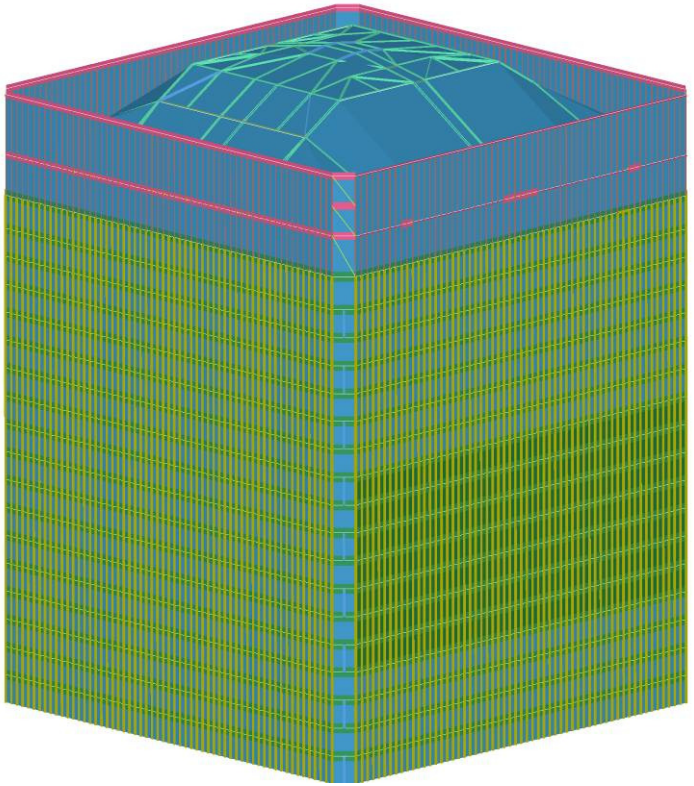
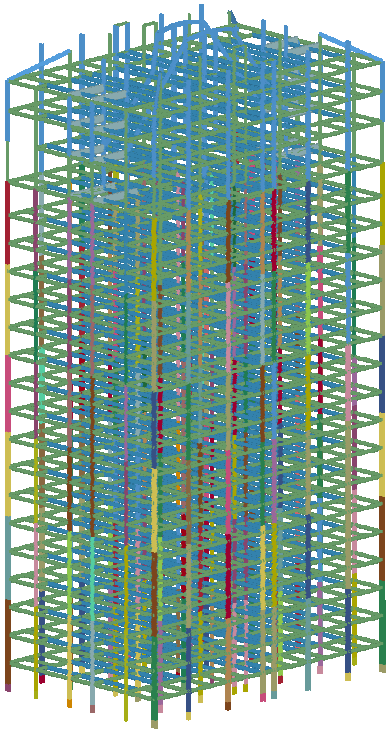
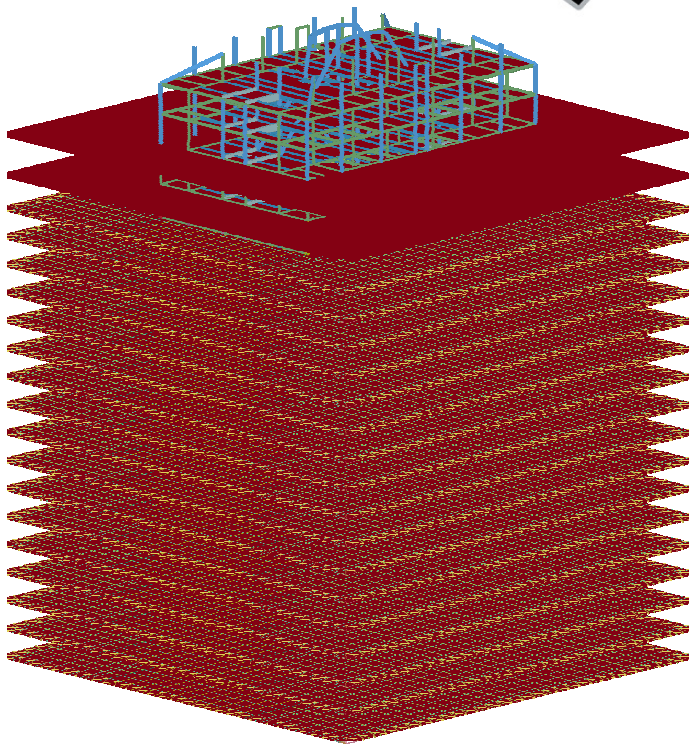
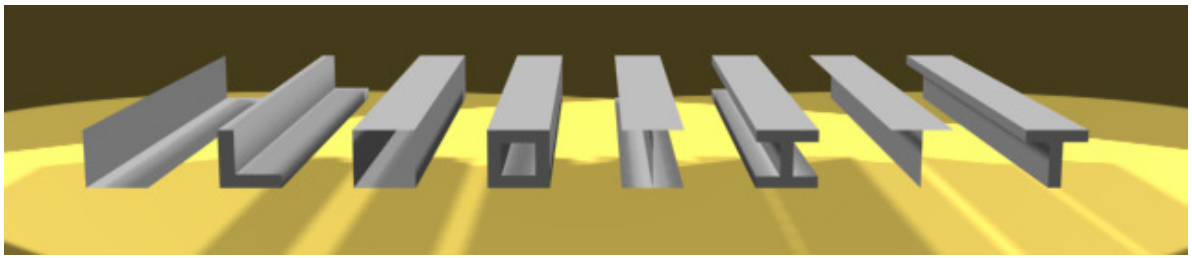






Complex Beam Profiles

- L, rectangular, I, and T cross sections modeled
- Both thick and thin versions modeled
- Thin versions were chosen to help keep the vertex and face count more managable

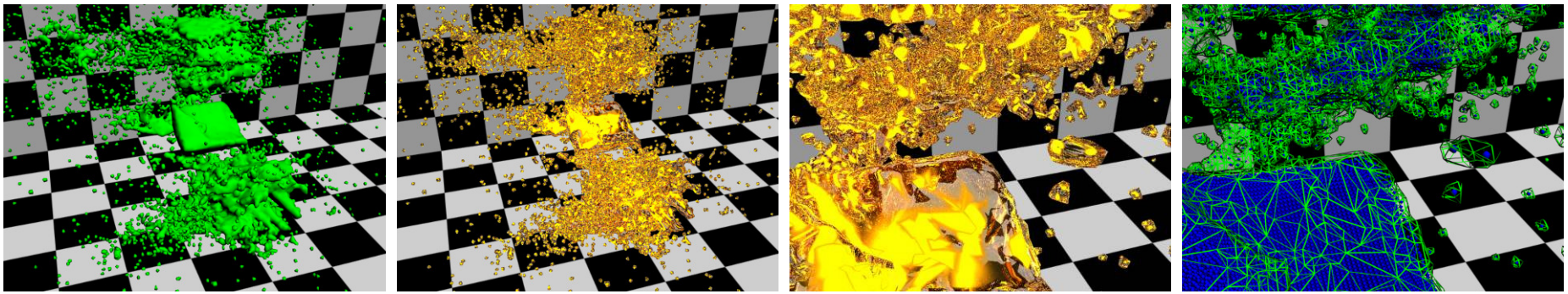


Video

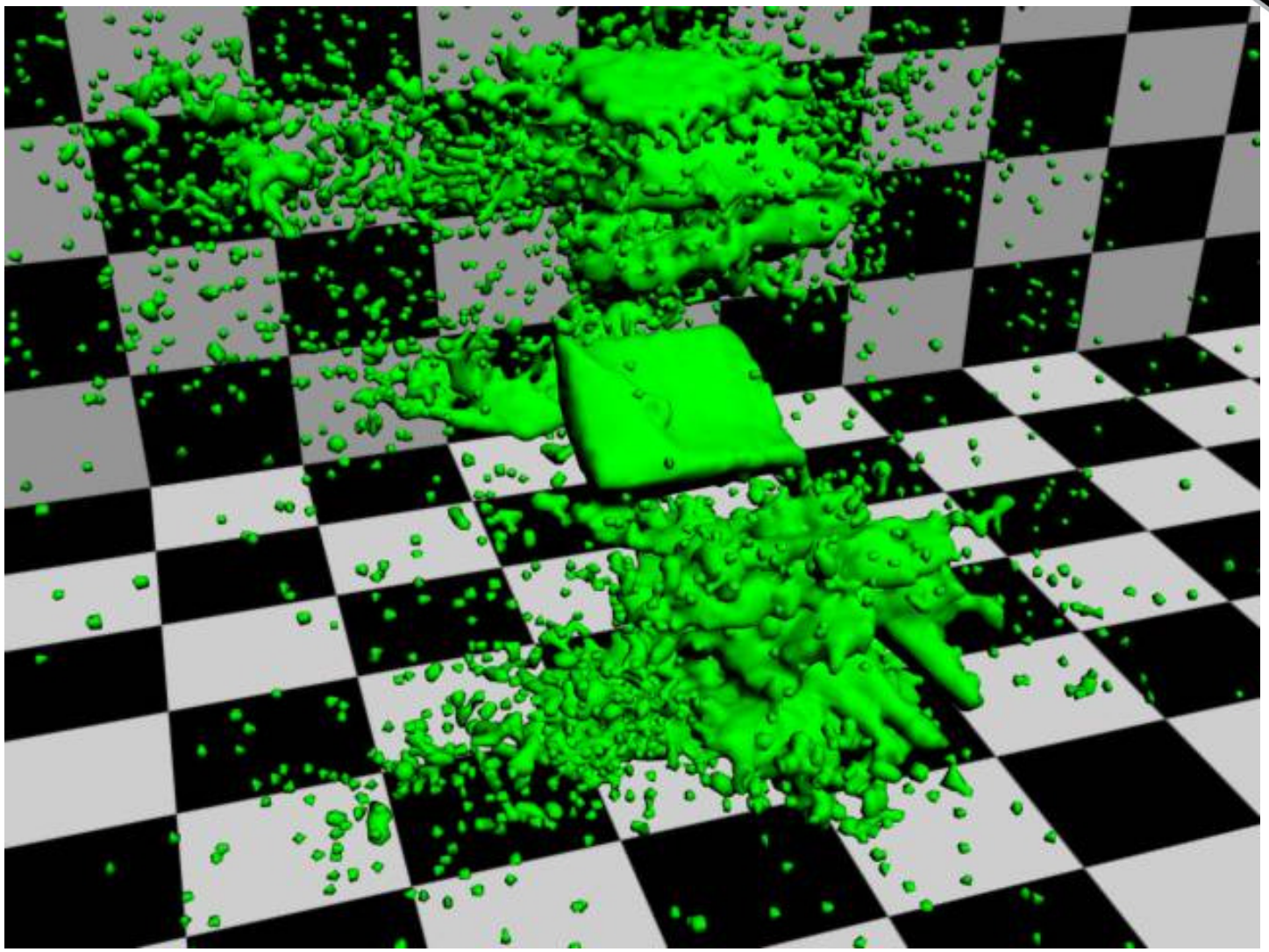
- Geometry Video

SPH Elements

- SPH chosen over ALE because of ease of set up in the context of the highly compartmentalized aircraft fuel tanks
- SPH elements are imported individually then are automatically fused into a mesh using a 3ds Max geometry modifier
- Liquid material then applied to the mesh



SPH Elements



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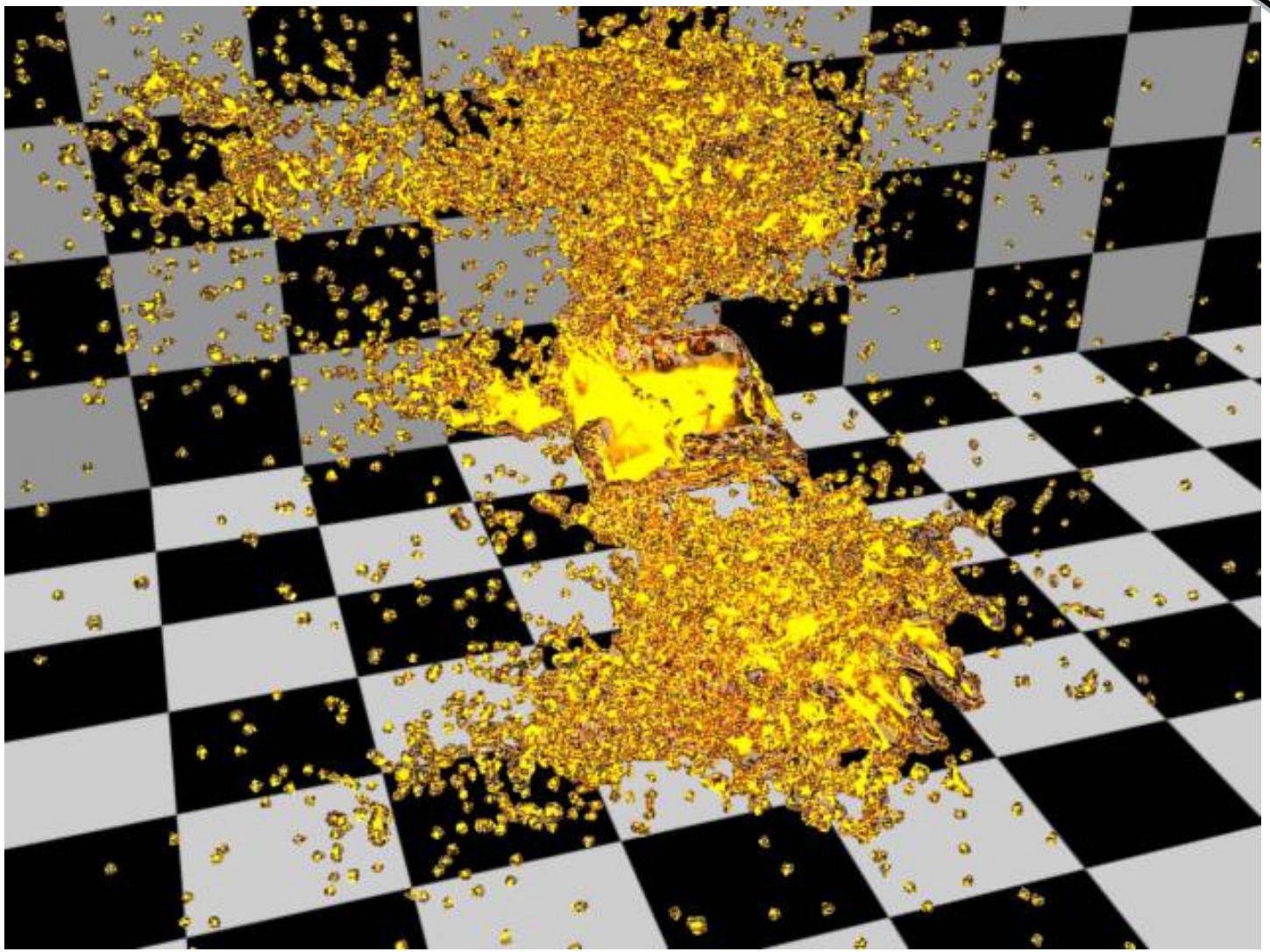

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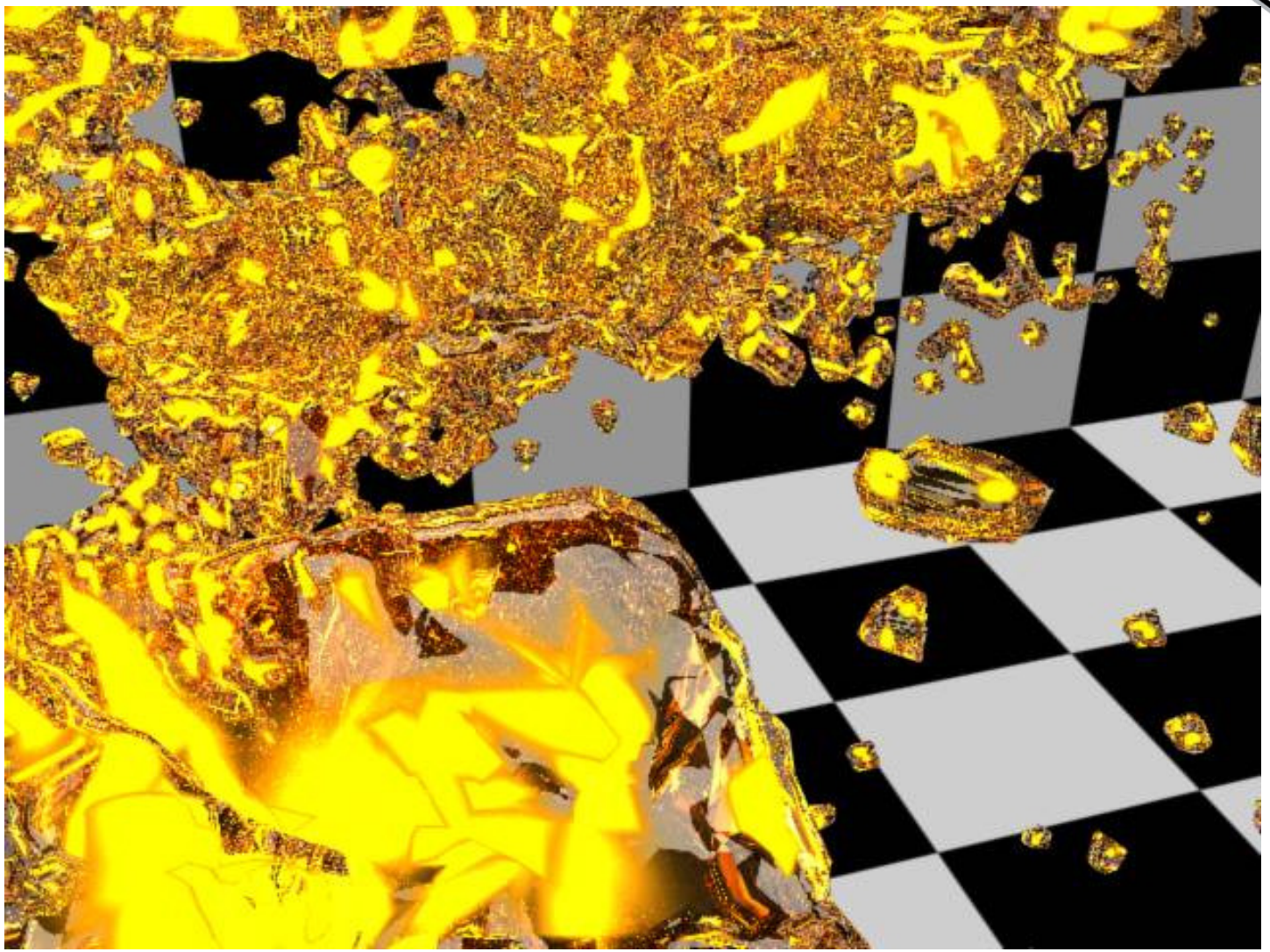

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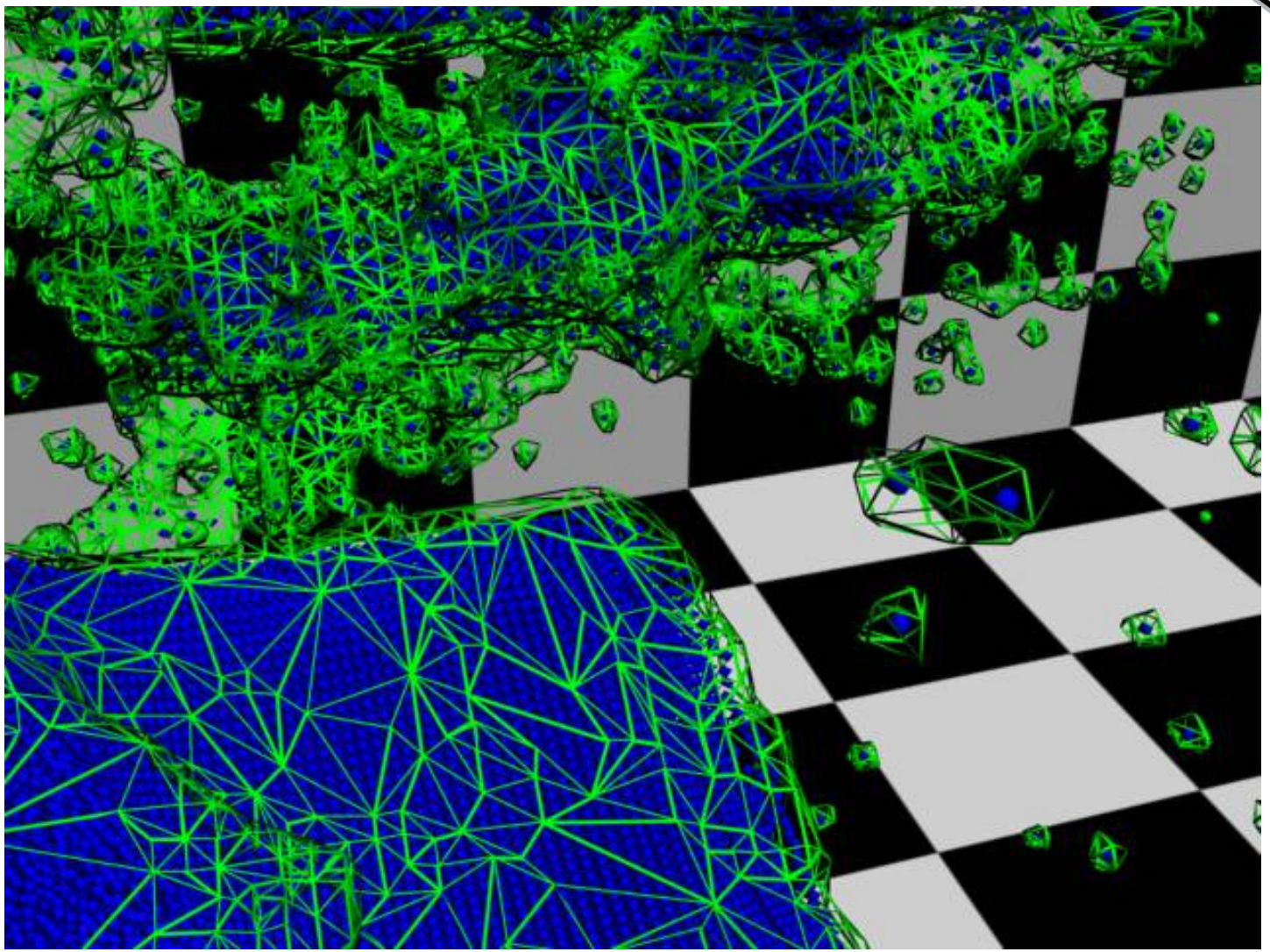


Video

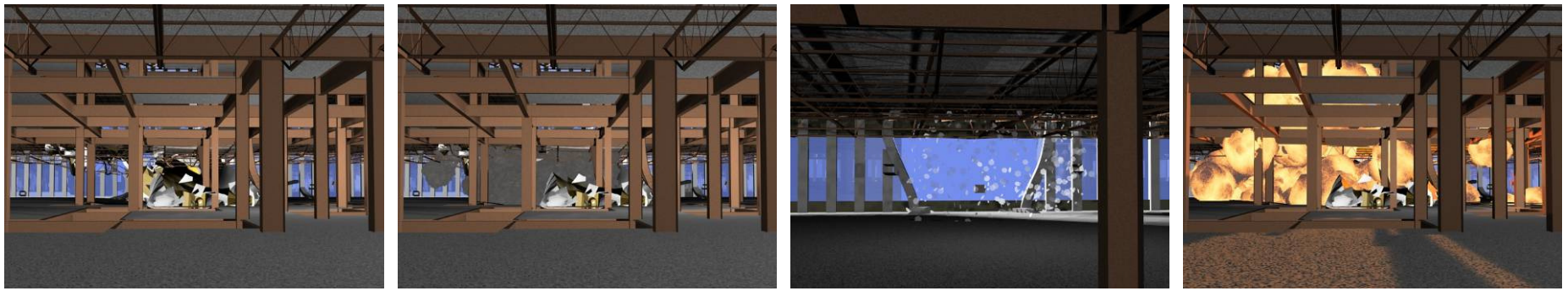
- Fuel Video

Out-of-Core Animation

- 3ds Max very capable animation system, but
- Simulation contains over 400 states, 332,862 nodes per state, 133 million nodes total!
- At over 5 vertex positions node, quickly approaching 1 billion vertex positions
- 3ds Max was never designed to animate that volume of data

Visual Effects

- Pseudo meshes generated from erosion and SPH data
- Importer generates a script which generates particle systems using vertices as particle sources



Video

- Dust and Glass Shard Effects
- Fire Effect

Implementation

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Video

- Highlighted Core Columns
- Additional Effects Shots

Conclusions

- This type of visualization is important for non-expert users
- Achieve high fidelity visualization without sacrificing physical reality
- This type of visualization can uncover modeling errors
- This is not a replacement for post processors, simply an additional tool

Acknowledgements

- Mete Sozen
- Santiago Pujol
- Ingo Brachmann
- Oscar Ardila-Giraldo
- Tom Miller
- Joe Farris
- Scott Meador
- Supported in part by NSF, DOE, the Tellabs Foundation, and by Purdue's Rosen Center for Advanced Computing
- Some of the runs were done using NCN's Regatta and this support is also gratefully acknowledged.