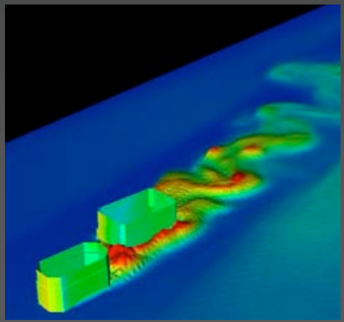

The Role of Modeling and Simulation in Extreme Engineering Projects

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Introduction

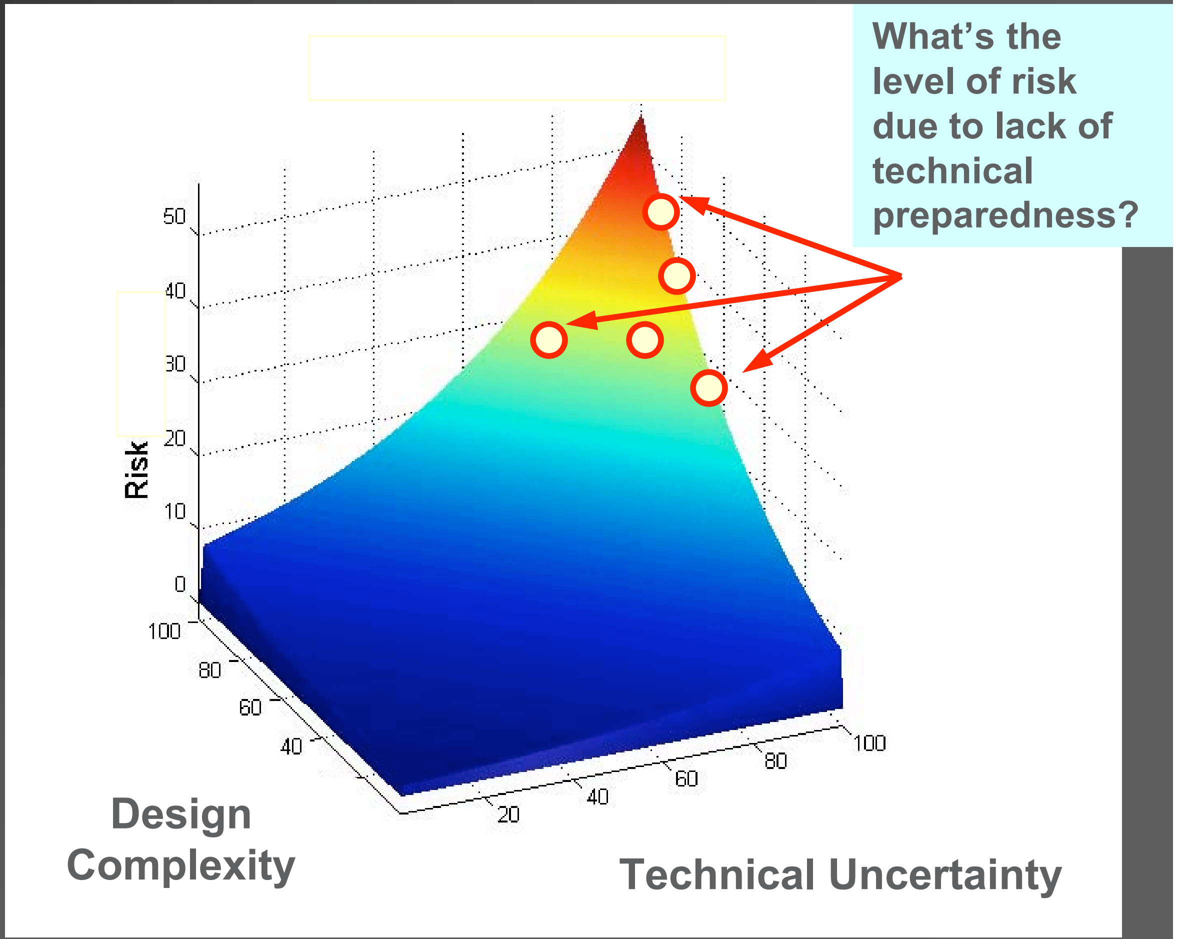
- Extreme environments add Design Complexity and Risk to Engineering Projects
  - Wind/Water
  - Thermal
  - Contamination
  - Remoteness

- “An Experimental No-Man’s Land”

Not much Engineering work going on here!

Risk Management of EEE Prospects

- Customers are increasingly asking contractors to take on more risk
- Engineering challenge is to reduce risk to ensure success
- Successful companies can execute these jobs safely



Why Use Computer Simulation?

- A *multi-disciplinary* approach to analysis and visualization can reduce risk by simulating the physical environment a component or system may encounter before substantial time/cost has been invested
  - Tools that specialize in modeling physical environments and conditions are particularly useful for many complex projects (plants and infrastructure)
  - In particular, models can be used to investigate safety implications of complex, off-normal conditions whose evaluation is not straightforward to the project engineering team

Simulation Tools Discussed Today

- Computational Fluid Dynamics (CFD)
  - A computer-based tool for simulating the behavior of systems involving fluid flow, heat transfer and other related physical processes.
- Advanced Visualization and Virtual Reality (VR)
  - Makes complex concepts simple to review and understand using interactive exploration of lifelike 3D scenes

CFD Modeling for Tacoma Narrows Bridge Upgrade Project

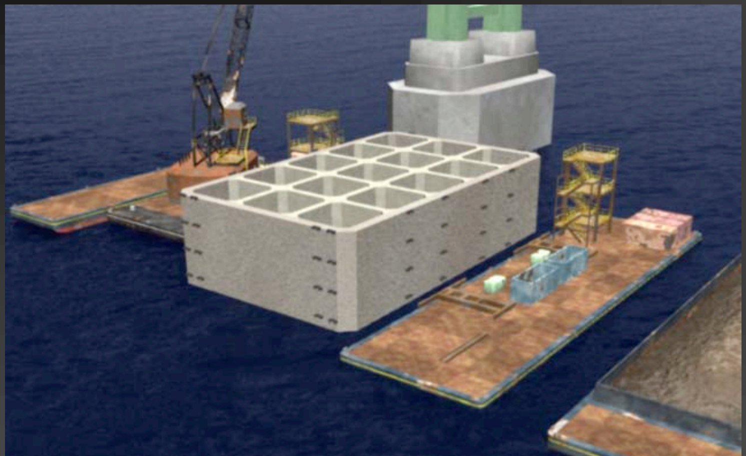
First Bridge – “Galloping Gertie”

Existing Bridge

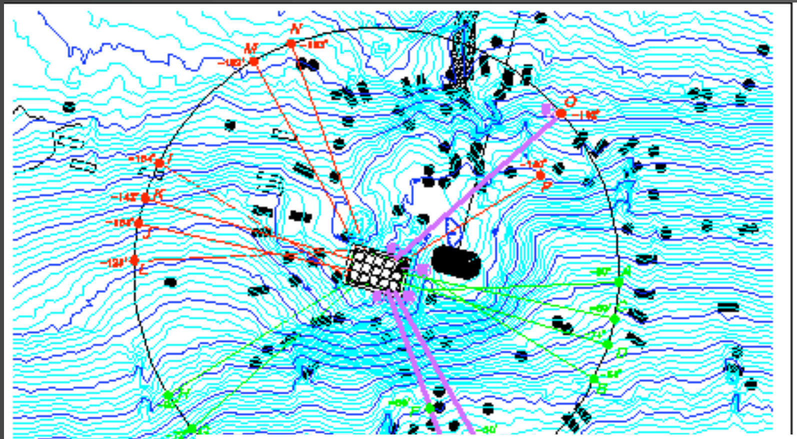
Rendering of New Bridge Side-by-Side

Tacoma Narrows – Large tidal swings, fast currents, and strong winds

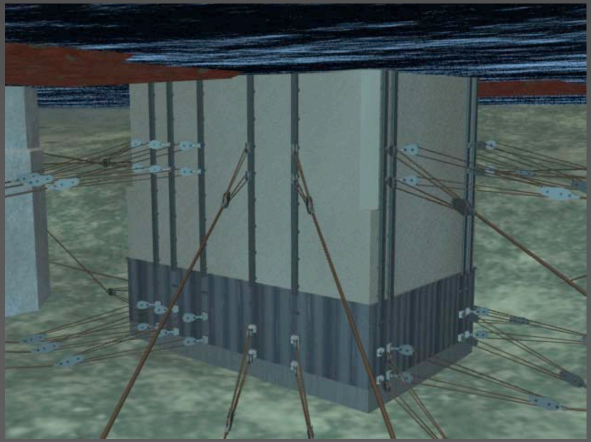
Engineering Challenge: Caisson Installation and Anchoring



Caisson form in position
40m x 24m x 24m



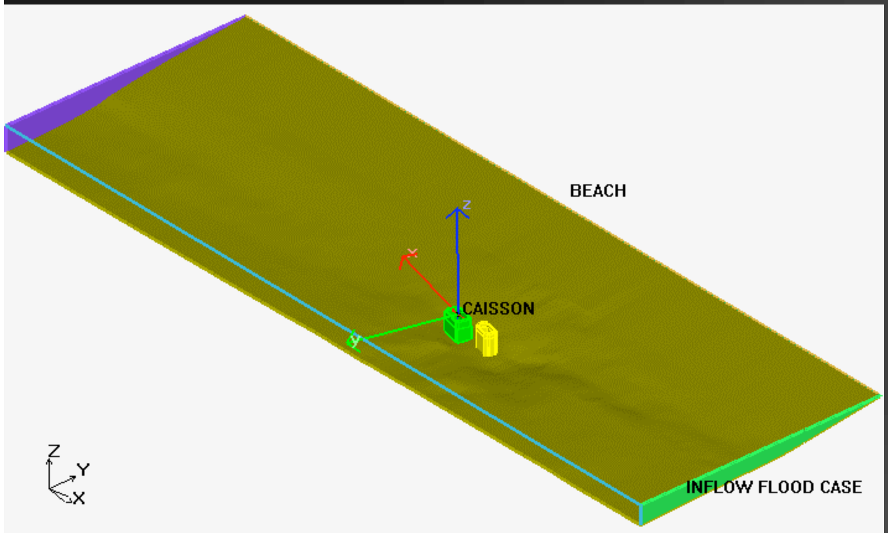
Plan view of Anchor System Design



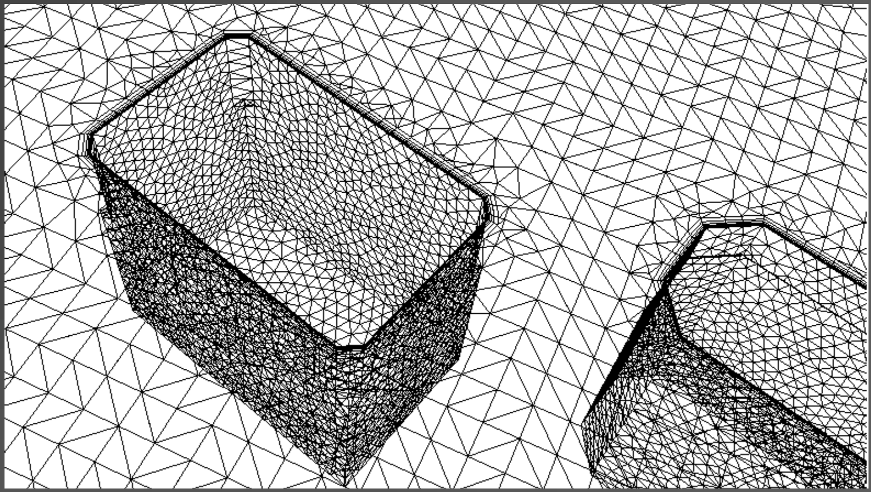
Caisson at full draft anchored to ground - 50m depth

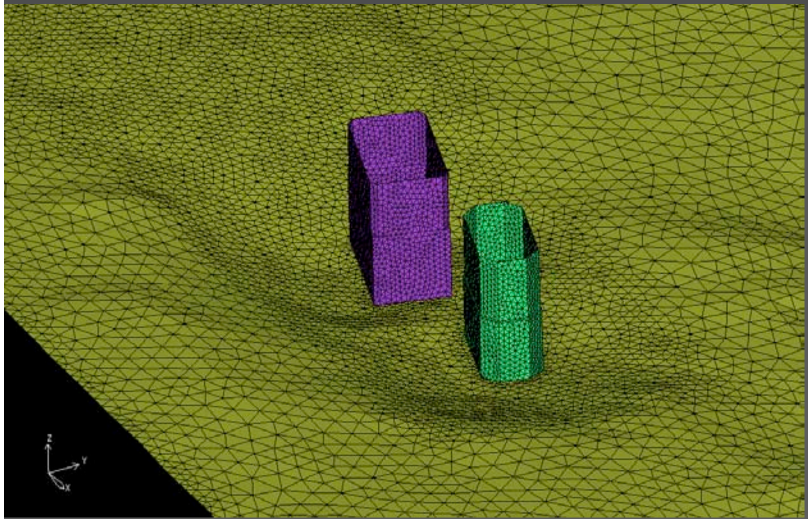
4 inch diameter chain link anchor "cables"

Goal - Use CFD to predict time-varying loads and moments on new bridge caissons



Mesh based on detailed mapping of Narrows Bathymetry CAD model

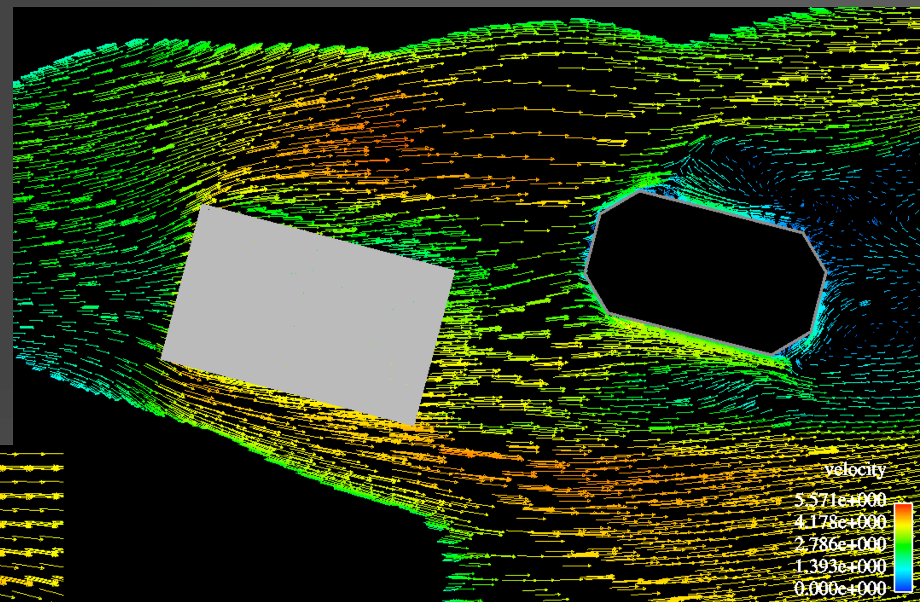




Transient simulation
Hybrid RANS/LES model
3 Million Tet/Prism-elements

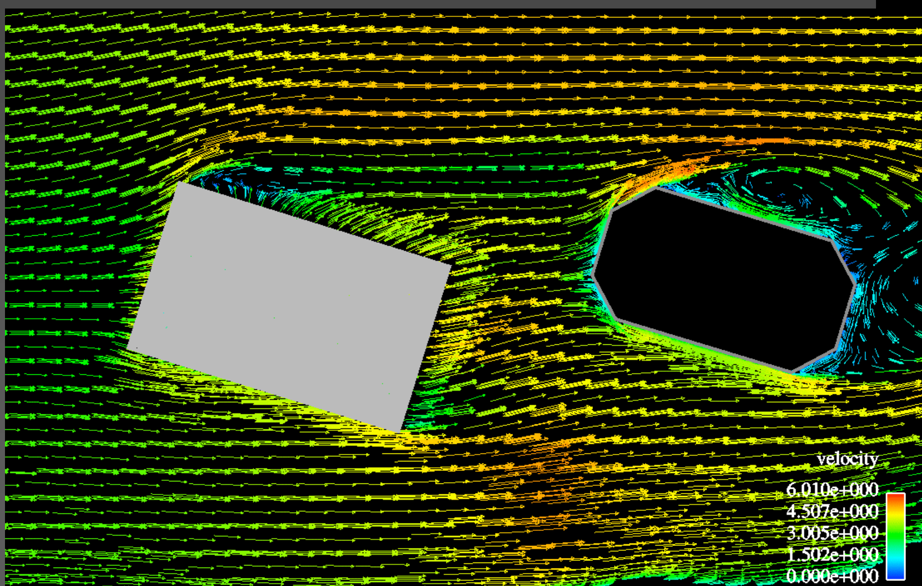
CFD Results for Ebb Flow Direction

Velocity profile at 120 ft depth

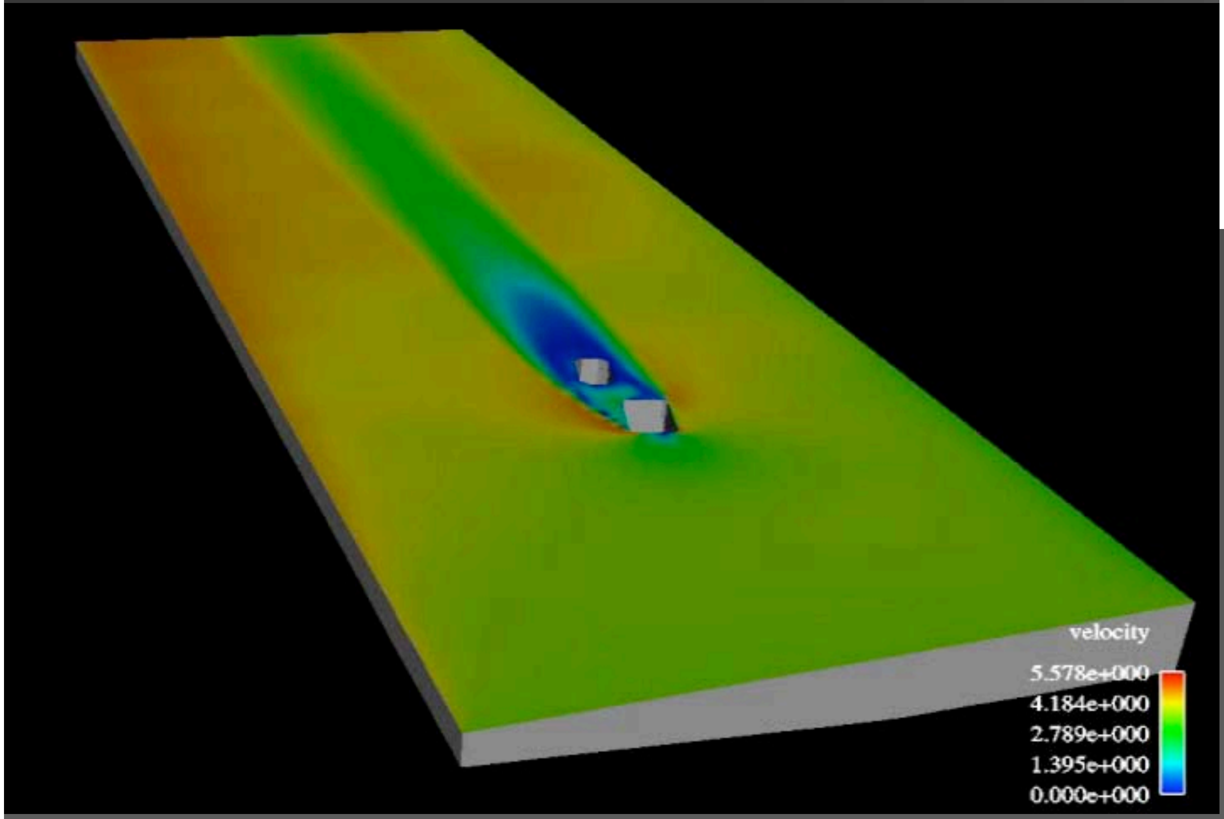


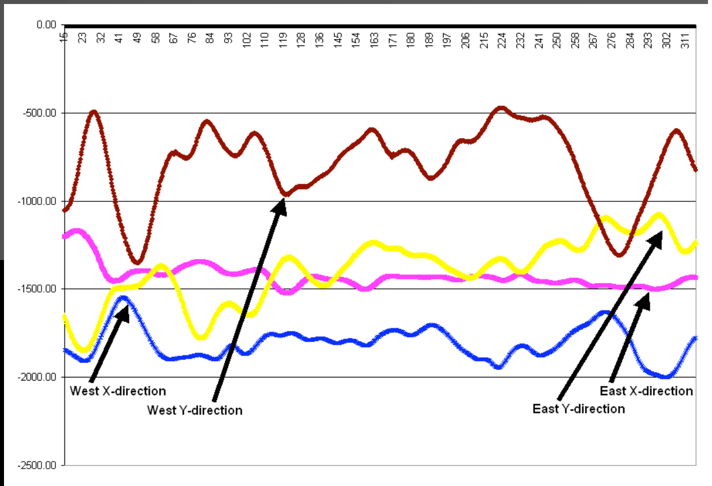
West Side

East Side



CFD Animation for Ebb Flow Direction





VR Modeling of Tower Construction

Animation serves as a visualization aide to help community members, and project personnel understand the complexities of the bridge tower construction.

Hanford WTP: The Cleanup Challenge

Hanford's 177 Waste Tanks

149 single-shell tanks

- Built from 1943-1964
- Tanks range from 37 to 50 feet tall and are 20 to 75 feet wide

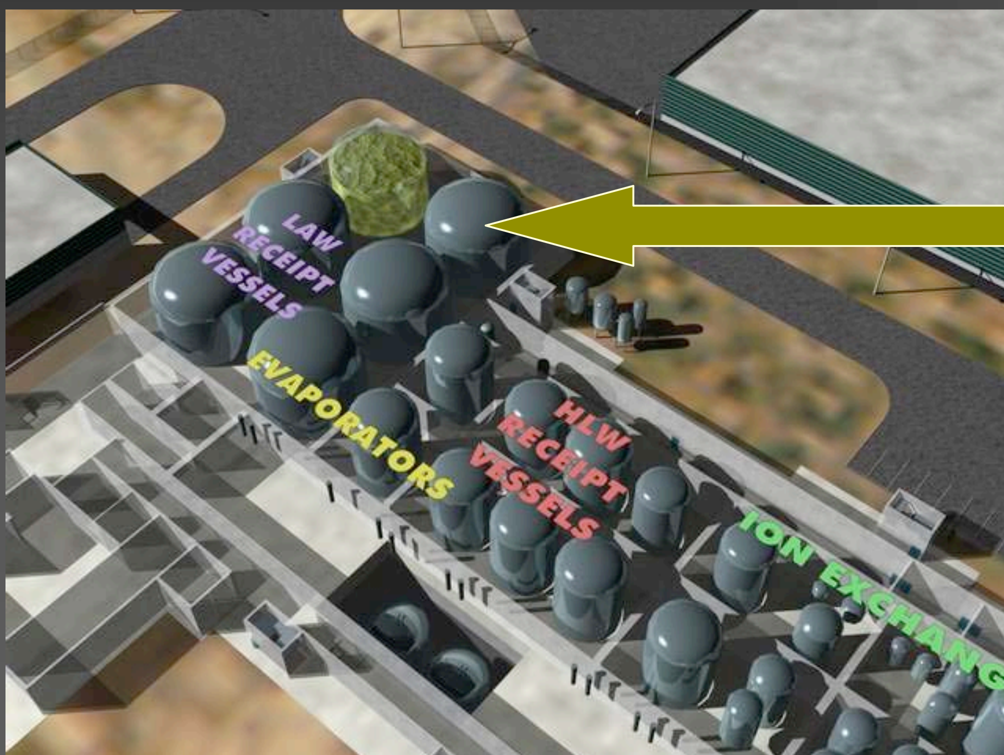
28 double-shell tanks

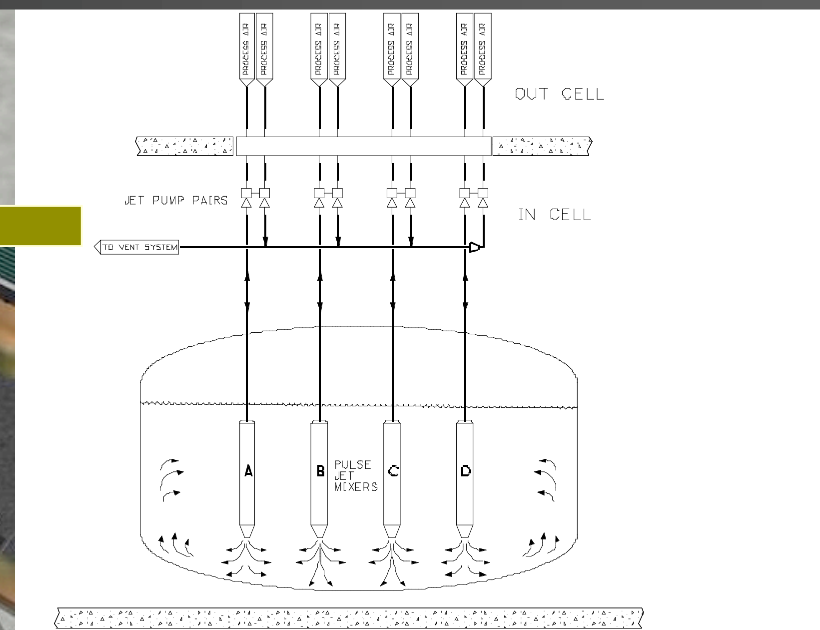
- Built from 1968-1986
- Tanks are 55 feet tall and 75 feet wide

Vitrification offers the best solution for immobilizing Hanford's high-level radioactive waste and preventing an environmental catastrophe

Engineering Challenge: Pulsed-Jet Mixing System

- Keep solids suspended throughout the Pretreatment and into the Waste Processing Facilities in isolated "Black Cells"
  - This must be done remotely with no moving parts and human intervention
  - Air Handling system used for Drive and Suction Phases of Cycle



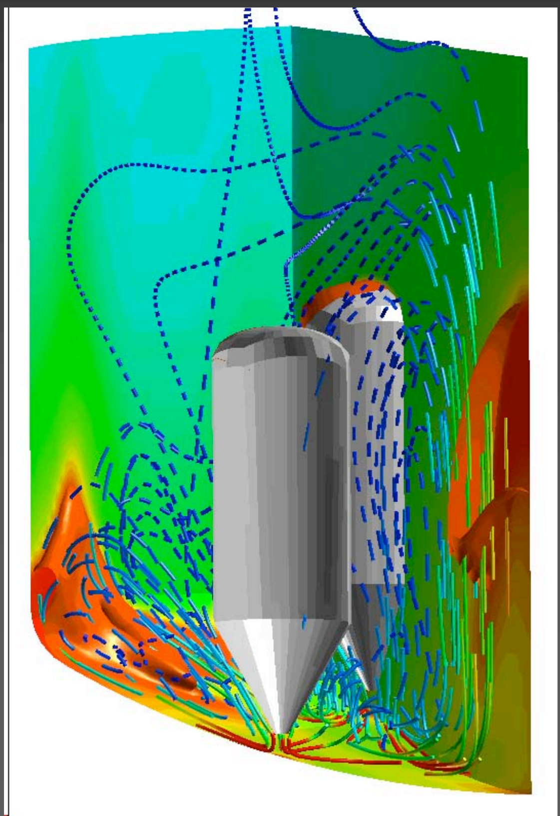


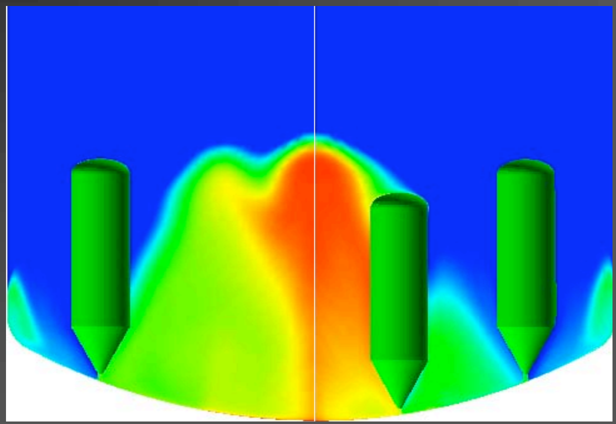
"Pulsed Jet Mixers"

Videotape of PJM Testing (for Gas Release)

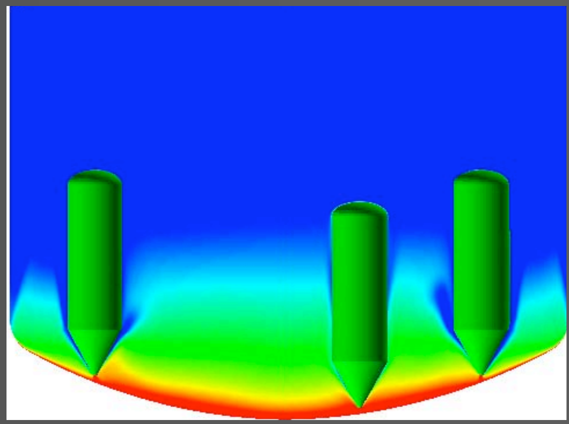
Goal : Use CFD to predict Waste Solids Concentration over time (buildup)

- Extreme engineering sometimes forces us to work with a process that is inefficient
  - And then we need to prove it will work!

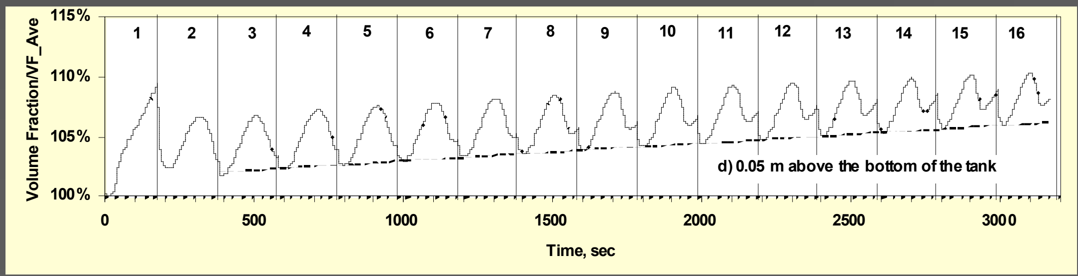




Pulsed Jet Mixer Drive Phase



Suction Phase



PJM installation in progress – late vessel delivery delays Project schedule

Chornobyl New Safe Confinement (NSC)

- At the Chornobyl nuclear power facility in Ukraine, a “sarcophagus” was hastily erected over Unit 4 after the world’s worst nuclear accident 17 years ago
- Unit 4 is still releasing deadly radioactive material
- Now a Bechtel-led consortium, including Battelle and Electricité de France, is designing what could be the largest moveable structure ever built—an 18,000-tonne steel shell—to enclose the damaged unit
- The NSC is intended to minimize occupational exposure for at least 100 years

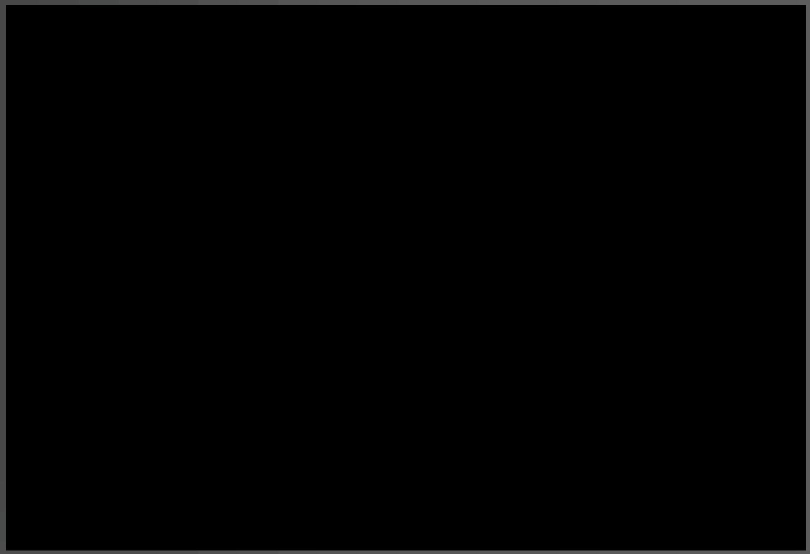
Engineering Challenge: Design world's largest pre-fabricated enclosed structure

- The design team chose a movable, arch-shaped building to facilitate initiation of deconstruction of the sarcophagus and Unit 4
  - Dimensions
    - 12 meters (40 feet) thick (chord depth)
    - 245 meters (803 feet) wide (arch span)
    - 150 meters (492 feet) long
    - 113 meters (370 feet) high
- The site's contaminated topsoil layer would be removed to minimize schedule risk and radiation exposure to workers

Blimp hanger built to demonstrate construction method for new confining shelter

Goal: Employ rapid prototyping based on state-of-the-art computer 3D animation

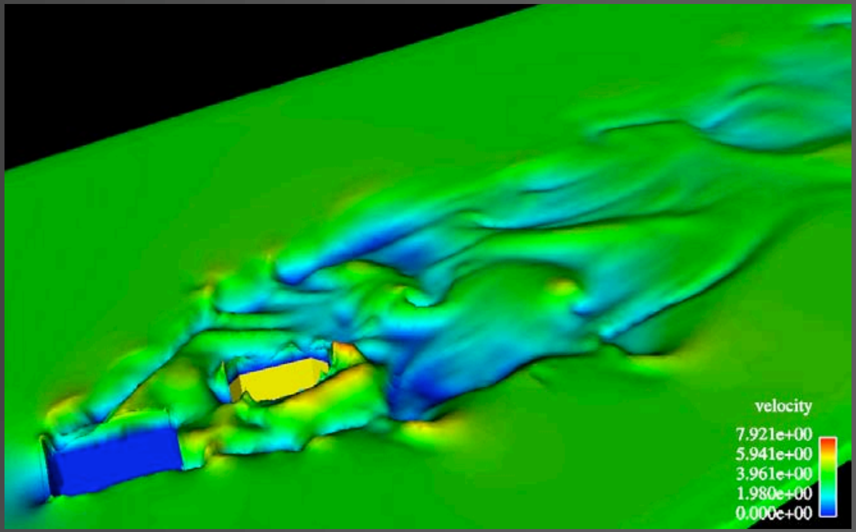
- The modeling team quickly developed 3D simulations and generated large scale animations by using distributed rendering technology
- The simulations provided a view of the confinement construction and operations in dynamic form, which facilitated the project's review



Plans call for constructing the arch in sections, away from its final location. The combined sections will then slide along lubricated steel tracks over the unit. Once the enclosure is in place, robotic cranes will pry apart twisted girders and sort chunks of radioactive debris for long-term storage.

Conclusions

- By "prototyping" areas of uncertainty on the computer early on, potential downstream risks can be minimized, and opportunities for cost savings can be realized
- Implementing simulation technologies is no longer cost and schedule prohibitive if the right tools and people are in place
- *Acknowledgement – Thanks for the help of my team and project engineers who did the real work and got the job done*



Cutting edge being towed into place under the Narrows.