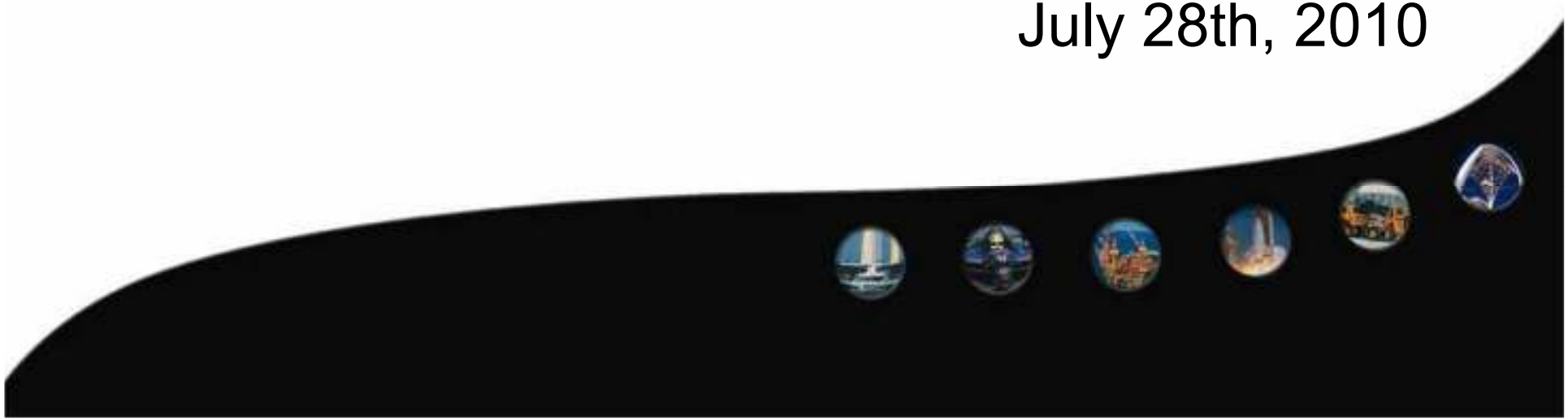
NAFEMS

Visualization Challenges in CAE

July 28th, 2010



Agenda

Visualization Challenges in CAE

July 28th, 2010

8:00am PDT (Seattle) / 11:00am EDT (New York) / 4:00pm BST (London)

- **Welcome & Introduction (Overview of NAFEMS Activities)**
  - Matthew Ladzinski, NAFEMS North America
- **The Role of Visualization in Digital Prototyping and Performance Simulation**
  - Don Tolle, CometSolutions
- **The Role of Scientific Visualization in CAE**
  - Shawn Zhang, Visualization Sciences Group
- **CAE Visualization Challenges: VCollab's Perspective**
  - Joe Walsh, IntrinSim (Representing VCollab)
- **Q&A Session**
  - Panel
- **Closing**

THE INTERNATIONAL ASSOCIATION
FOR THE ENGINEERING ANALYSIS
COMMUNITY

An Overview of NAFEMS Activities

Matthew Ladzinski
NAFEMS North America

Planned Activities

➢ Webinars

- New topic each month!
  - Simulation of Variability in the Hybrid 3 Crash Test Dummy – August 25th
  - Practical Approach to Deformation Analysis – November 8th (NAFEMS Italy)
- Recent webinars:
  - Visualization Challenges in CAE - July 28th
  - Strategies for Deploying Expert and Casual CAE Tools - TODAY
  - Fire Modelling in CFD
  - "Accepted Practices in FEA" (NAFEMS India Webinar)
  - Product Performance Simulation in the Year 2020
  - What is V&V
  - How to Ensure that CFD for Industrial Applications is Fit for Purpose
  - Practical CFD
  - Composite FE Analysis
  - 10 Ways to Increase Your Professional Value in the Engineering Industry
  - Dynamic FE Analysis
  - Modal Analysis in Virtual Prototyping and Product Validation
  - Pathways to Future CAE Technologies and their Role in Ambient Intelligent Environments
  - Computational Structural Acoustics: Technology, Trends and Challenges
  - CCOPPS: Power Generation: Engineering Challenges of a Low Carbon Future
  - Practical CFD Analysis
  - Complexity Management
  - CCOPPS: Creep Loading of Pressurized Components – Phenomena and Evaluation
  - Multiphysics Simulation using Implicit Sequential Coupling
  - CCOPPS: Fatigue of Welded Pressure Vessels
  - Applied Element Method as a Practical Tool for Progressive Collapse Analysis of Structures
  - A Common Sense Approach to Stress Analysis and Finite Element Modeling
  - The Interfacing of FEA with Pressure Vessel Design Codes (CCOPPS Project)
  - Multiphysics Simulation using Directly Coupled-Field Element Technology
  - Methods and Technology for the Analysis of Composite Materials
  - Simulation Process Management
  - Simulation-supported Decision Making (Stochastics)
  - Simulation Driven Design (SDD) Findings

To register for upcoming webinars, or to view a past webinar, please visit: www.nafems.org/events/webinars

- Established in 2009
- Next courses:
  - Non-Linear Analysis – July 20th, 2010 (*four-week course*)
  - Composite FE Analysis – August 24th, 2010 (*four-week course*)
  - Dynamic FE Analysis – TBA (*seven-week course*)
  - Simulation-Supported Engineering – TBA (*four-week course*)
- Proposed course offerings:
  - Optimization – TBA
- For more information, visit: www.nafems.org/e-learning

SEPTEMBER 8-9 2010

WWW 2010 NAFEMS VIRTUAL CONFERENCE
2020 VISION OF ENGINEERING ANALYSIS AND SIMULATION

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SIEMENS

Silver Sponsors

esi get it right

SIMULIA

CEI

- Date: TBA
- Location: Online (virtual)
- Keynote Speakers: Prof. Jim Wood, University of Strathclyde, *plus three others TBA in the coming weeks*
- Conference Themes:
  - Business developments to increase the financial impact of CAE investments
  - Technical developments to improve speed, accuracy, reliability, accessibility, and applicability of results
  - Human issues (e.g. Teaching simulation as part of the basic engineering curricula, certification, etc.)
- For more information, visit: www.nafems.org/virtual

appel à communication

OCT 12 13 2010 | PARIS FRANCE

FR 2010 NAFEMS CONFERENCE

SIMULATION NUMÉRIQUE : MOTEUR DE PERFORMANCE

Principal Sponsors

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SIEMENS

SIMULIA

- Date: October 12-13, 2010
- Location: Paris, France
- Keynote Speaker: TBA
- Conference Themes:
  - State of the art technologies and applications of digital simulation
  - Optimization, robust design and reliability of the products
  - Benchmarking, verification and validation
  - Economic impacts of simulation
- For more information, visit:
  www.nafems.org/events/nafems/2010/francecongres

OCTOBER 26 - 27 2010
GOTHENBURG, SWEDEN

NORDIC 2010 NAFEMS CONFERENCE
TRENDS AND FUTURE NEEDS IN ENGINEERING SIMULATION

call for papers

- Date: October 26-27, 2010
- Location: Gothenburg, Sweden
- Keynote Speaker: TBA
- Conference Topics:
  - Trends and future needs in engineering simulation
  - Robustness and confidence of analysis results
  - Optimization / stochastics
  - Multiphysics / coupled analysis
  - Materials
  - Nonlinear Analysis
  - Plus much more...
- For more information, visit: www.nafems.org/events/nafems/2010/NORDIC2010/

Conference Sponsors

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BETA CAE Systems SA

LMS

- Date: May 23-26, 2010
- Location: Boston, MA
- Current Call for Papers (Deadline: October 18th, 2010)
- For more information, visit: www.nafems.org/congress

NAFEMS Events

- Multiple opportunities to attend conferences, seminars/workshops and training courses

Leveraging CAE for Greater Business Value Through Simulation
17th Feb 2010
Webinar
Online,USA

Delivering CAE for the Nuclear Energy Industry
23rd Feb 2010
Seminar
Knutsford,UK

Non-Linear Analysis
2nd Mar 2010
Course
e-Learning,Online

Practical Stress Analysis & Finite Element Methods
8th Mar 2010
Course
Stratford-Upon-Avon,UK

Introduction au Calcul de Structures, aux Éléments Finis et à la Simulation Numérique
16th Mar 2010
Course
Paris,France

Coupling 1D and 3D CFD: The Challenges and Rewards of Co-Simulation
17th Mar 2010
Seminar
Gaydon,UK

FEM Basic 1 - Praxisorientierte Strukturmechanik / Festigkeitslehre
24th Mar 2010
Course
Wiesbaden,Germany

Composites FE Analysis
13th Apr 2010
Course
e-Learning,Online

Practical Stress Analysis and Finite Element Methods
19th Apr 2010
Course
Madrid,Spain

Verbindungstechnische Aspekte bei Finite-Elemente-Berechnungen
28th Apr 2010
Seminar
Wiesbaden,Germany

Finite Elements and Numerical Simulation of Forming Processes
28th Apr 2010
Seminar
Aveiro,Portugal

Thermalmanagement mit CFD-Simulationen
4th May 2010
Seminar
München - Ismaning,Germany

FEM Basic 2 - Praxisorientierte Grundlagen für FEM-Analysen
5th May 2010
Course
Wiesbaden,Germany

Practical CFD Analysis
11th May 2010
Course
Stratford-Upon-Avon,UK

UK Conference 2010 - Engineering Simulation: Contributing to Business Success
8th Jun 2010
Conference
Oxford,UK

Introduction au Calcul de Structures, aux Éléments Finis et à la Simulation Numérique
8th Jun 2010
Course
Paris,France

Introduction au Calcul de Structures, aux Éléments Finis et à la Simulation Numérique
5th Oct 2010
Course
Paris,France

Congrès NAFEMS France 2010 - Simulation Numerique : Moteur de Performance
12th Oct 2010
Conference
Paris,France

Introduction au Calcul de Structures, aux Éléments Finis et à la Simulation Numérique
23rd Nov 2010
Course
Paris,France

Practical CFD Analysis
24th Nov 2010
Course
Wiesbaden,Germany

- Let us know if you would like to schedule an on-site training course

For more information, please visit: www.nafems.org

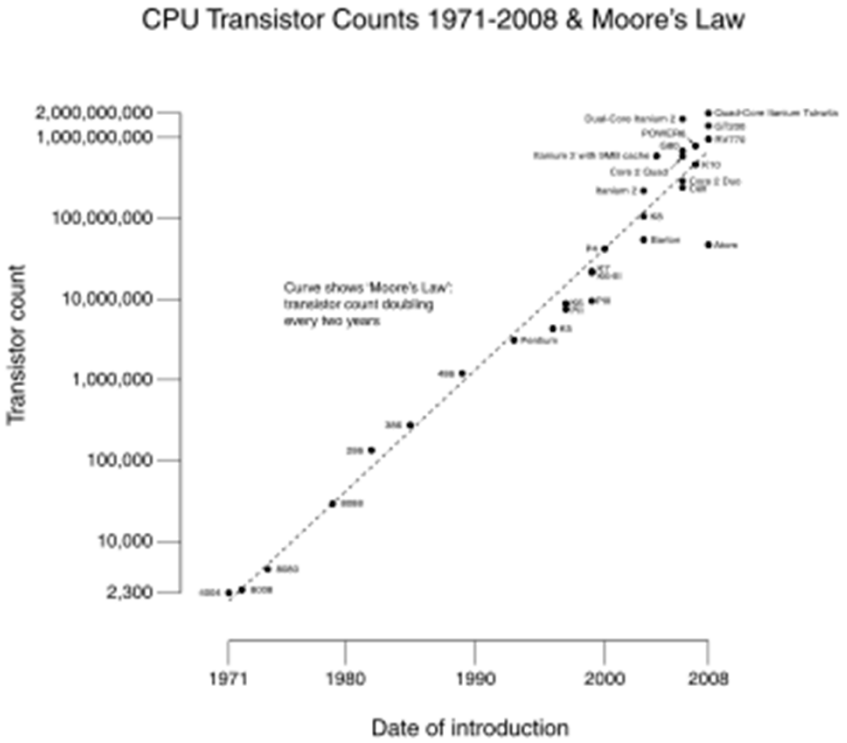
NAFEMS

The Role of Visualization in Digital Prototyping and Performance Simulation

July 28, 2010

“A single picture is worth a thousand words”

Widespread Availability of Cheap Computing

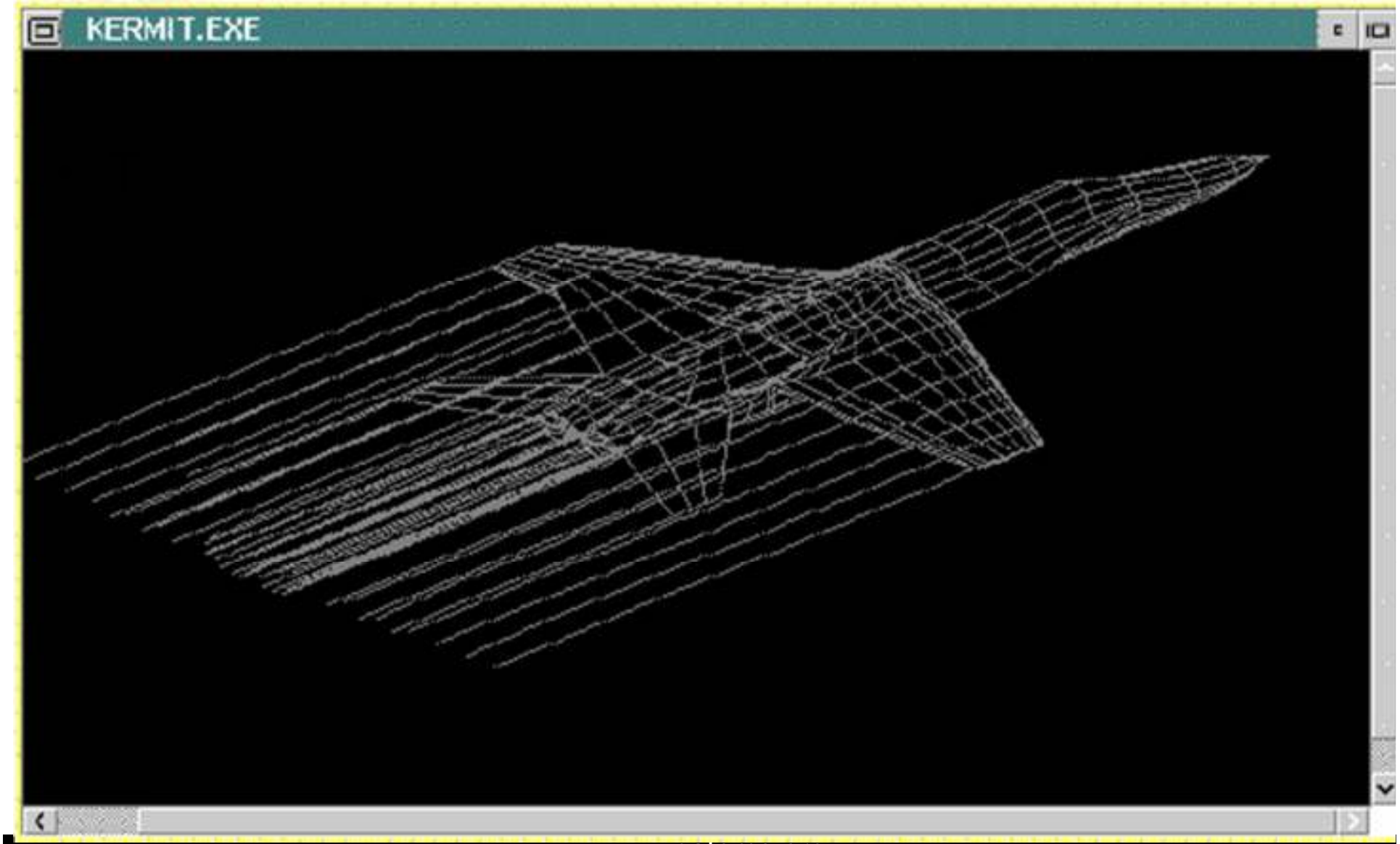


- An Osborne Executive portable computer, from 1982, and an iPhone, first released in 2007. The Executive weighs100 times as much, has nearly 500 times the volume, cost 10 times as much, and has1/100th the processing power of the iPhone.

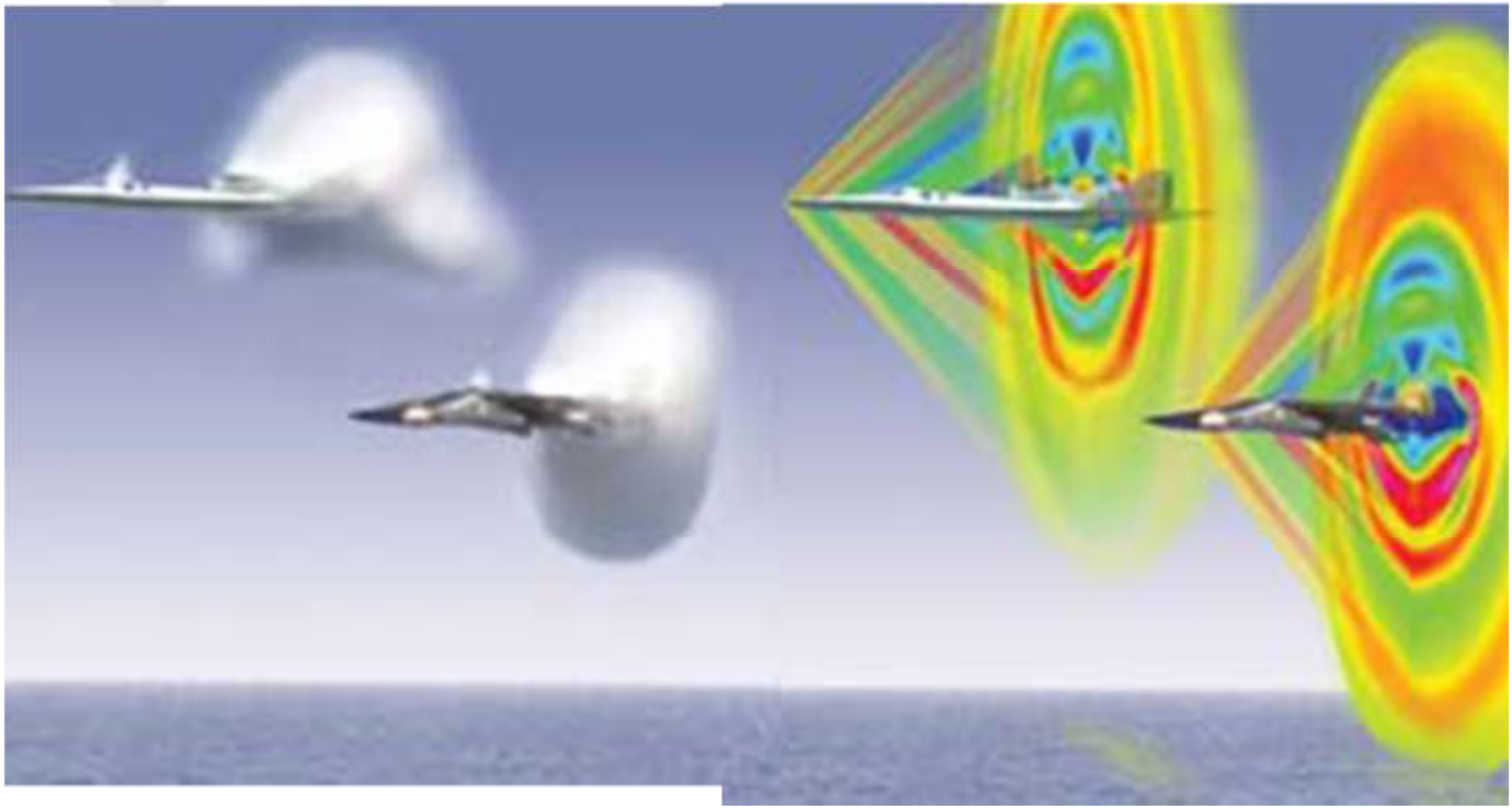
Digital Information Access is now global and pervasive…24 x 7 X 365

- Internet and Corporate Intranets access
- Web 2.0 – Communications & Social Media abound
  - Skype
  - Yahoo & Gmail
  - Google Docs
  - Facebook
  - Twitter
  - Wikipedia
  - YouTube

Visualization's Evolving Role in Product Engineering



Visualization's Increasing Role in Virtual Prototyping & Design



Visualization's Role in Simulation: The Industry Challenges

- Explosion of Simulation Data (Too Much Information?)
  - Size & Quantity of both Input Models and Results Files (Terabytes)
  - Need for higher fidelity and complex, cross-disciplinary simulations to adequately predict physics of product performance vs hardware
  - More analysis iterations per engineer with multiple CPUs available
  - Trend towards the use of DOE/stochastic/robust design methods vs the deterministic approach (to deal with variability & complexity)
- Provide design guidance sooner vs. late stage "forensics"
- Enable non-experts to readily understand and consume product design alternatives based on simulation results

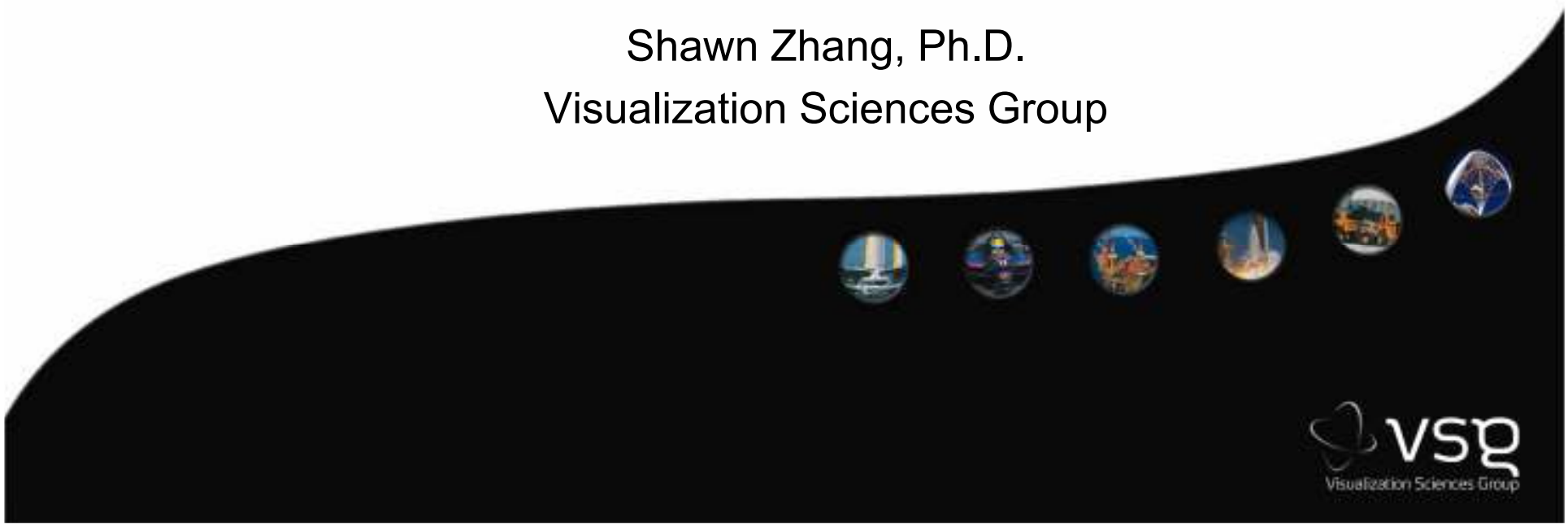
Visualization's Future Role in Virtual Engineering: What can we expect from the vendors?

Visualization's Role in Simulation: Today's Industry Presenters

- Visualization Sciences Group (VSG)
  - Shawn Zhang, PhD - Product Leader
- Visual Collaboration Technologies (VCollab)
  - Joe Walsh - President & Founder of IntrinSim

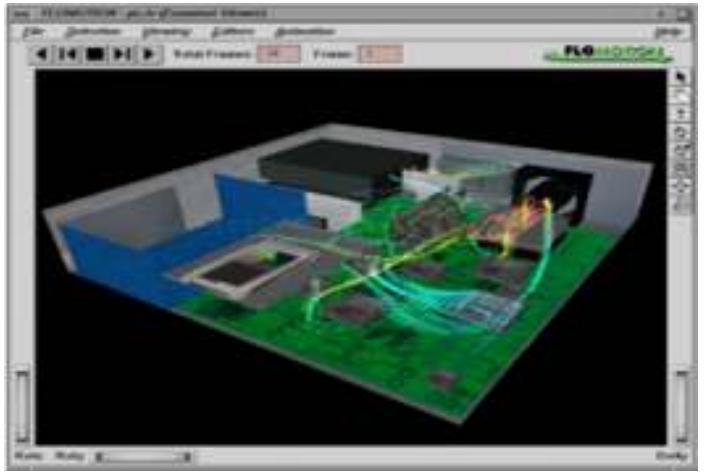
The Role of Scientific Visualization in CAE

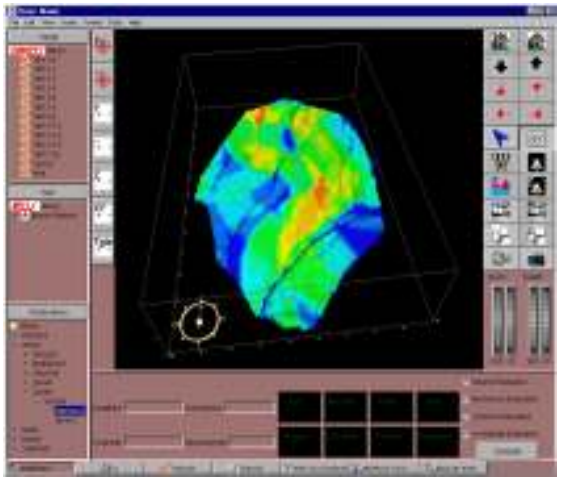
Shawn Zhang, Ph.D.
Visualization Sciences Group



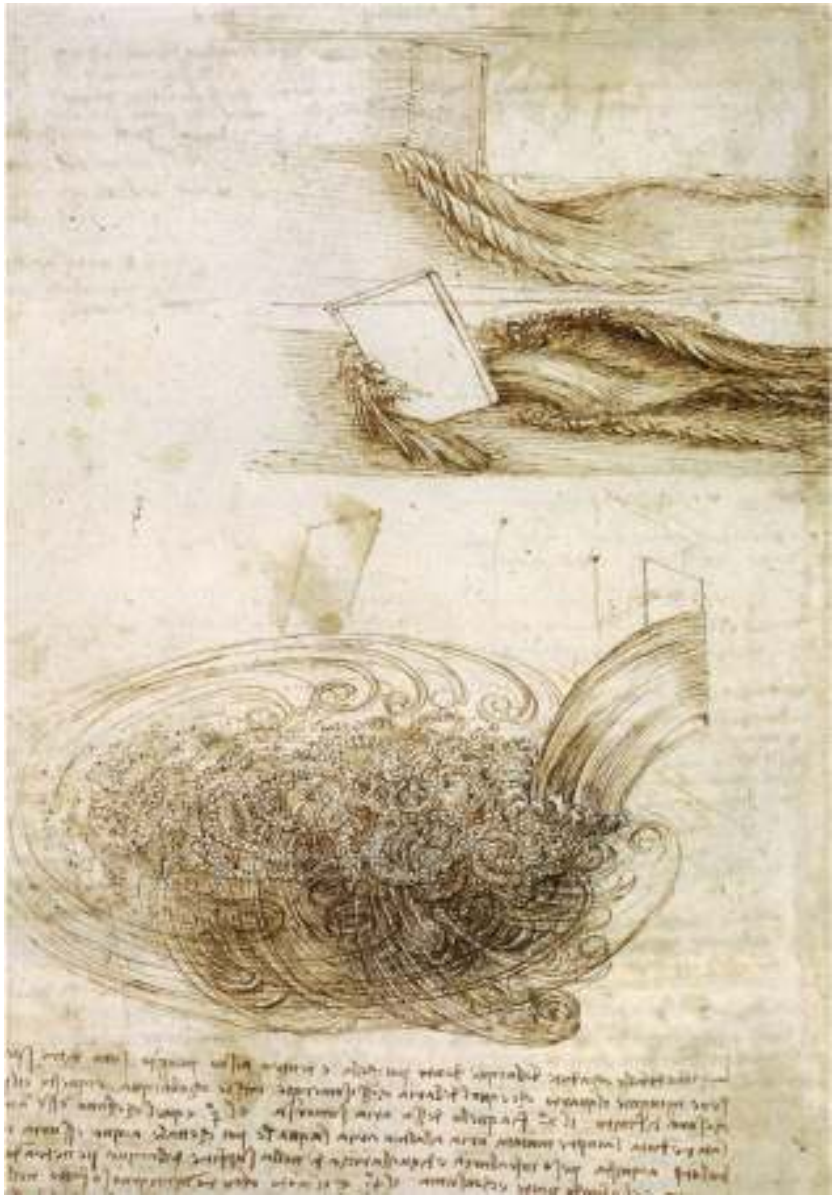
Visualization's Role in CAE challenges

- Visualization = Post-processing
  Post-processing = icing on the cake?
- Visualization > Post-processing
  - CAD
  - Meshing
  - Solver
- Visualization >> icing on the cake





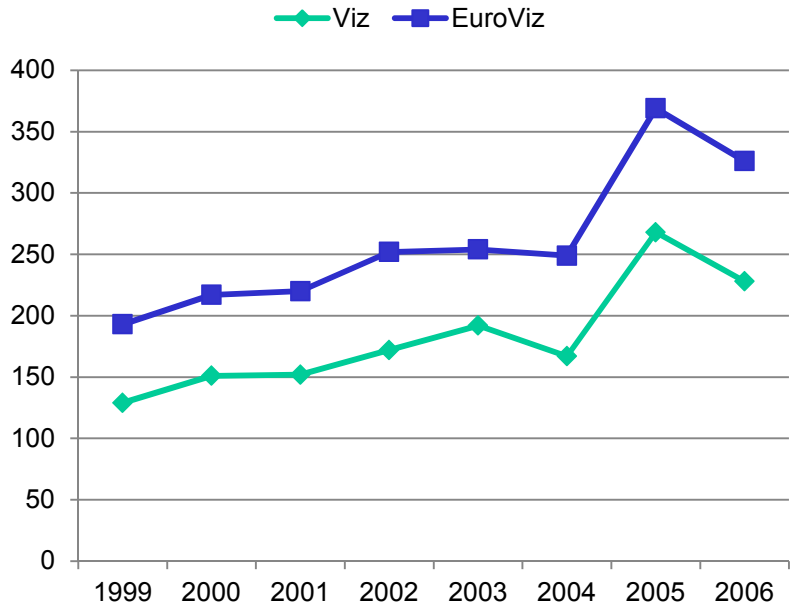
Scientific Visualization: The history

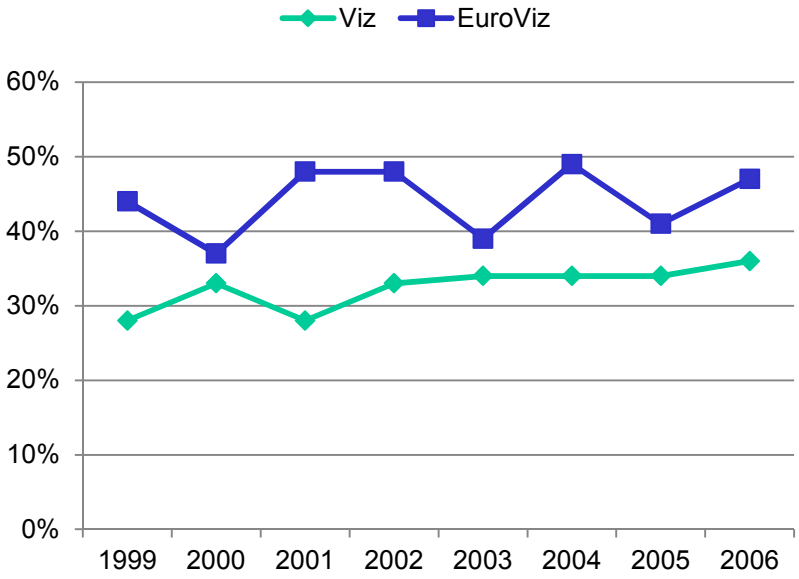


Scientific Visualization: The community

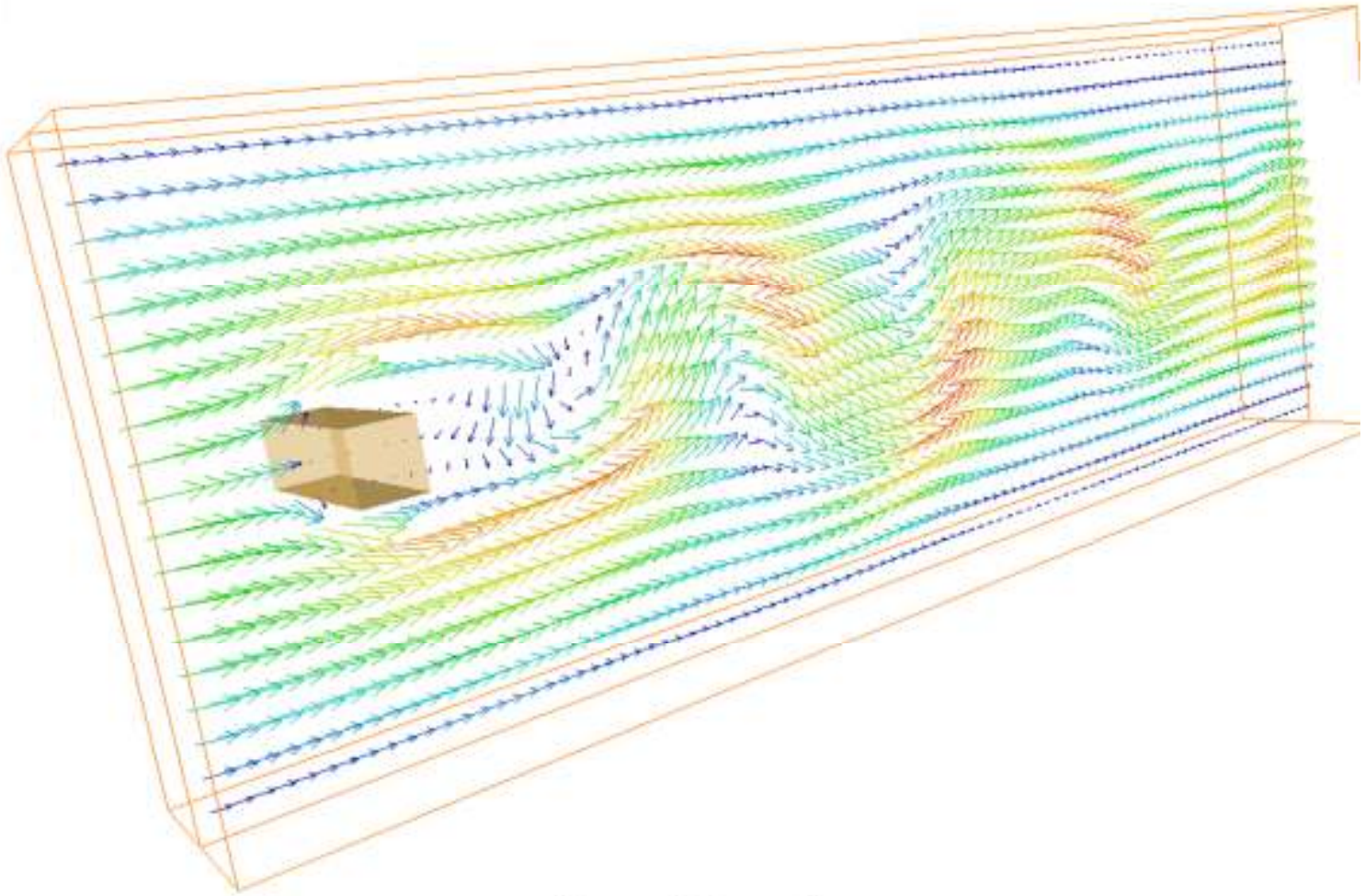
- IEEE Visualization (Viz), EuroViz, PacificViz
- More than 1000 papers published since the 1987 inception
- Vis2009 Section “Time Dependent Data Visualization”
  - Visualization and Exploration of Temporal Trend Relationships in Multivariate Time-Varying Data (The Ohio State University)
  - Isosurface Extraction and View-Dependent Filtering from Time-Varying Fields Using Persistent Time-Octree (PTOT) (Polytechnic Institute of New York University)
  - Visual Exploration of Climate Variability Changes Using Wavelet Analysis (German Climate Computing Centre),
  - Interactive Coordinated Multiple-View Visualization of Biomechanical Motion Data (University of North Carolina)

Scientific Visualization: The research work





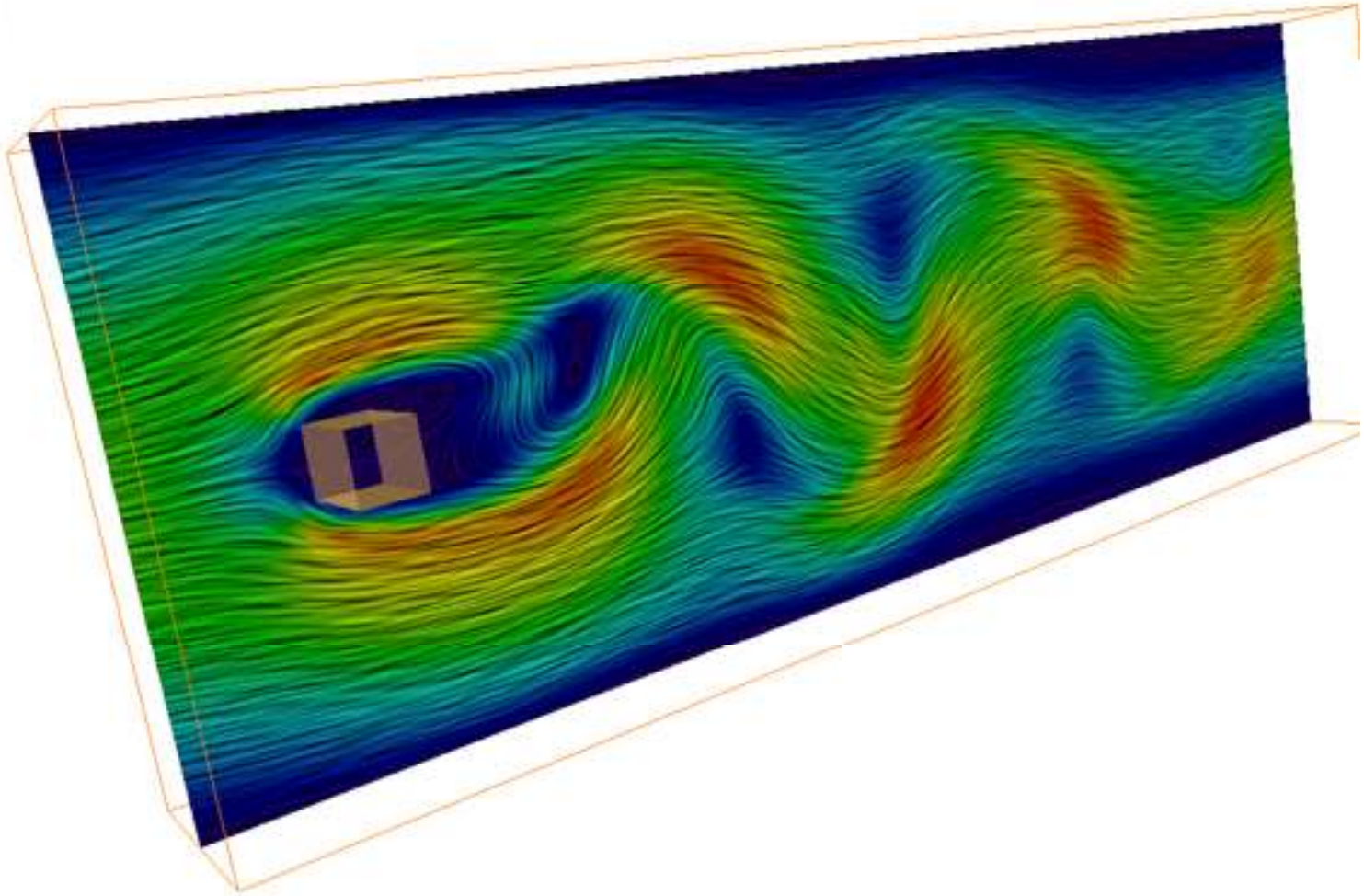
Postprocessing VS Scientific Visualization:
Vector Plot -- Arrow heads



Avizo

vsg
Visualization Sciences Group

Postprocessing VS Scientific Visualization:
Vector Plot -- LIC



Avizo

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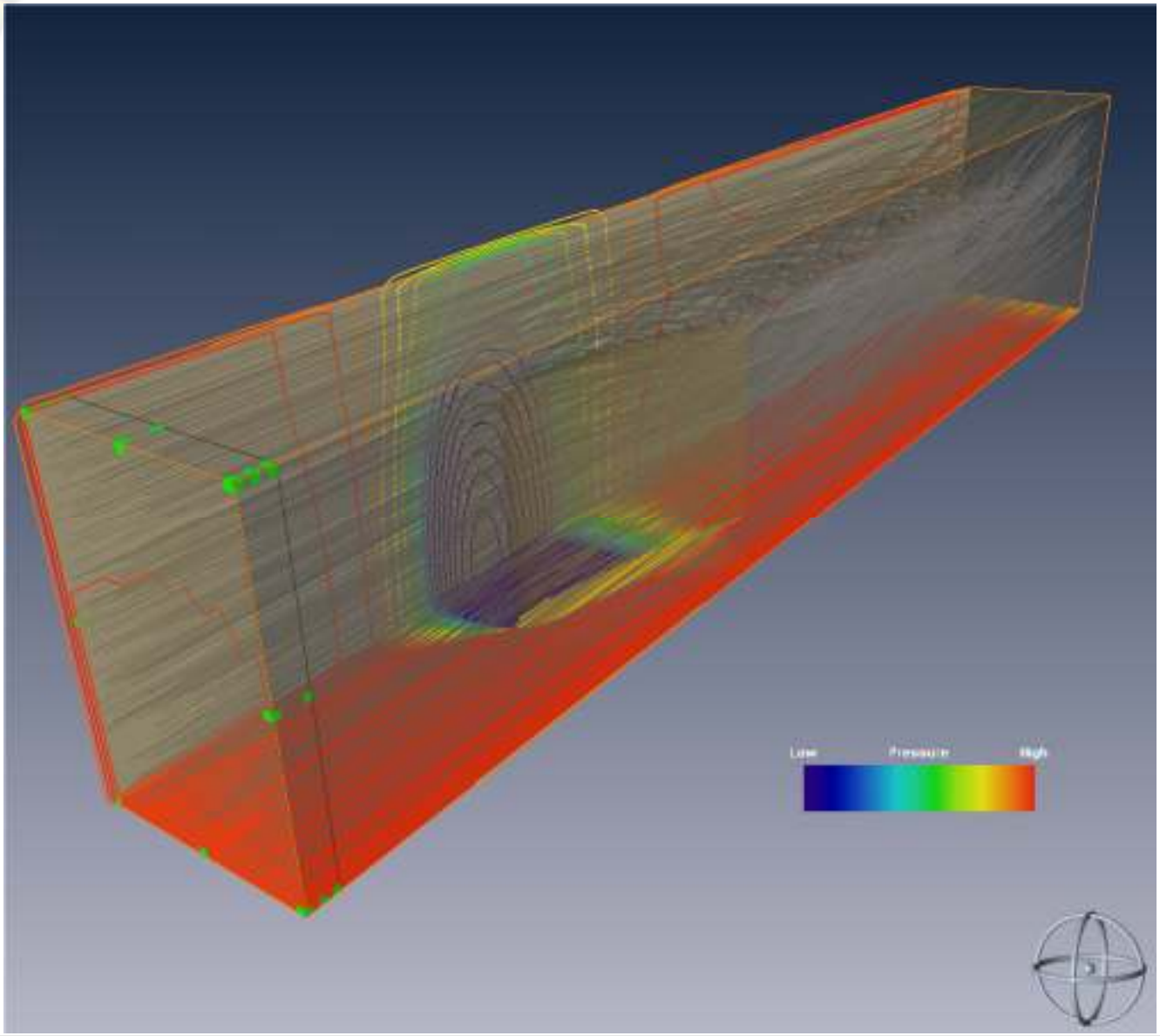
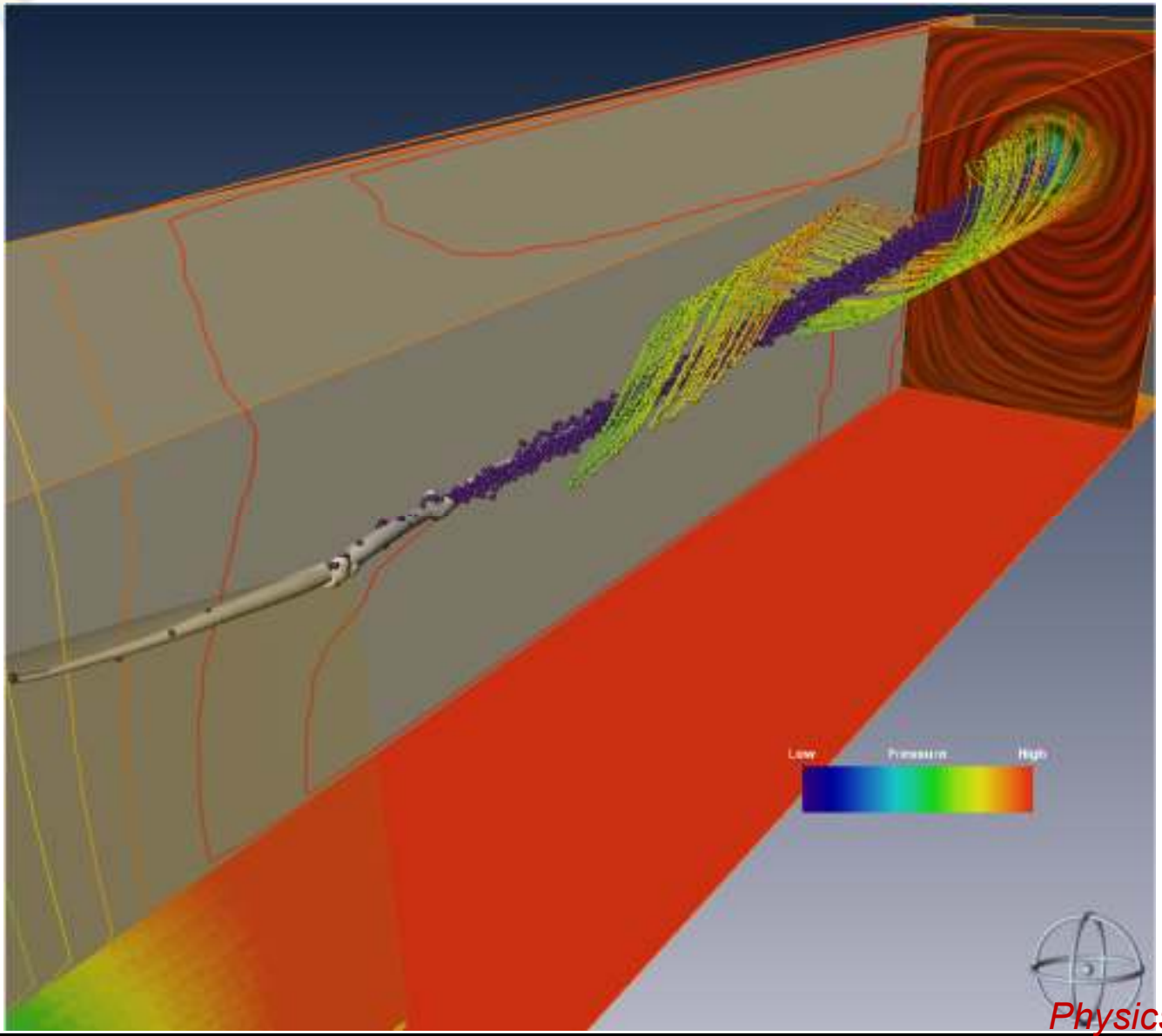
Visualization Sciences Group

Postprocessing VS Scientific Visualization:
Tip vortex study: Streamline



Postprocessing VS Scientific Visualization: Flow feature extraction



Physics of Fluids, 2006
AIAA, 2007

A more active role of scientific visualization: motivation re-iterated

1. CAE data has grown larger, CAE problems are getting complex and cross disciplinary
2. Associated visualization problems are not readily addressed by CAE practitioners either due to expertise constraints or due to resource constraints

Results:

Challenges unmet or under-met

Key to success

Common framework for CAE users to address common challenges

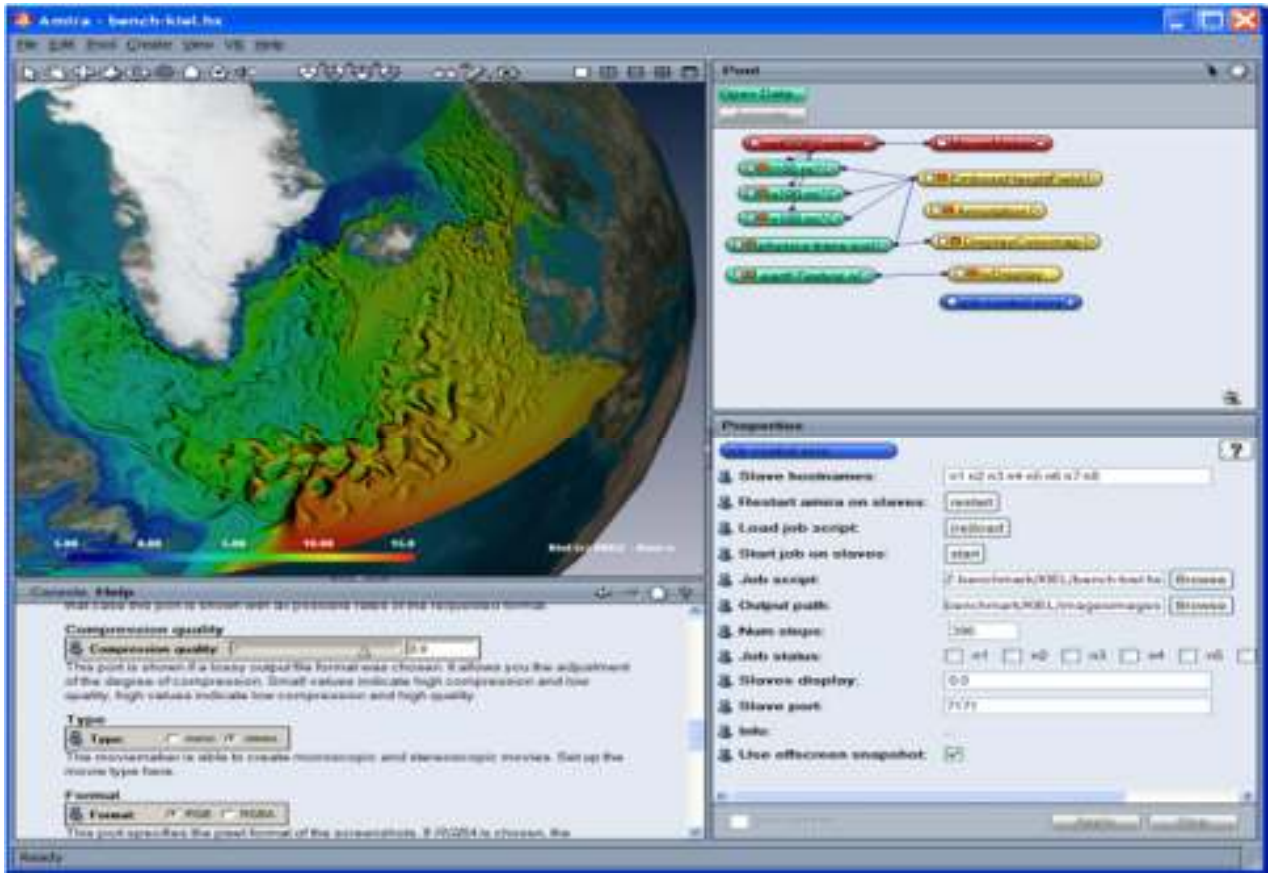
Benefit

- Graphics hardware and API evolution made transparent
- Cross platform and cross display supported
- Common visualization algorithms developed and maintained once for all

These will allow CAE developers to focus on core competency by avoiding re-inventing the wheel, and provide the CAE customers with shortest path to best visualization performance and quality

Common Data Interfaces

1. Uniform data storage
2. Federating multiple data sources



Federating different data sources

Simulation formats

- FEA formats
  - Abaqus, Ansys, Nastran
- CFD formats
  - Fluent, Star-CCM+
- Multiphysics formats
  - Comsol, Ansys multiphysics
- Crash simulation format
  - Madymo, Radioss
- Scientific Data Formats
  - Matlab, Tecplot, AVS
- Climate simulation formats
  - NetCDF
- Molecular simulation formats
  - PDB, AMBER, CHARMM, PHI, TRIPOS

Modeling and Experiment Formats

- 3D Scene/Geometry and CAD Formats
  - VRML, Open Inventor (.iv), DXF, IGES, STEP CATIA…
- 3D imaging (MRI, CT, FIB-SEM)
  - TIFF, JPG, PNG, BMP, RAW Binary... DICOM
- Microscopy Formats
  - Leica, Zeiss, Bio-Rad, FEI, MRC, STK...
- Surface Scanner Formats
  - PLY, PSI

Customizable with modern programming/scripting

Common Large Data Processing

- Parallel data extraction
- Parallel rendering
- Remote visualization
- Co-processing
- Feature extraction

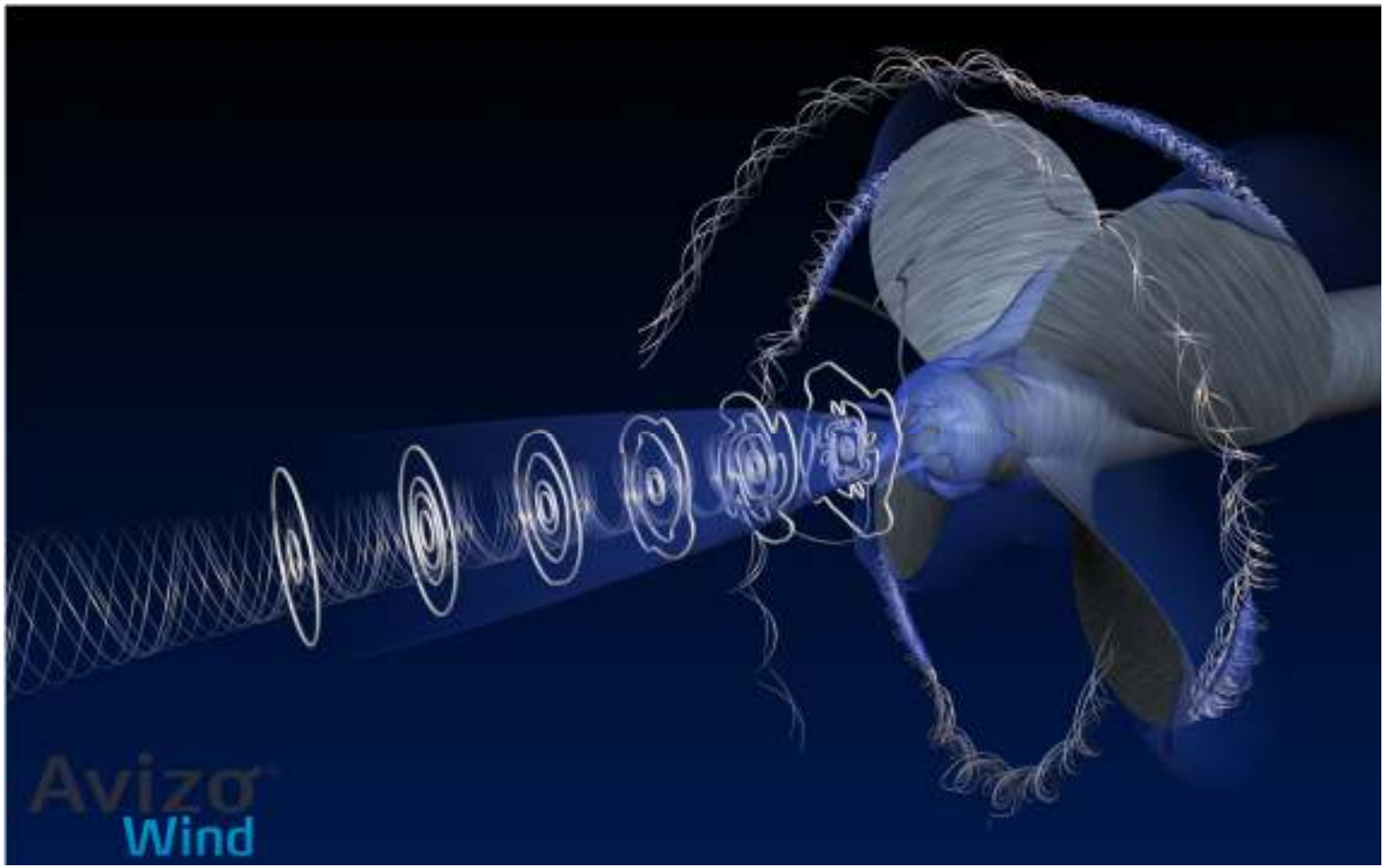
Common utilities

- Data compression
- GPU computing
- Usability, interactivity
- Collaboration and presentation
- Framework openness: extensible, automation

Feature extraction

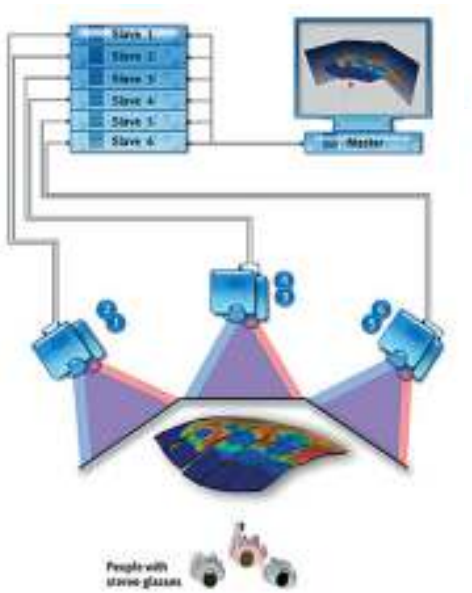
Technologies: Vector Field Topology, GPU Acceleration

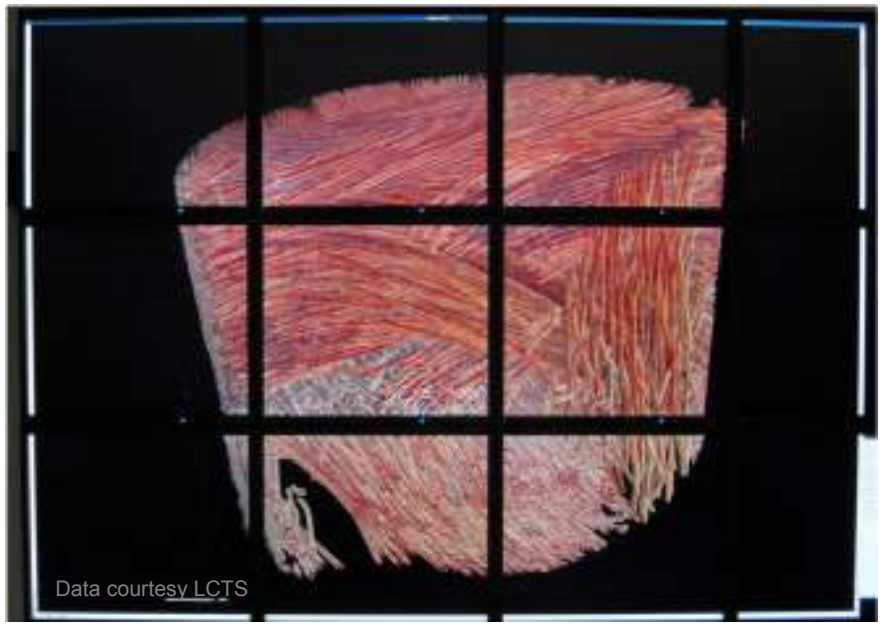
Benefit: Automatic identification of ROI, data reduction, interactive exploration of large data



Parallel rendering

Technologies: multi-GPU, Tile and depth decomposition
Benefit: Rendering large scene with possibly trillions of data elements;
Supporting high end visualization systems



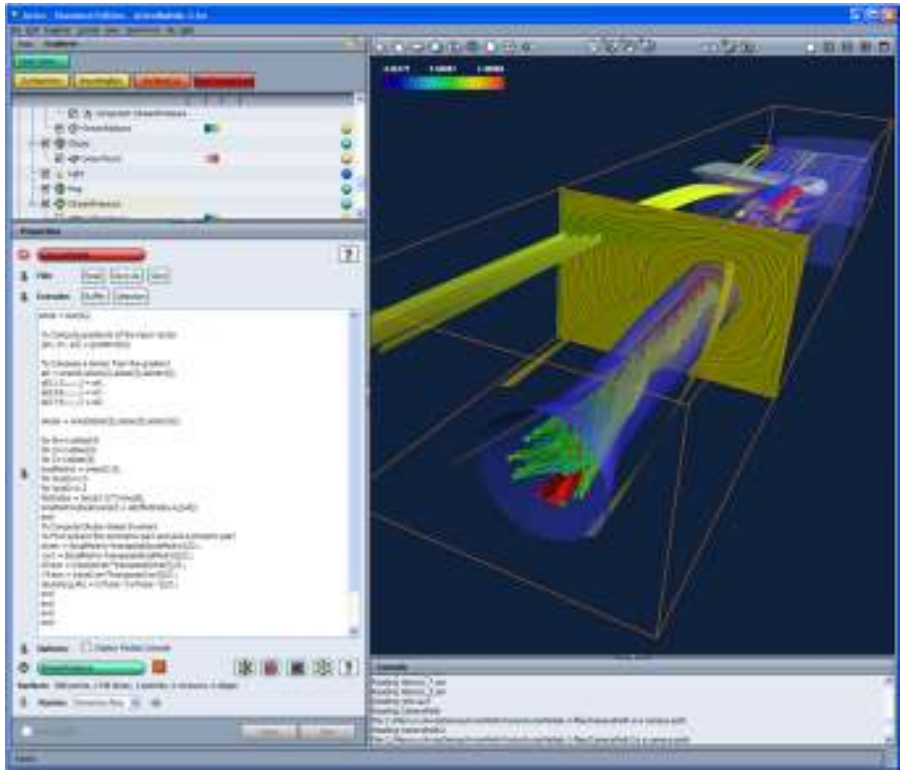


Tiled Display Case

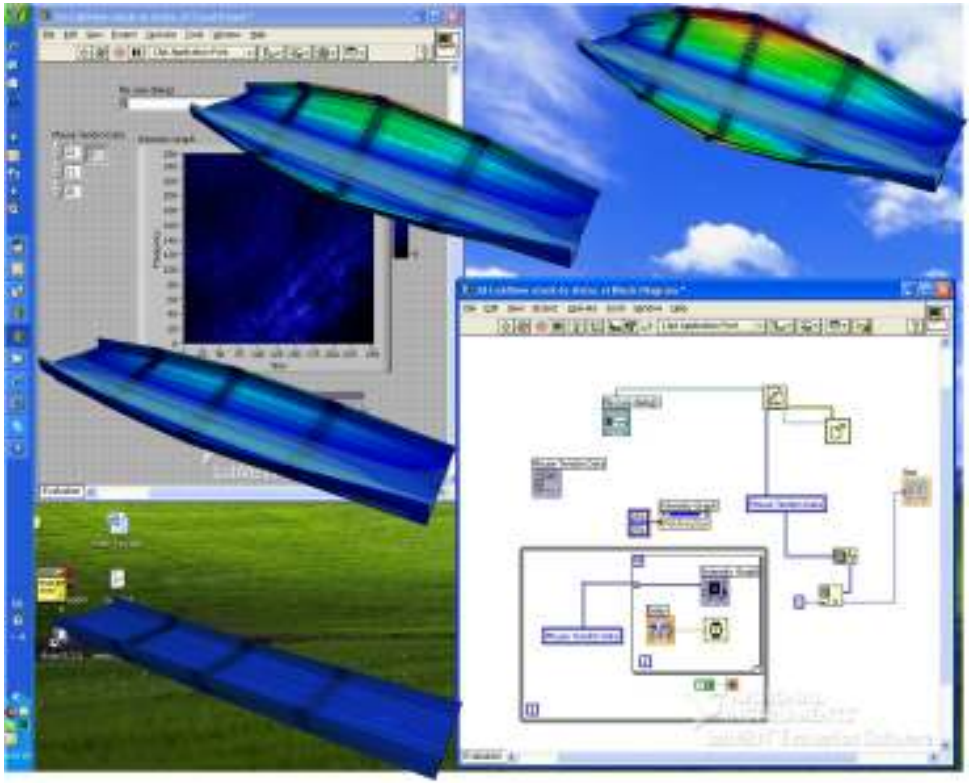
Immersive Cave Case

Co-processing

- **Technology:** Common API access; data extraction; data communication
- **Benefit:** Data reduction; Real-time visualization



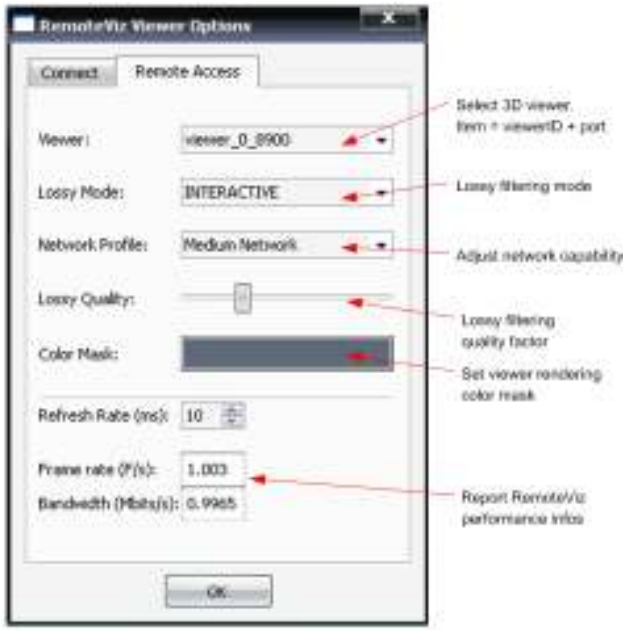
Avizo-Matlab Bridge

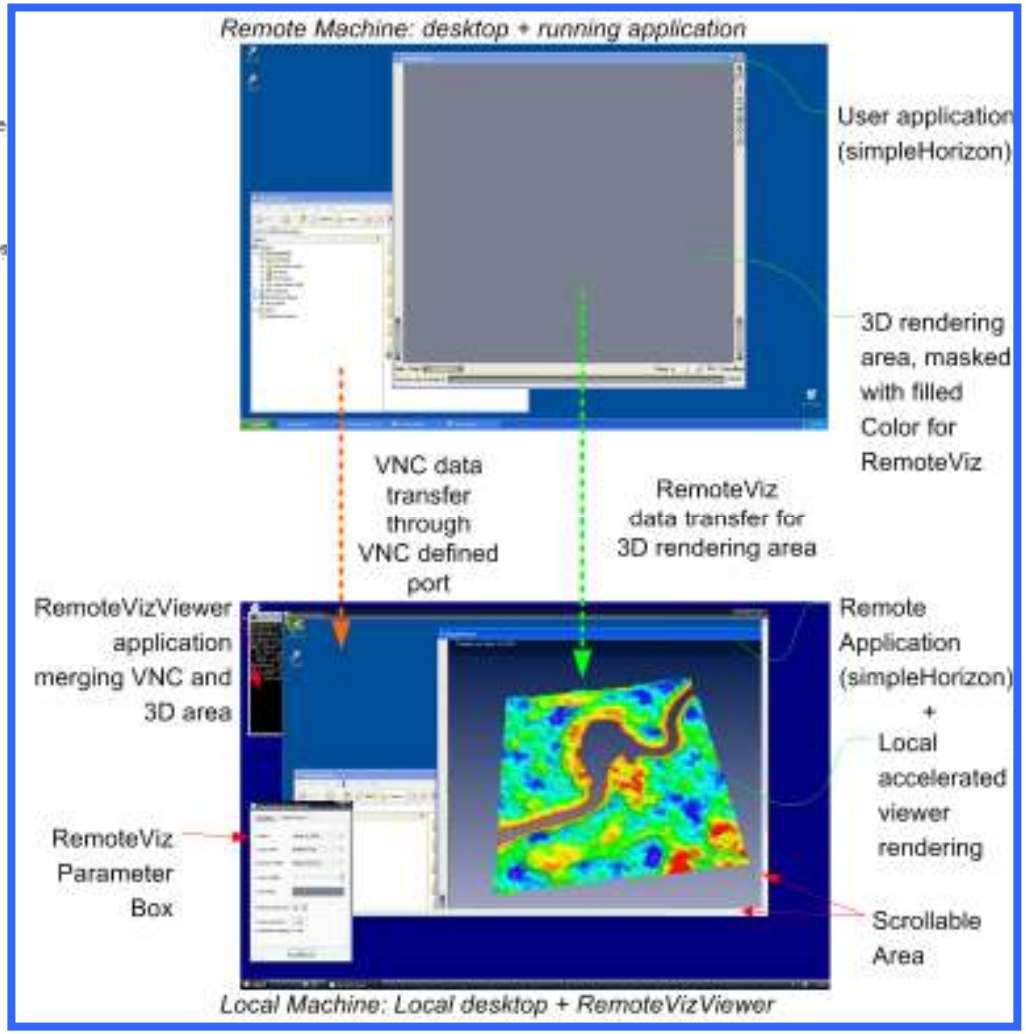


Avizo-LabVIEW Bridge

Remote visualization

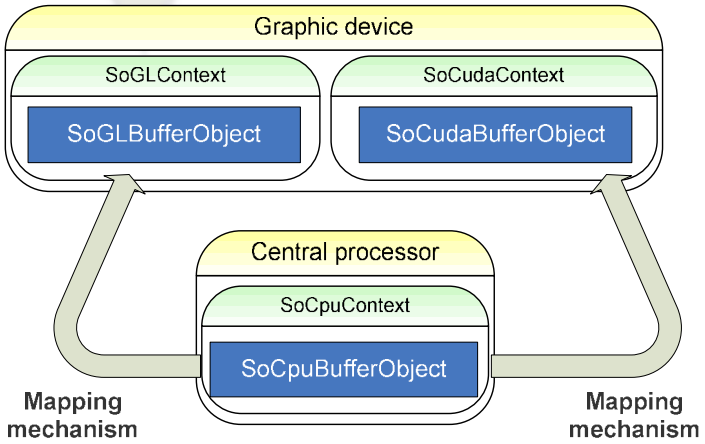
- **Technologies**: GPU acceleration on client and server; Compression
- **Benefits**: Large or confidential data; Share high performance resource…

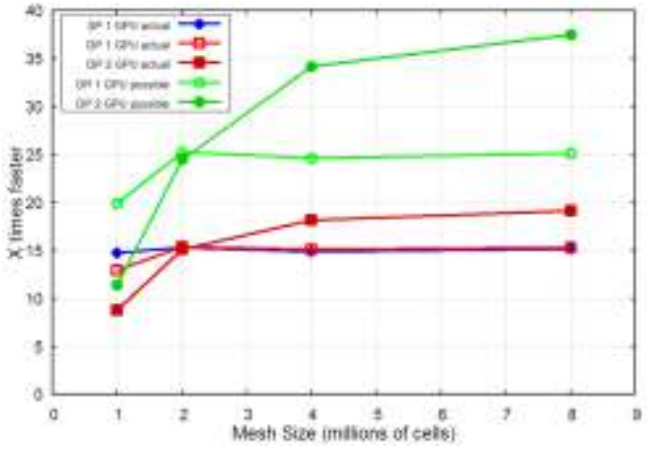


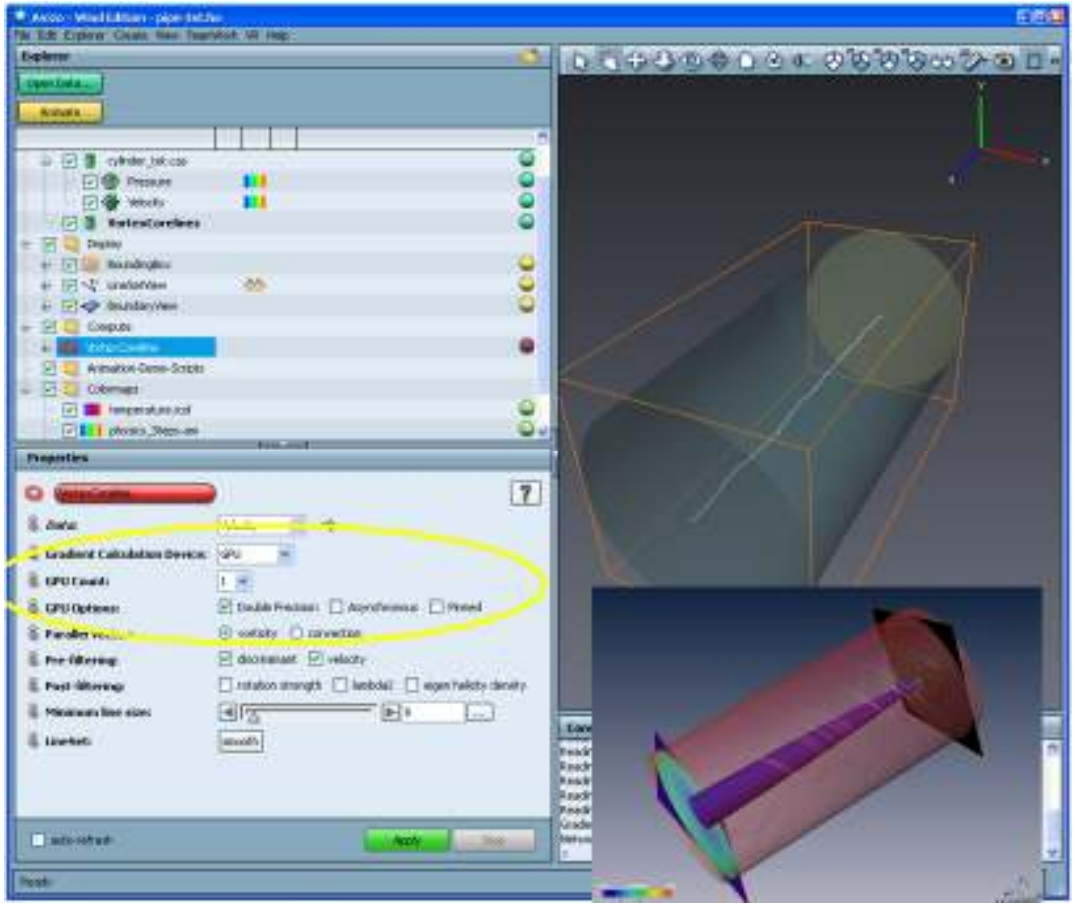


GPU Accelerated Visualization

Technology: GPU Computing to CAE applications
Benefit: Interactive exploration of large amount of data; take full advantage of existing GPU power for both visualization and computing

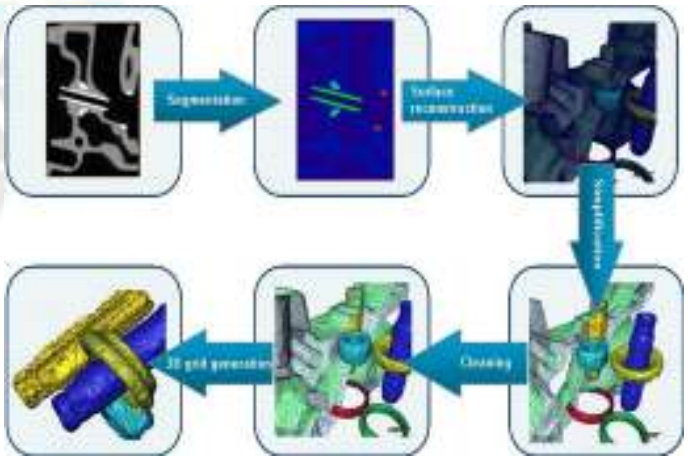




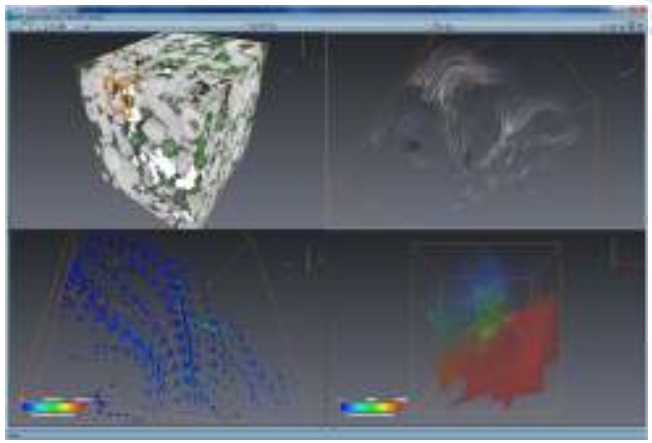


NAFEMS World Congress, 2009
Nvidia GPU Tech Conference, 2009

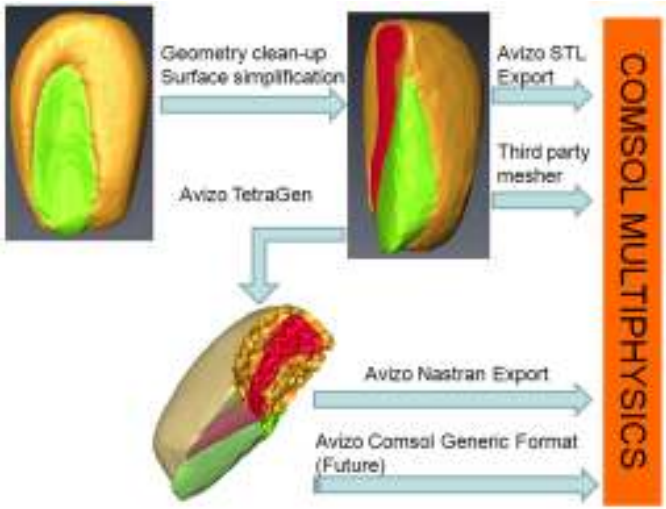
From Image to Simulation



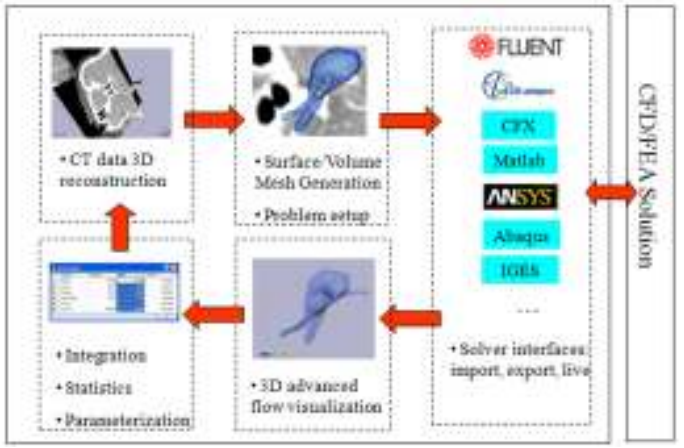
Metrology: CT->Stress Analysis



Rock pore analysis: FIB/SEM->Porous flow analysis



Corn drying: MicoCT->Multi-physics



Aneurysm blood flow: MRI->Flow analysis

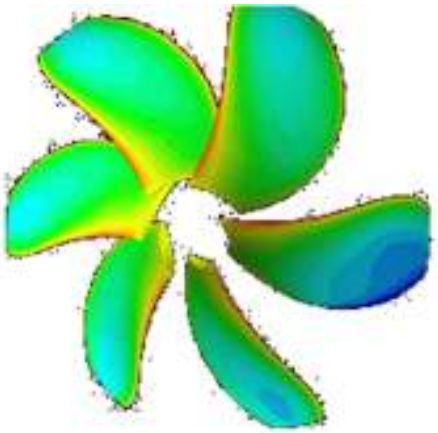
Comsol Conference, 2009

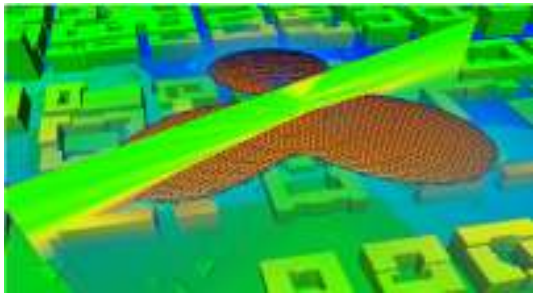
Conclusion: Open is the key

- Open framework
- Open discussion
- Open mind

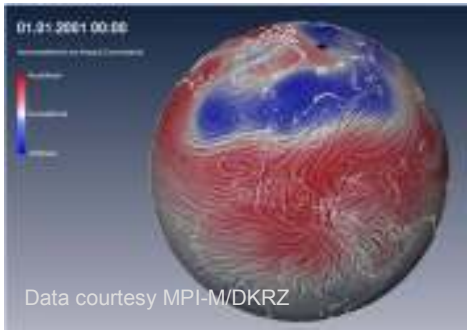
Challenge us

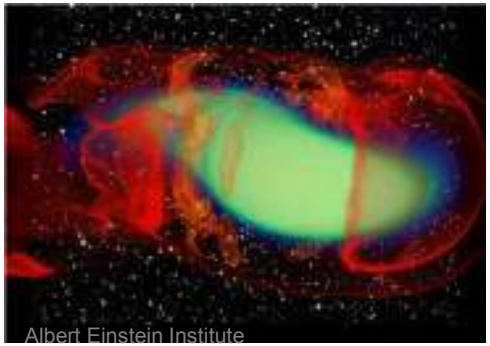
- Can you do better?

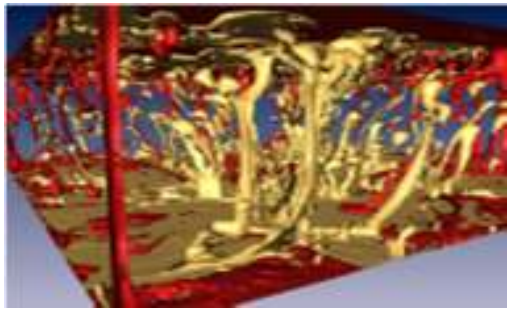


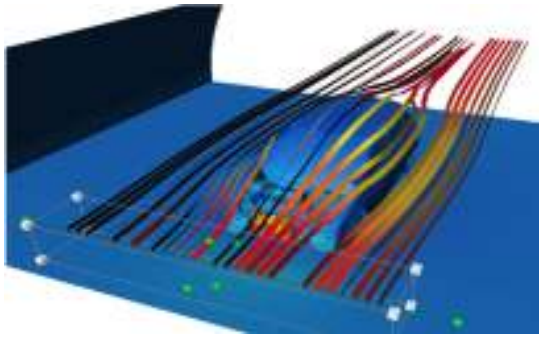


Cell phone antenna
coverage simulation









Acknowledgement

- NAFEMS
- All visualizations are generated with VSG technology by VSG or VSG Customers
- Some research results are documented in Physics of Fluids and Conferences Proceedings organized by AIAA, NAFEMS, Comsol and Nvidia

Contact

- shawn.zhang@vsg3d.com
- www.vsg3d.com

NAFEMS

CAE Visualization Challenges: Vcollab's Perspective

Visual Collaboration Solutions

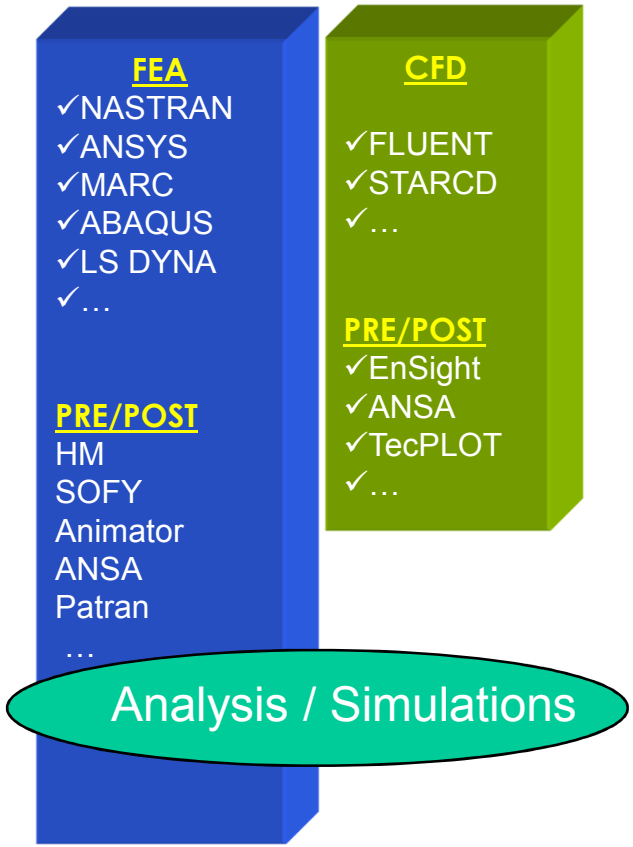
VCollab Overview

- VCollab established in 2000
- VCollab HQ at Troy, MI
- Develop and market VCollab brand of Software Solutions
- Currently 3 out of 5 major Automotive OEMS are using the VCollab solution as the visual collaboration platform for sharing CAx (**modeling & simulation**) data

- **VCollab provides a common light-weight CAE Data Visual Collaboration platform i.e. "pdf for CAE"**

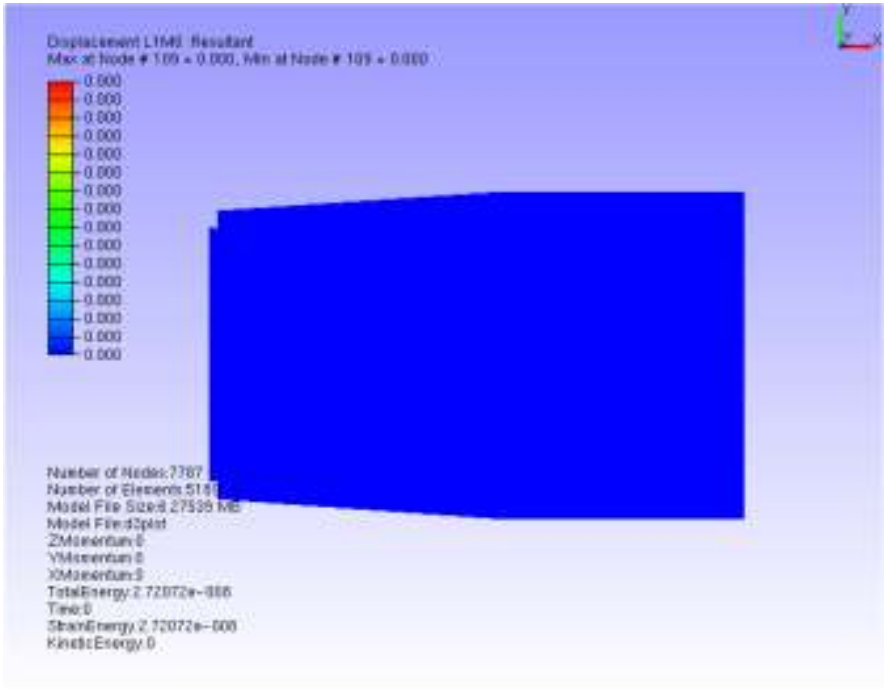
CAE Visualization Challenges

- Data, data, and more data, and then even more data
  - Many CAE applications and many formats
  - CAE results files are very large
  - Increased usage of CAE is dramatically increasing the number of simulations and large result files
  - Higher level tools (DSE, Systems Engineering, Robust Engineering, stocahstics…) will cause data to exlode



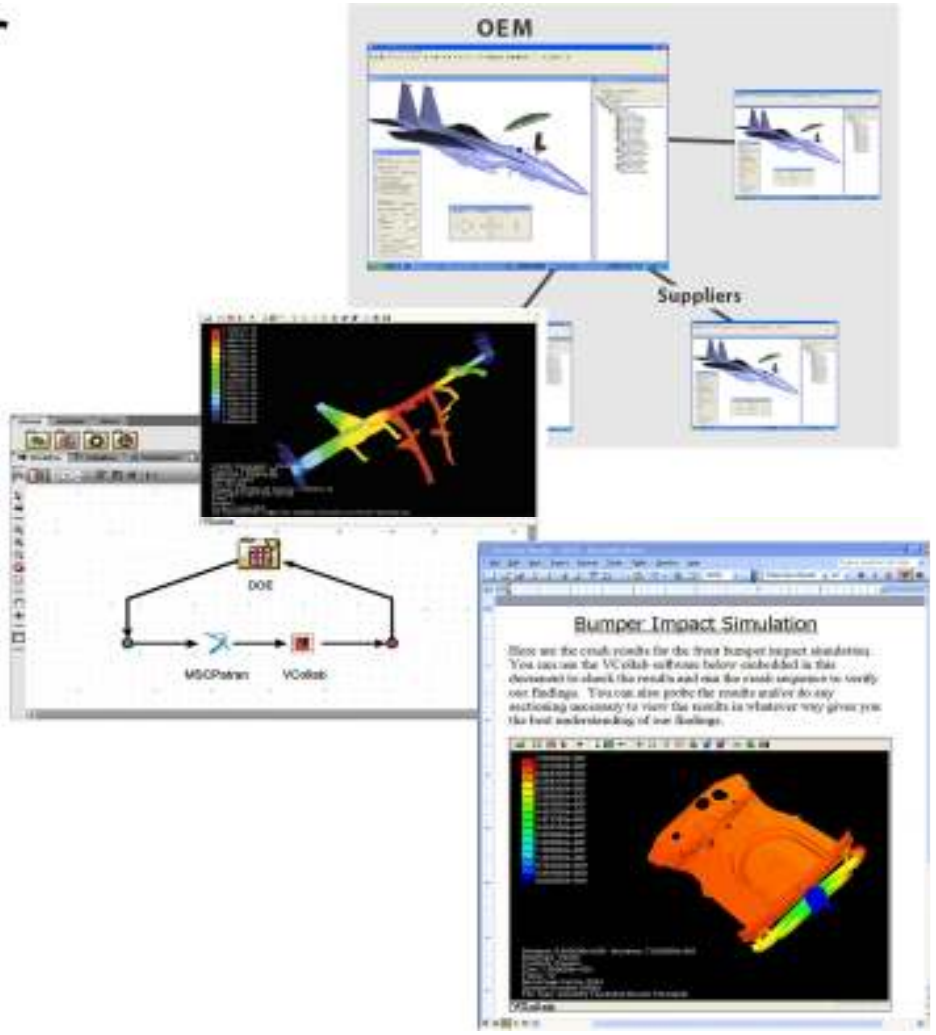
CAE Visualization Challenges

- CAE data is complex and varied
  - Many CAE applications and many formats – no standard
  - Complex field results for different physics
    - Solid Mechanics
    - Fluid Mechanics
    - ElectroMagnetics
    - Acoustics
    - Others …
  - Transient results
  - 2D images are not enough
  - 2D movies are not enough
- **Data files are HUGE !!!**



CAE Visualization Challenges

- Multiple use cases for CAE visualization
  - Expert interactive review
  - Report generation
  - Simulation review (peer & management)
  - Presentation & collaboration
  - Data Archival
  - Integration with PIDO / SLM and other processes

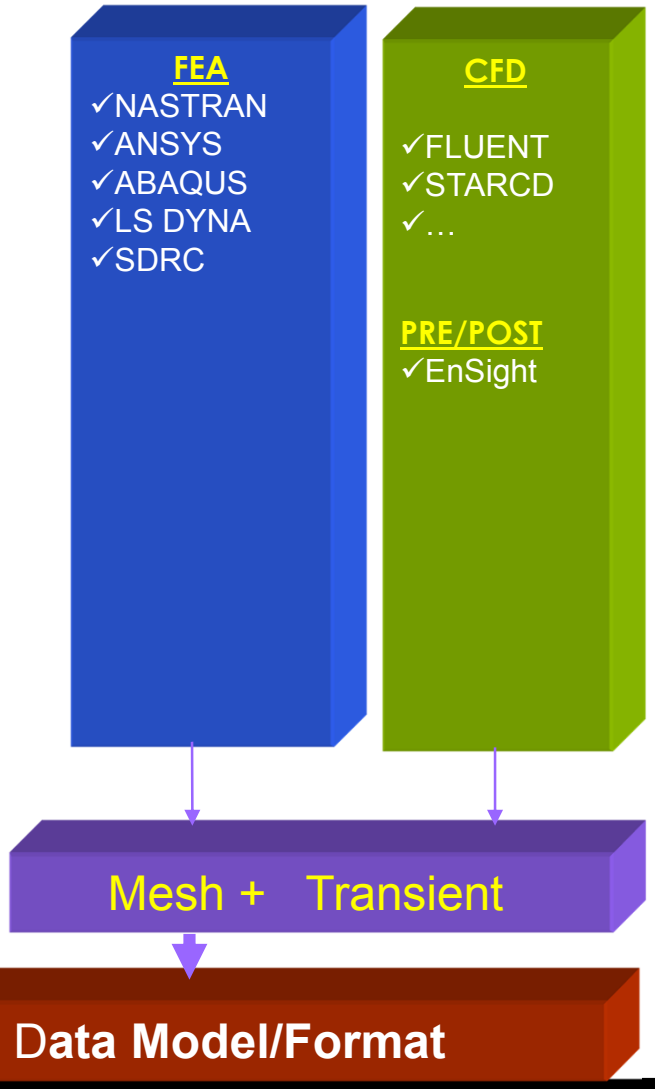


VCollab Perspective

- **Focus on complex 3D transient CAE Data being accessible broadly**
  - **Significant visualization required beyond expert usage**
    - **Need support for presentation/communication and simulation reviews**
    - **Need support for automated reporting**
    - **Need support for archival**
  - **Large number of iterations required for high end processes (ie design space exploration, systems engineering, SLM, …)**
    - **Significantly reduced data size with accuracy is critical**

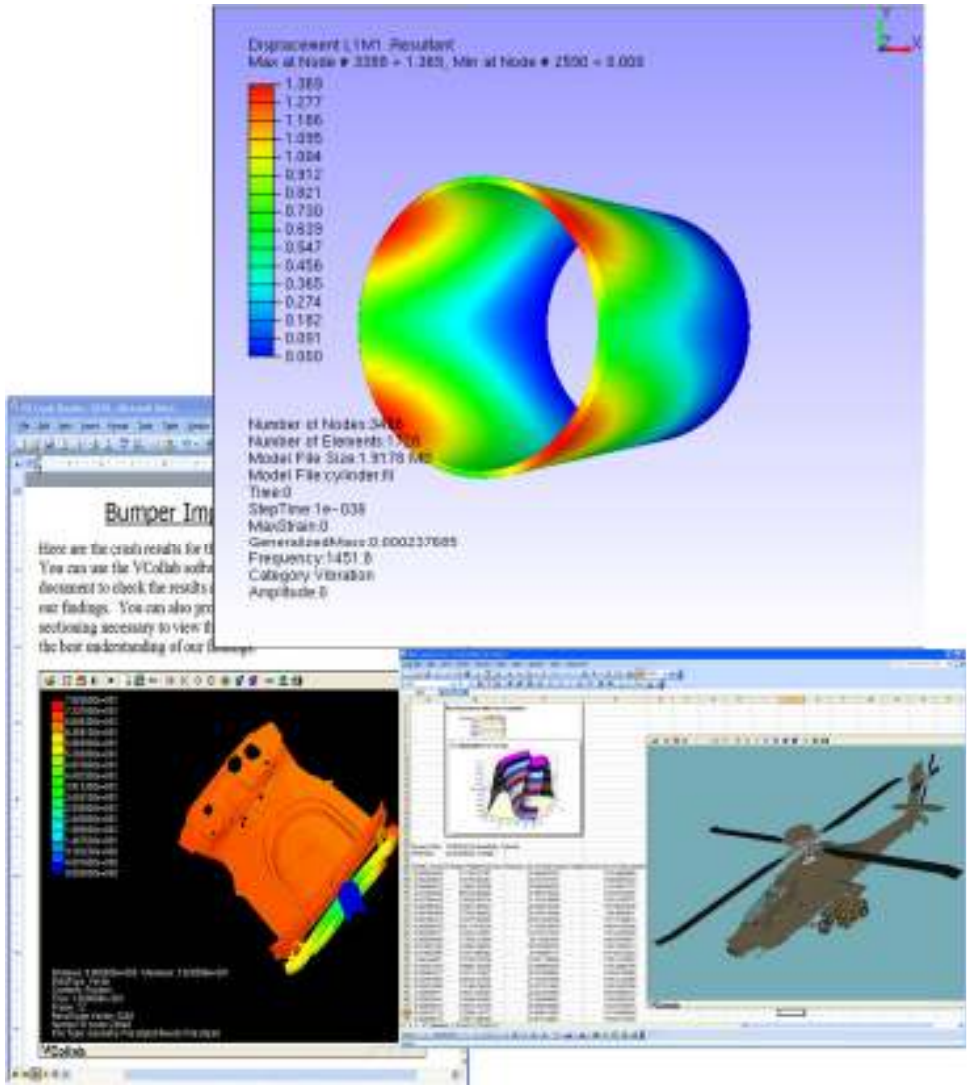
VCollab Perspective

- **Need for universal compact CAE format**
  - Typically need 95% or greater compressions rates
- **Need for CAE data reduction tools to create compressed files**
  - Support for leading CAE software
  - Support for in-house codes
  - Support for les used and specialty codes
- **Need for automated metadata extraction**



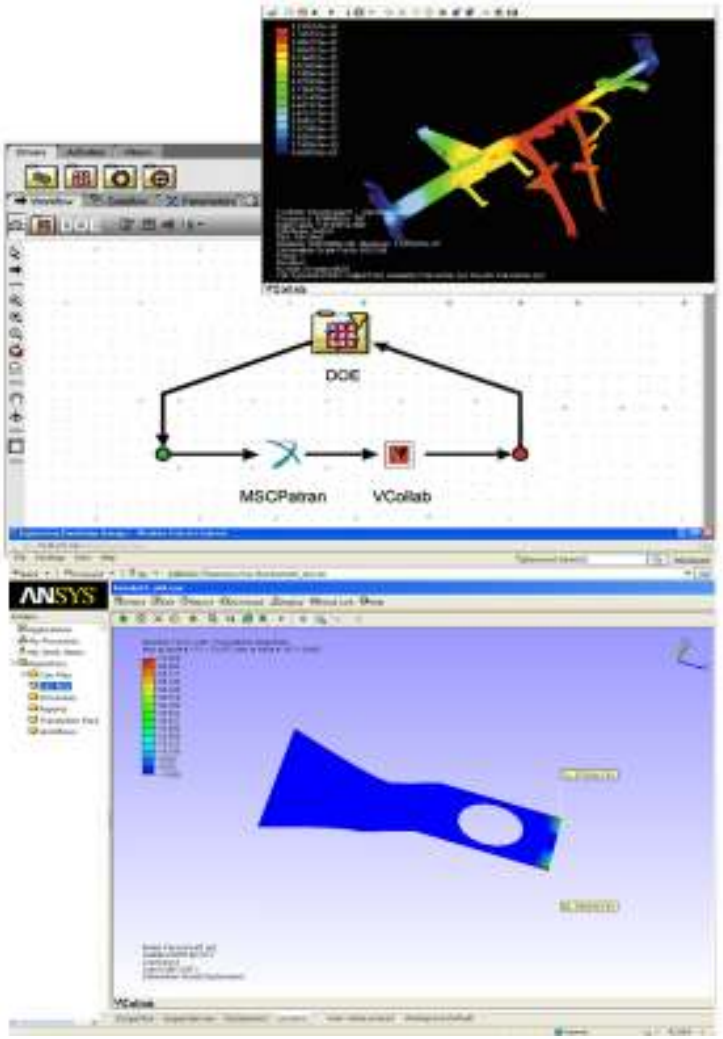
VCollab Perspective

- **Need for easy to use, professional, light weight CAE Viewers**
  - Basic viewer
  - Advanced viewer for data exploration
  - Professional viewer for Modification of compressed data
- **Need for interfaces with general tools**
  - Internet Browser
  - MS/Office
  - MS SharePoint



VCollab Perspective

- **Need for integration with PIDO / SLM solutions**
  - iSightFD – now part of DS SLM offerings
  - ANSYS EKM
  - Siemens – TeamCenter for Simulation
  - Others …



VCollab Approach

- Focus on non-interactive CAE Visualization usage
  - Provide universal compact CAE format (.CAX)
  - Provide CAE data reduction tools (VMOVE) to create CAX files
  - Provide Easy to use, professional, light weight CAE Viewers (VCollab) with interfaces with other tools
  - Provide community for sharing analysis results www.marechi.com
- Make complex 3D transient CAE Data broadly accessible

Questions

Website: www.nafems.org

THE INTERNATIONAL ASSOCIATION
FOR THE ENGINEERING ANALYSIS COMMUNITY

Thank you!