

Transportation Research and Analysis Computing Center

TRACC

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TRACC Director

Energy Systems Division

Argonne National Laboratory

November 7, 2012

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www.tracc.anl.gov

In cooperation with the U.S. Department of Transportation

Argonne: One of DOE's Largest Research Facilities



- Located 25 miles from the Chicago Loop, it was the first national laboratory, chartered in 1946
- Argonne is managed by [UChicago Argonne, LLC](#), for the [U.S. Department of Energy's Office of Science](#).
- Major research missions include basic science, environmental management, and advanced energy technologies
- About 3,000 employees, including about 1,000 scientists and engineers, of whom 750 hold doctorate degrees
- Annual operating budget of about \$475 million (80% from DOE)
- Since 1990, Argonne has worked with more than 600 companies and numerous federal agencies.

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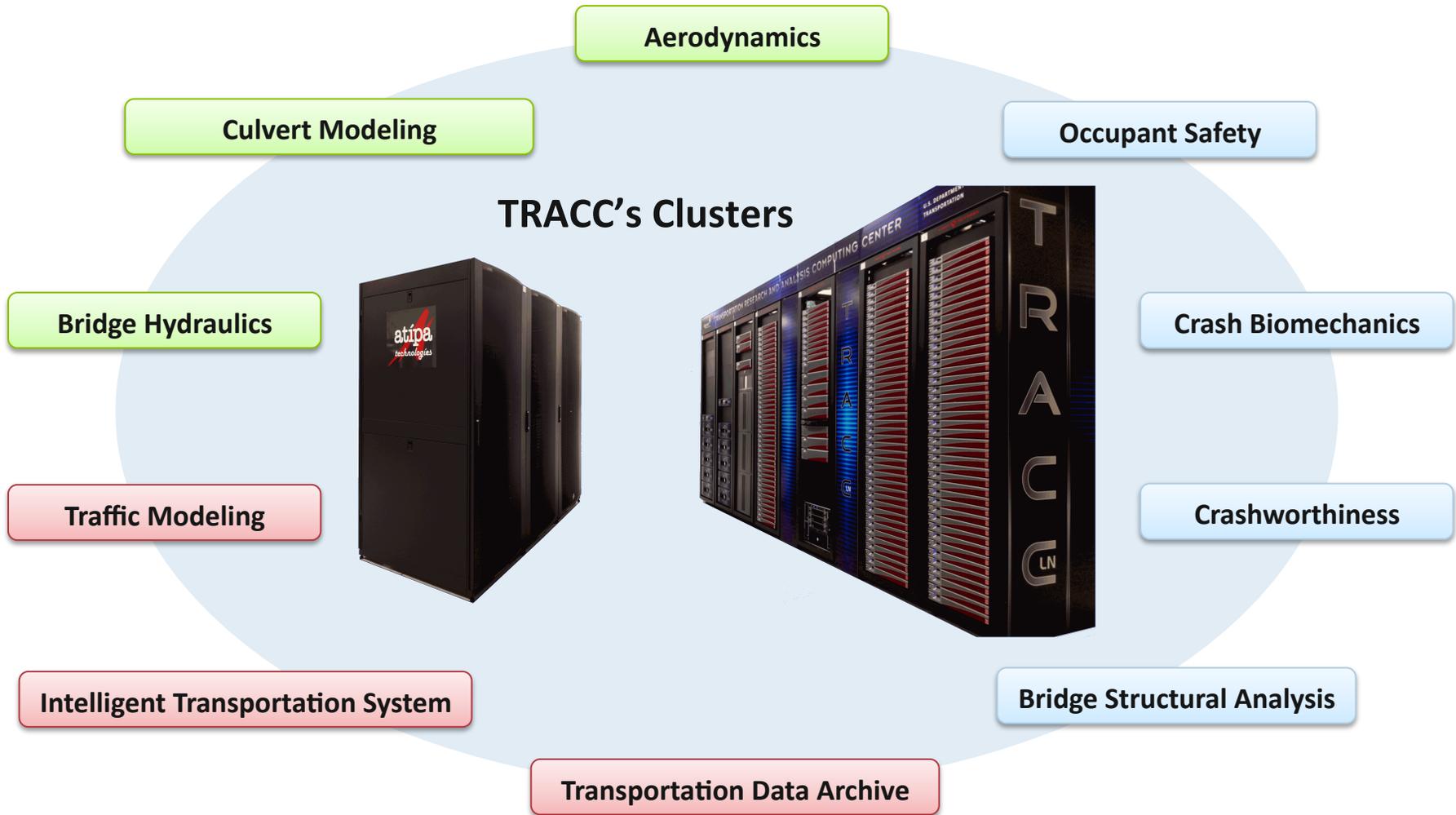


TRACC - A National User Facility to Meet USDOT Advanced Computation Needs

- USDOT and USDOE transportation research programs, private industry, and state and regional transportation agencies are moving to simulation-based design and analysis for improvements in efficiency, economics, and safety
- Higher fidelity analysis in areas such as crashworthiness, aerodynamics, combustion, thermal management, weather modeling, and traffic simulation require access to state-of-the-art computational and visualization facilities
- Argonne expertise in high-performance computing and transportation system analysis provides the basis for a national HPC user facility and a focal point for computational research for transportation applications



TRACC - High-Performance Computing for Transportation Research and Applied Technology



TRACC is a National USDOT Supercomputing Facility



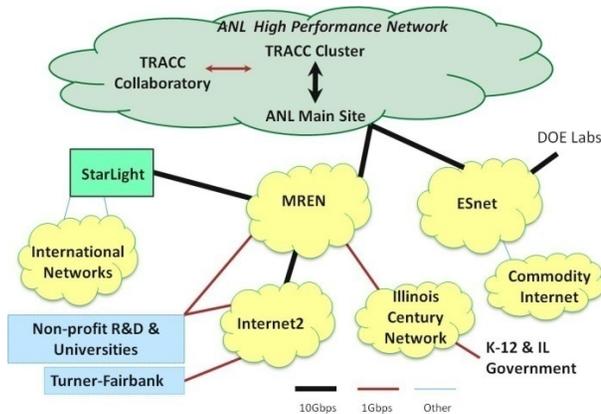
TRACC High Performance Compute Clusters

Zephyr

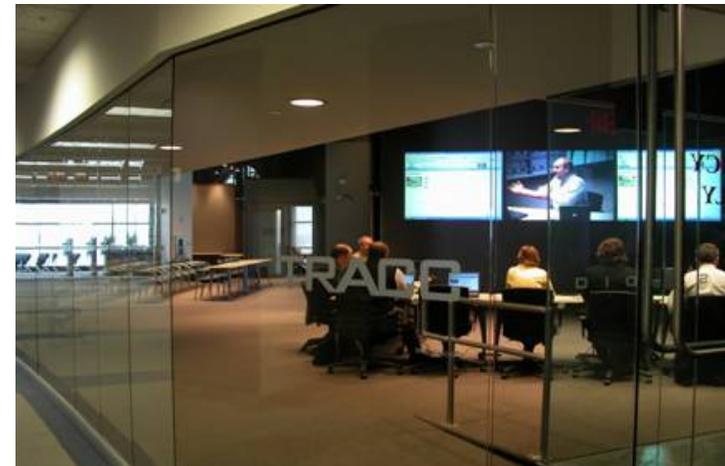
- 2944 cores, 184 16 core processors, 92 compute nodes
- 120 TB Lustre Disk Storage
- Shared 160 TB Archive/Backup Tape Storage

Phoenix

- 1024 cores, 256 quad core processors, 128 compute nodes
- 90TB Global Parallel File System Disk Storage
- Shared 160TB Archive/Backup Tape Storage



High-bandwidth connectivity is provided via the Argonne high-performance network to world-wide research and education networks (Internet2 and ESnet)



TRACC Collaboratory - Training, Meetings, and Digital Video Conferencing



TRACC Partner Organizations

■ TRACC Partners

- TRACC is linked to Federal and non-Federal research and development facilities, regional, state and city departments of transportation, and university transportation research centers
- Federally sponsored USDOT partners currently include the Federal Highway Administration (FHWA) with its Office of Planning (OoP) and the Turner-Fairbanks Highway Research Center (TFHRC), and include the National Highway Traffic Safety Administration (NHTSA)

■ Technology Development and Commercialization

- Starting in FY2013, TRACC increased its emphasis on establishing cost-sharing research programs through sponsored research
- A primary objective of DOE is to promote the economic interests of the United States
- Partnering with organizations facilitates the development, transfer and use of Federally owned or originated technology by industry for public benefit
- Sponsored research provides a mechanism to leverage DOE resources such as those of TRACC through partnering with industry



Current Focus Areas

- Traffic Modeling and Simulation and Emergency Transportation Planning
 - Chicago metropolitan area model using multi-modal simulation techniques
 - Collaboration with the Chicago Metropolitan Agency for Planning, the Illinois Department of Transportation, the Federal Highway Administration, and other federal agencies
- Computational Fluid Dynamics for Infrastructure Analysis
 - Hydraulics analysis of flow at bridges and culverts, flooding and scour, storm water runoff, laboratory flume, and field device flows
 - Wind engineering applied to roadside hardware and bridge aerodynamics
 - Analysis of salt spray and aerosol dispersion from trucks
- Computational Structural Mechanics for Transportation Applications
 - Vehicle crash analysis, roadside barrier impact, accident reconstruction and occupant response
 - Bridge dynamic response due to traffic loading, stay-cable response due to traffic loading and wind loading, stability of bridges with piers in scour holes, including fluid-structure interaction
- High-performance Computing Center
 - Two high-performance computing clusters
 - National and international network connectivity
 - Training and collaborative facilities



Traffic Modeling and Simulation and Emergency Transportation Planning



In cooperation with the U.S. Department of Transportation

Transportation Systems Simulations at TRACC

TRANSIMS Activities

- Development of tools and methodologies to support a faster and more reliable modeling process
 - **Parallelization** and coordination of simultaneous execution of partitioned data sets
 - Adaptation of TRANSIMS to run effectively **on high performance computing** platforms
 - Development of high level tools such as network editors and **TRANSIMS Studio**
 - High performance **visualization** to aid in developing and debugging large complex transportation system models
 - **Training classes** to support new and advanced TRANSIMS users
- Development of a Chicago TRANSIMS model
 - Used as the basis for TRANSIMS **software and methodology improvements**
 - Model is largely based on data and previous models from **CMAP**
 - The model is being shared with other research teams, e.g. IIT/CDOT

POLARIS Activities

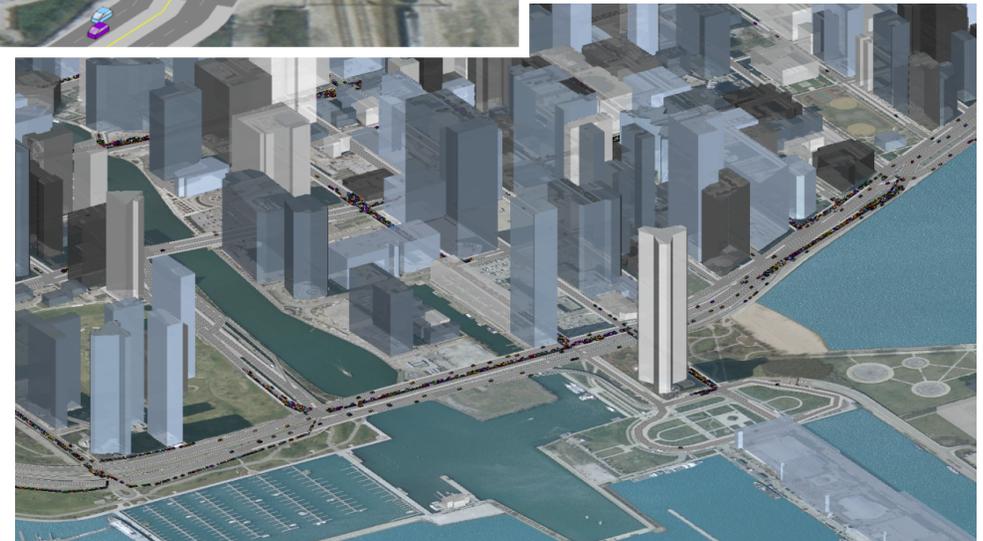
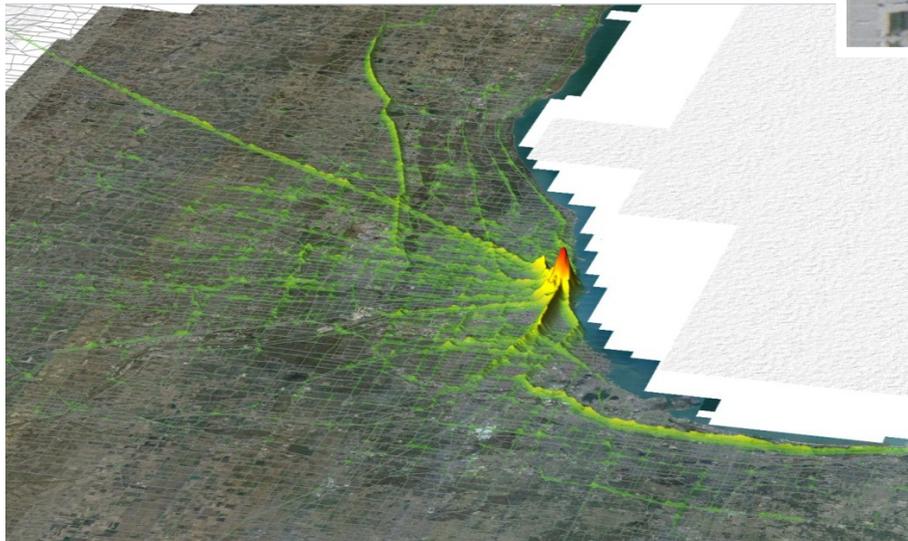
Planning and Operations Language for Agent-based Regional Integrated Simulation

- Mandates from FHWA:
 1. Model **Traffic Control Centers** and other **ITS Systems**
 2. Enhance Interoperability among Existing Tools
- Core Goals and Philosophies of the POLARIS Effort:
 - Develop Transportation Modeling Standards and Protocols
 - Create an **Open Source** Model Development Environment
 - Seek Out Opinions from and Actively Listen to the Transportation Community
 - Connect Sub-Communities with a **Common Modeling Language**
 - Offer Helpful Tools while Maintaining **Flexibility and Modularity**
- Repository of useful code and code fragments built using a standard methodology
 - Includes a library of common objects found in transportation models
 - Will be extended by users and other researchers



Transportation Systems Visualization

- Implementation of powerful visualization concepts to analyze complex computational simulations
- Effective visualization allows the human brain to detect simulation flaws or actual congestion problems



TRANSIMS Models at TRACC

Washington, DC



Atlanta



Chicago



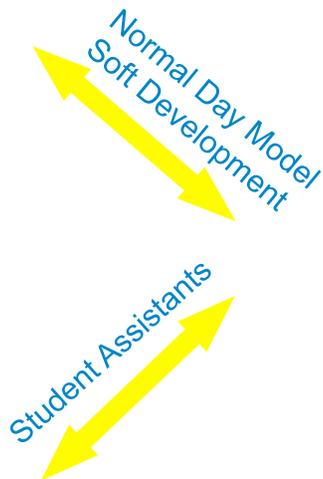
Los Angeles



Sacramento



The 2011 RTSTEP Evacuation Simulation Team



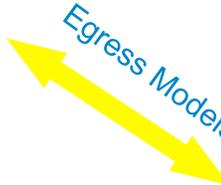
Social Science
Research



GIS Data
Feedback



Egress Models



Network Data
Trip Tables



Chicago Metropolitan
Agency for Planning



TRACC

Transportation Research and Analysis Computing Center
In cooperation with the U.S. Department of Transportation

TRANSIMS User Support and Training



Argonne NATIONAL LABORATORY

TRANSIMS Training Course
 April 21 - 23, 2008
 West Chicago, Illinois

Location
 The training course will be held at the DuPage Airport Flight Center in West Chicago where Argonne's TRACC offices are located. The training sessions will be held on the third floor of the flight center at the University of Illinois TRACC facility. The training sessions will also be broadcast over the Internet (using Adobe Connect) at <http://anl.acrobat.com/transims/>

Argonne NATIONAL LABORATORY

TRANSIMS Training Course
 June 23-25, 2009
 Houston, TX

Location
 Houston is acknowledged as the Energy Capital of the World and is one of the new TRANSIMS users.

Location
 The training course will be held at the College of Technology, University of Houston (UH) (see maps on reverse side), in room 225, Technology Building. The training sessions will also be broadcast over the Internet (using Adobe Connect) at <http://anl.acrobat.com/transims/>

Georgia Tech College of Engineering School of Civil and Environmental Engineering

TRANSIMS Training Course
 June 17-19, 2008
 Atlanta, Georgia

The Transportation Research and Analysis Computing Center at Argonne National Laboratory will hold a training course on the regional transportation analysis code TRANSIMS. The course is targeting primarily analysts new to the TRANSIMS methodology, and covers both the theoretical underpinnings as well as the practical application of the code. Participants will develop a full understanding of the general TRANSIMS principles, implementation details, requirements, capabilities, and limitations of the software. TRANSIMS (short for Transportation Analysis and Simulation System) is an integrated set of tools developed to conduct regional multimodal transportation system analyses. With the goal of establishing TRANSIMS as an ongoing public resource available to the transportation community, TRANSIMS is made available by the Federal Highway Administration under a NASA Open Source Agreement and is therefore ready available to the community.

The software is compatible with regular desktop or server systems, but can also make use of high performance computing systems such as the TRACC cluster, a 512 core Linux system with 24TB of disk space and extremely fast network connections across the United States. This cluster is generally available to researchers in the US transportation community and is currently being used for TRANSIMS traffic simulation, emergency evacuation modeling, computational fluid dynamics for bridge analysis, and structural mechanics codes to determine crashworthiness and structural integrity of highway components and vehicles.

www.tracc.anl.gov

Argonne NATIONAL LABORATORY

TRANSIMS Training Course
 January 27-29, 2009
 Moreno Valley, CA

Location
 Moreno Valley is one of TRANSIMS' newest users and was recently named one of the fastest-growing cities in the nation.

Location
 The training course will be held at the City of Moreno Valley Conference and Recreation Center (see maps on reverse side) in Alessandro Room A. The training sessions will also be broadcast over the Internet (using Adobe Connect) at <http://anl.acrobat.com/transims/>

Registration
 Participation in the training course is free. Travel, lodgings, and other expenses are the responsibility of the participant. Please contact us at the number or E-mail address shown below if you would like to attend the training sessions either by Internet or in person.

This is the sixth TRANSIMS training course held by TRACC. It has evolved from the need to quickly and efficiently train students and collaborators in the practical application of the code. While addressing the fundamental principles to a degree that allows for a better understanding of the capabilities and limitations of the TRANSIMS approach, the main focus is on the use of the individual components. It also focuses on the issues of network conversion, file conversion, routing, microsimulation, feedback, and visualization.

Local Arrangements:
 Victor Cheng, Ph.D.
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 713 743 1524

Heng Wang
 Houston-Galveston Area Council
 ICTPA - Texas Chapter
 h.wang@hgaac.org
 713 993 4560

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Local Arrangements:
 John Vining, P.E.
 City of Moreno Valley
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 951 413 3140
jvining@moval.org
www.moval.org

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TRACC Transportation Research and Analysis Computing Center at Argonne National Laboratory

UChicago Argonne UChicago Argonne, LLC

www.tracc.anl.gov

A.U.S. Department of Energy Laboratory managed by UChicago Argonne, LLC

■ TRACC is providing training courses on TRANSIMS and other subject areas to the transportation research community in the US

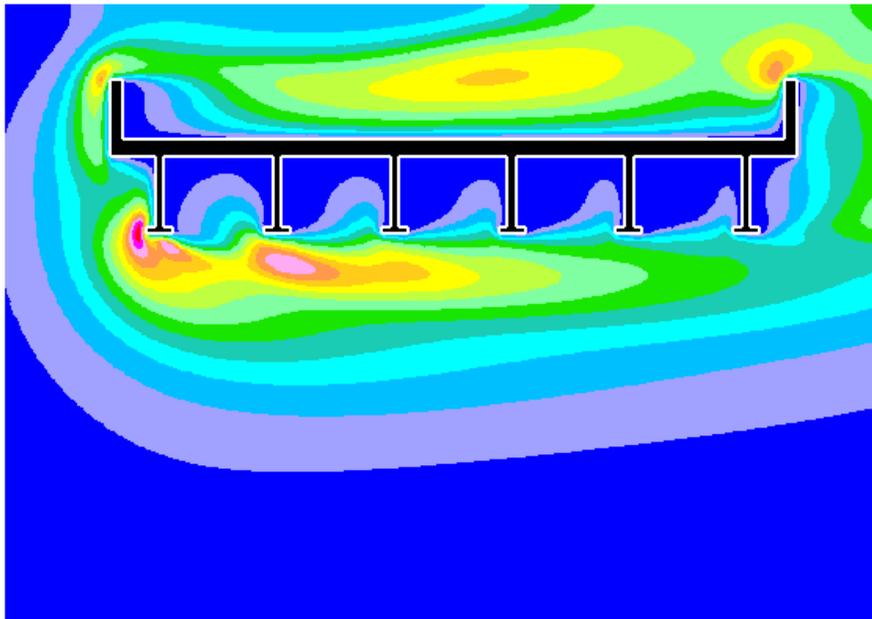
- Training courses are offered approximately 10 times per year in varying locations
- Participation is free, and training courses are broadcast over the Internet to reach additional users

■ TRACC is holding additional training sessions on emerging capabilities through the Internet

■ The goal is to build a strong community of expertise



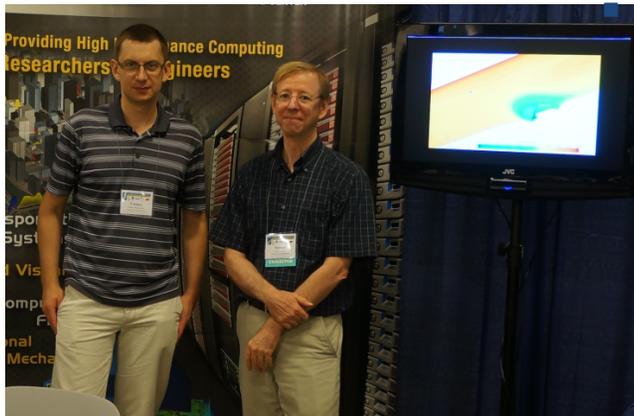
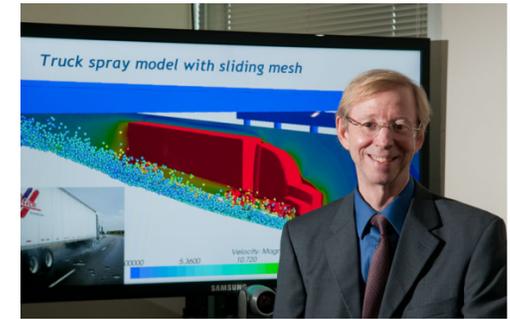
Computational Fluid Dynamics for Infrastructural Analysis



In cooperation with the U.S. Department of Transportation

Computational Fluid Dynamics and Computational Structural Mechanics

- Commercial applications such as LS-DYNA and CD-adapco STAR-CCM+ scale well on TRACC clusters
- Based on proven and reliable commercial models, **cutting edge research** involves the addition of crucial modeling capabilities such as
 - **Sediment erosion** at bridge pier and abutment foundations
 - Parametric vibrations in **bridge stay cables**
 - Many more ...



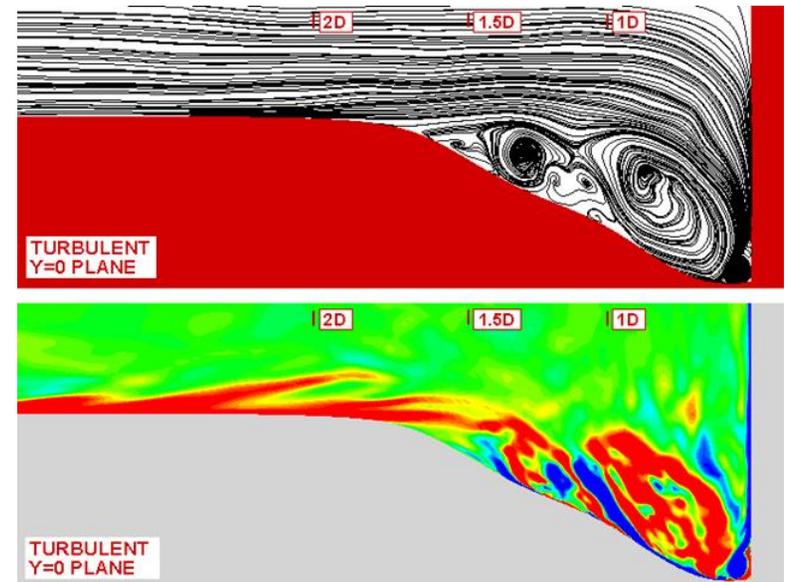
High priority **transportation-related issues** are “messy” and need robust and well-calibrated methodologies in the hands of many agencies and consulting companies

- TRACC provides a **platform that is substantially larger** than existing platforms available to transportation researchers
- TRACC focuses on **calibration and validation** of cutting edge modeling approaches



Current CFD Collaborative and User Projects

- Hydraulic Forces on Bridge Structures and Scour in Floods
 - FHWA Turner Fairbank Highway Research Center (TFHRC)
 - University of Nebraska
 - University of Iowa
 - Argonne National Laboratory
- Investigation of Bridge Pier and Abutment Scour Using Large Eddy Simulation (LES)
 - University of Iowa



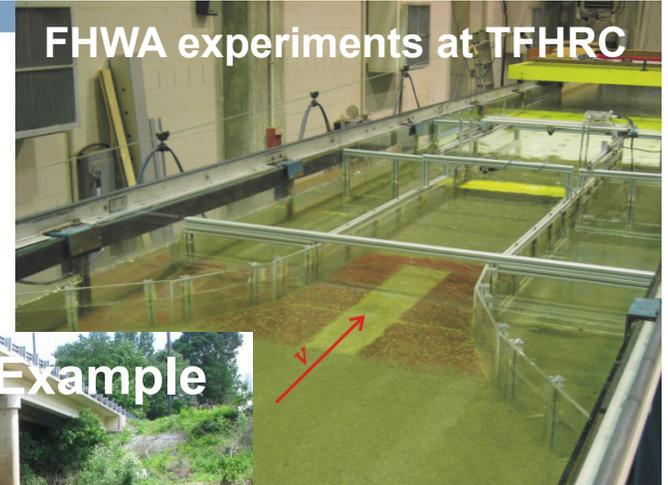
Flow in a scour hole in front of a pier

- Wind Loads on Highway Signs, Traffic Signal Structures, Bridge Cables, others
 - Argonne, TFHRC, University of Iowa
- Salt Spray from Trucks on Weathering Steel Bridges
- Flow and Fish Passage through Culverts
 - TFHRC, Argonne, University of Nebraska

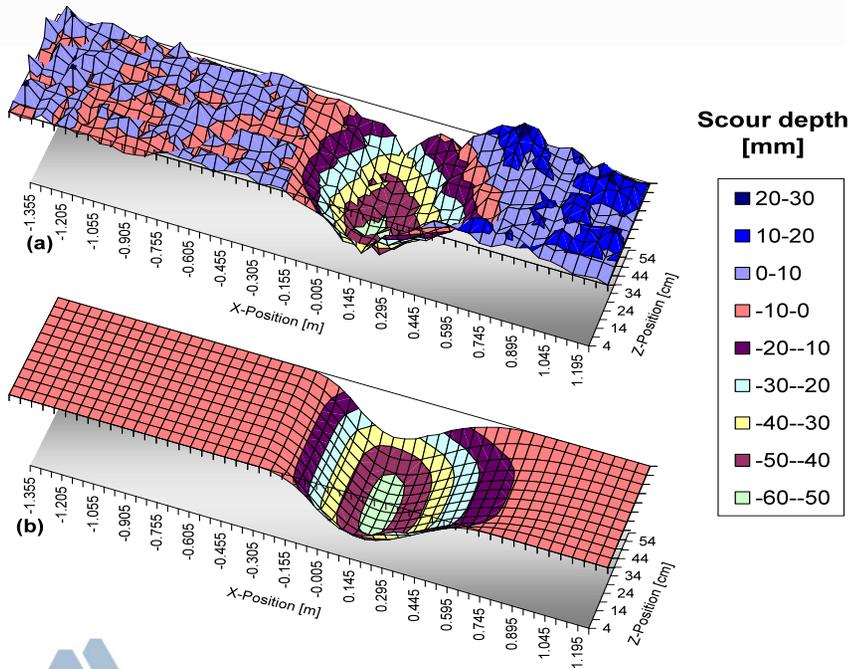
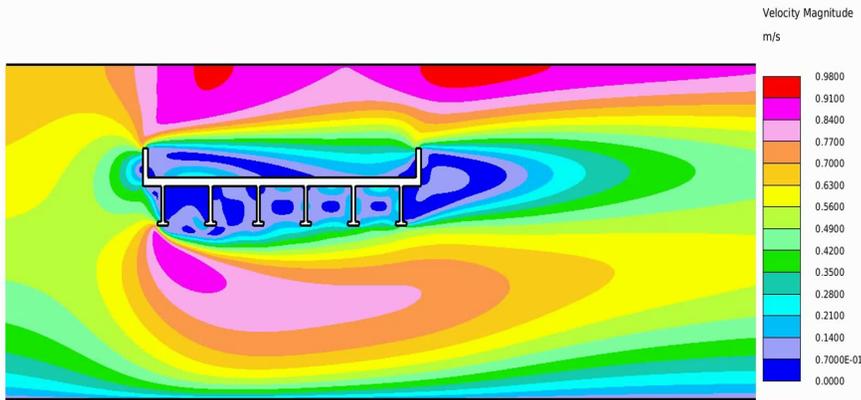


CFD - Turner Fairbank Highway Research Center, NIU, Argonne

FHWA experiments at TFHRC



Real World Example

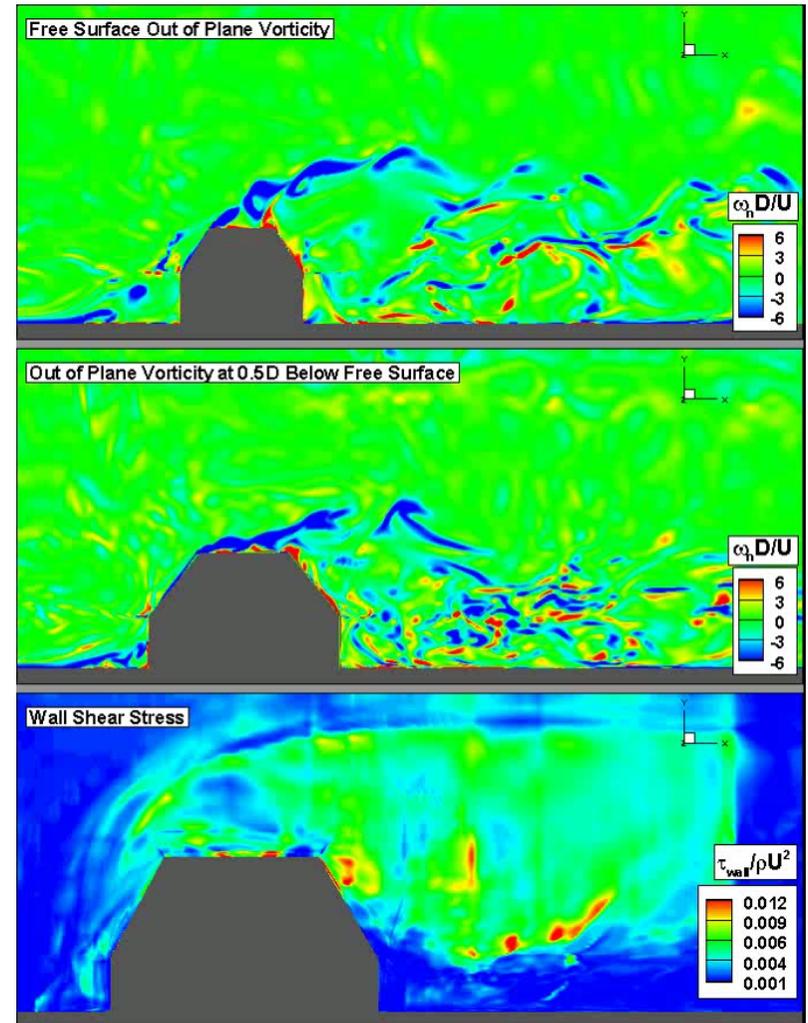
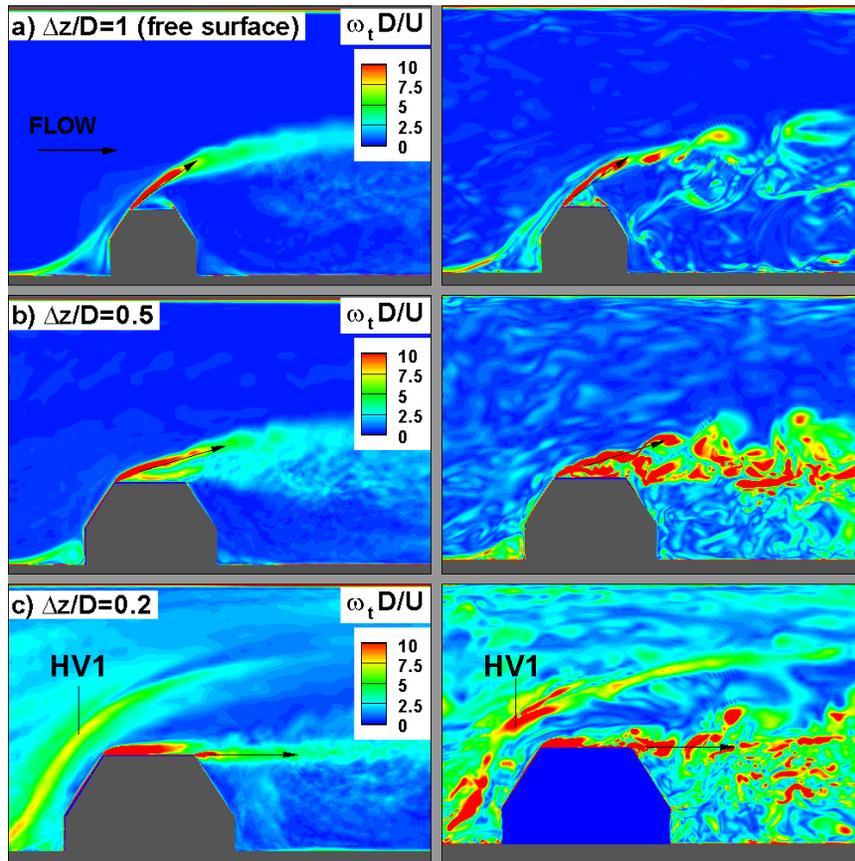


- Formation of scour holes in sediment under bridges during flood events
- Critical shear stress models to model the pickup of sediment and formation of holes
- Calibration of small models and scaling to a wide variety real world geometries
- Development of improved engineering guidelines for bridge inspectors and regulators

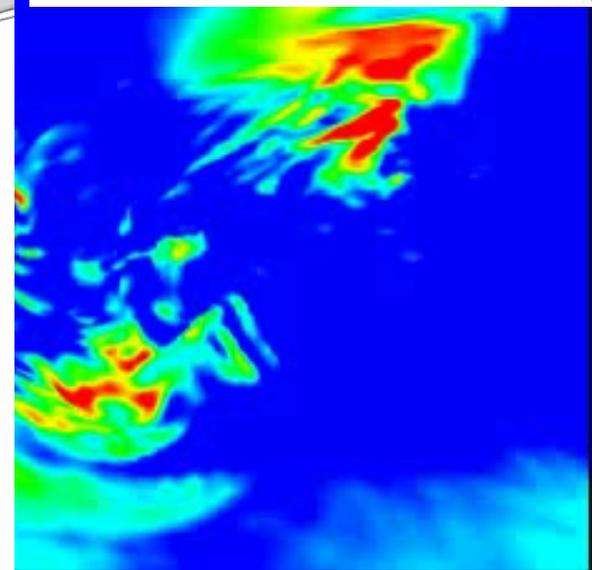
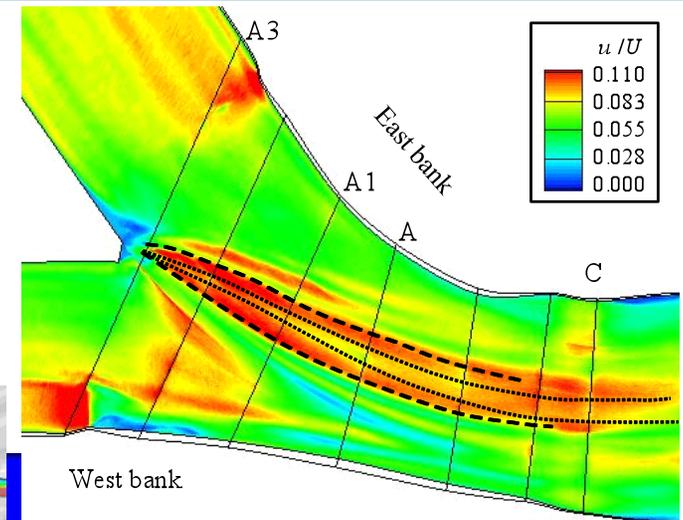
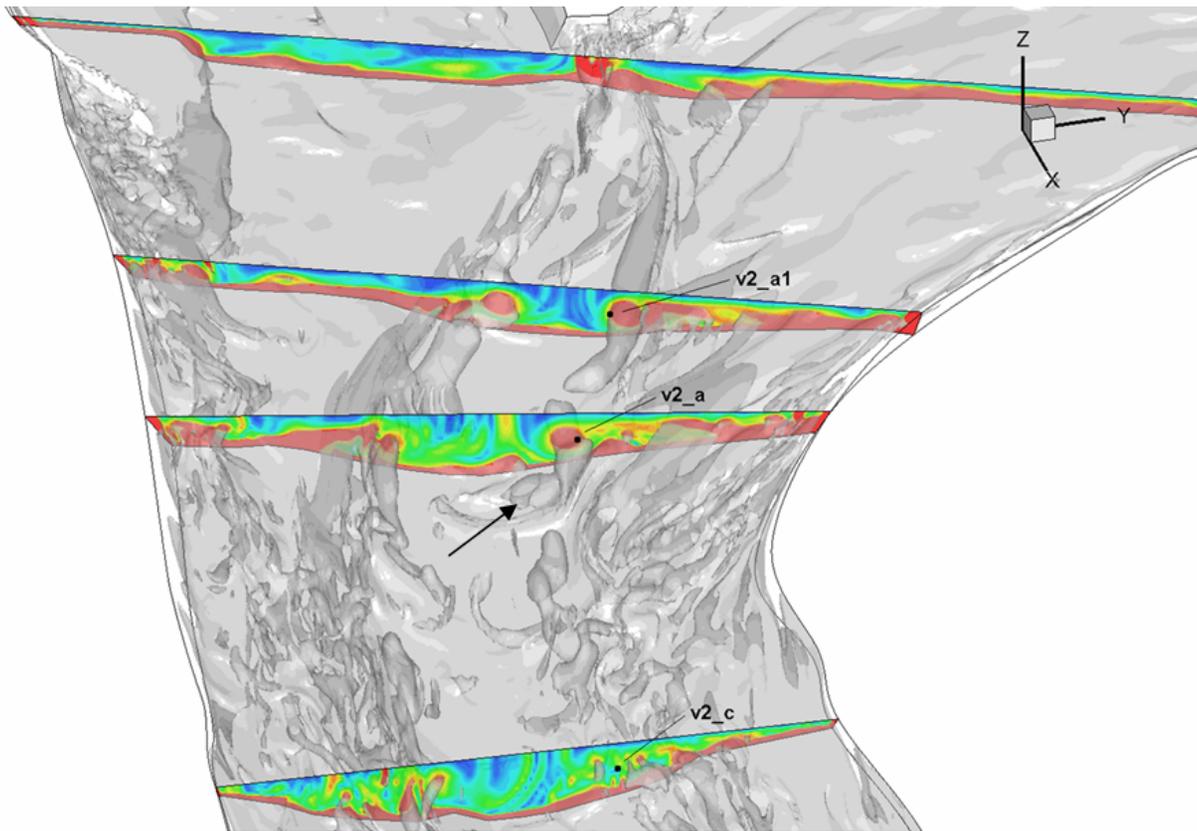


Cutting Edge CFD Analysis Platform at TRACC for Cluster Users

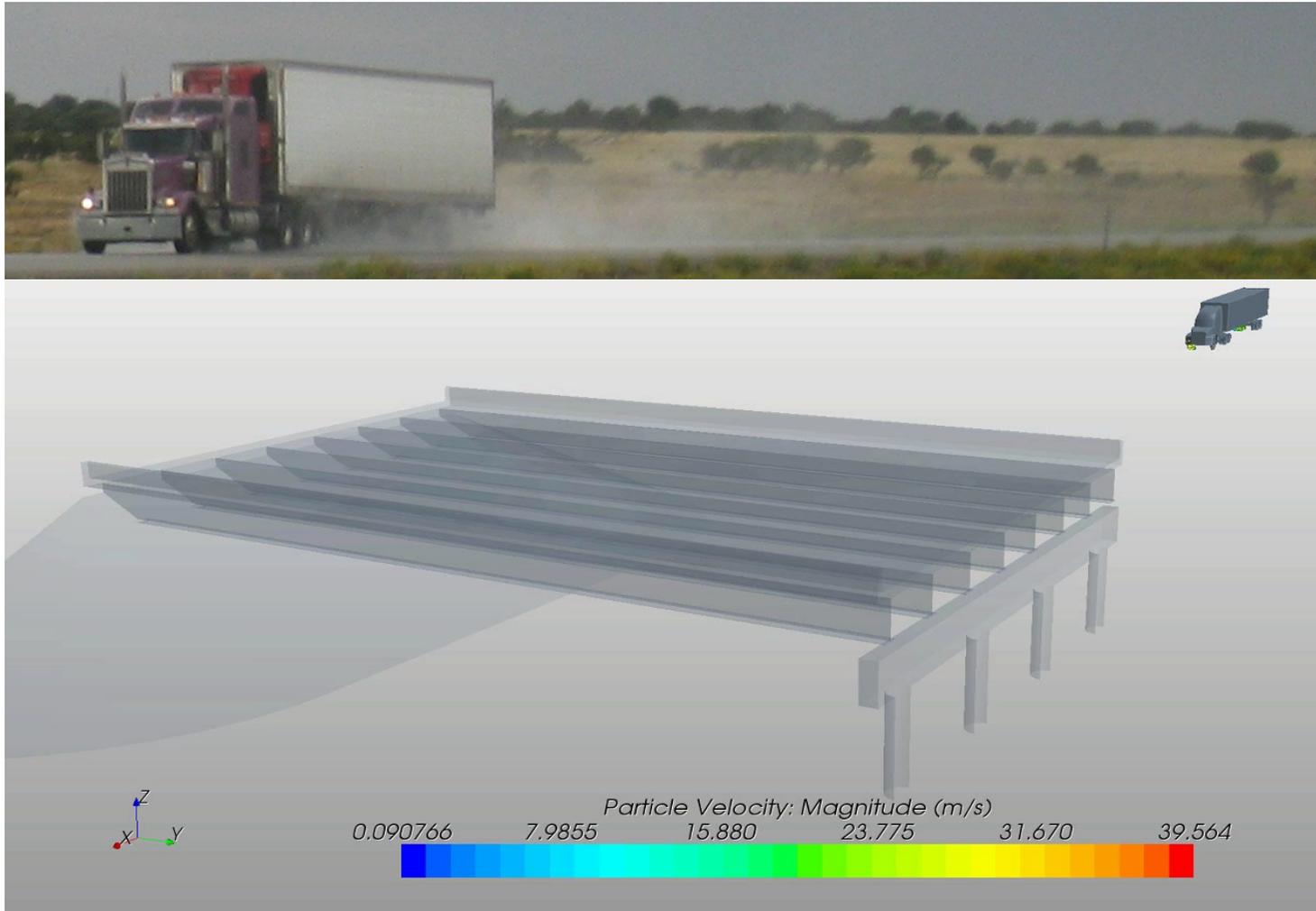
TRACC is providing a platform for cutting edge analysis, such as large eddy simulation, to provide much more detailed analysis results from CFD software in the transportation research area



CFD Examples from TRACC's Cluster Users



Computer Modeling and Analysis of Truck Generated Salt Spray under Bridges



Computational Structural Mechanics for Transportation Applications



In cooperation with the U.S. Department of Transportation

Computational Structural Mechanics Areas of Application

- TRACC's expertise:
 - Transportation Structures:
 - Analyzing extreme loadings on bridges (wind, earthquake, blast)
 - Stability of bridges in flood conditions using multi-physics approach
 - Vehicle Crashworthiness:
 - Supporting several crash related research projects
 - Fluid-Structure Interaction:
 - Analysis of transient deformations of structures resulting from action of surrounding fluid

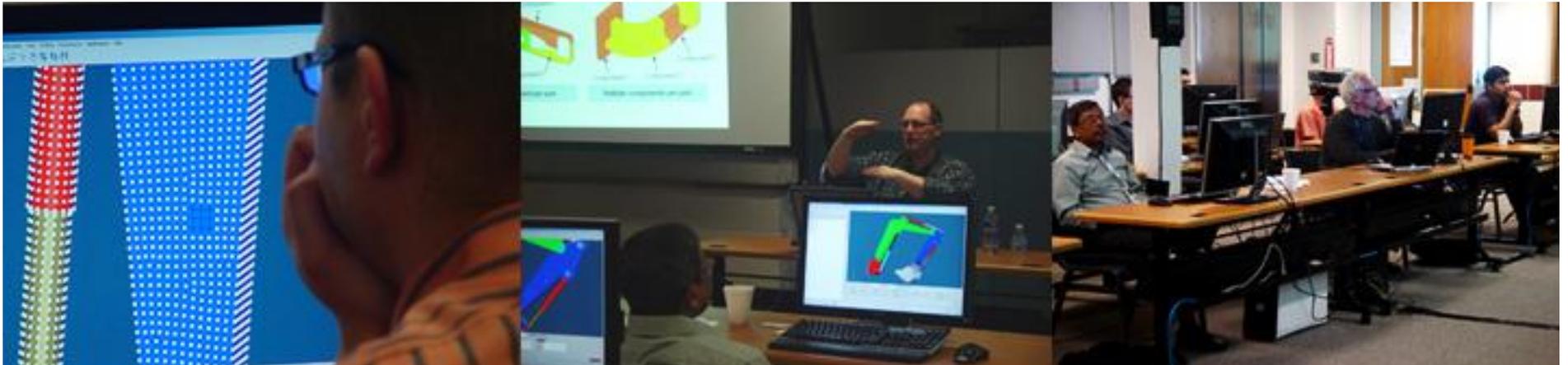
- TRACC's current users:
 - National Highway Traffic Safety Administration (NHTSA) - occupant safety assessment and crash biomechanics
 - University of Virginia - crash biomechanics
 - Florida State University - bus crashworthiness analysis



CSM Training Courses

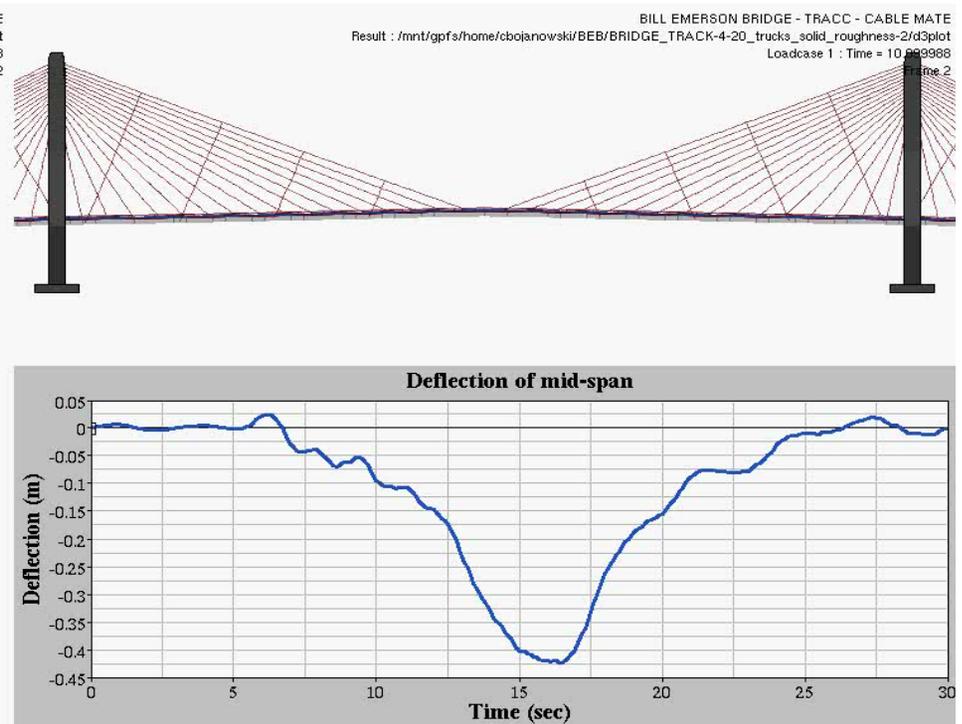
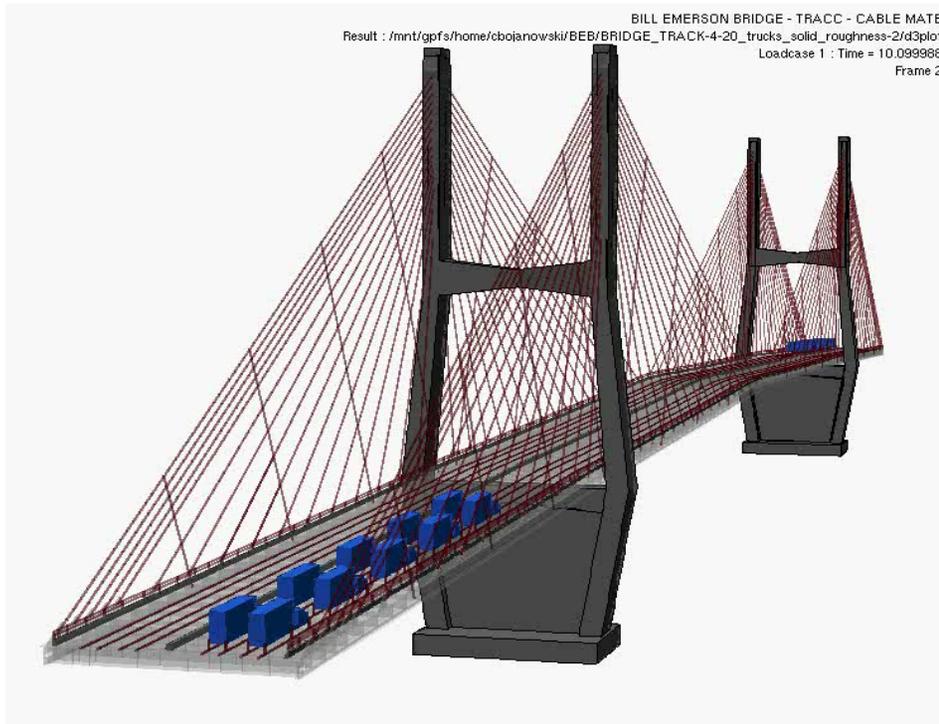
- An Introduction to LS-DYNA (L. Schwer, November 2008)
- Using LS-OPT on the TRACC Cluster (C. Bojanowski, January 2010) **
- Developing Compute-efficient, Quality Models with LS-PrePost 3 on the TRACC Cluster (C. Bojanowski, October 2010) **
- Introduction to Hypermesh and Hyperview (Altair Engineering, April 2011) **
- Modeling and Simulation with LS-DYNA: Insights into Modeling with a Goal of Providing Credible Predictive Simulations (P. DuBois and L. Schwer, February 2010)

** Available online: <http://www.anl.gov/TRACC/Training/CSM/index.html>



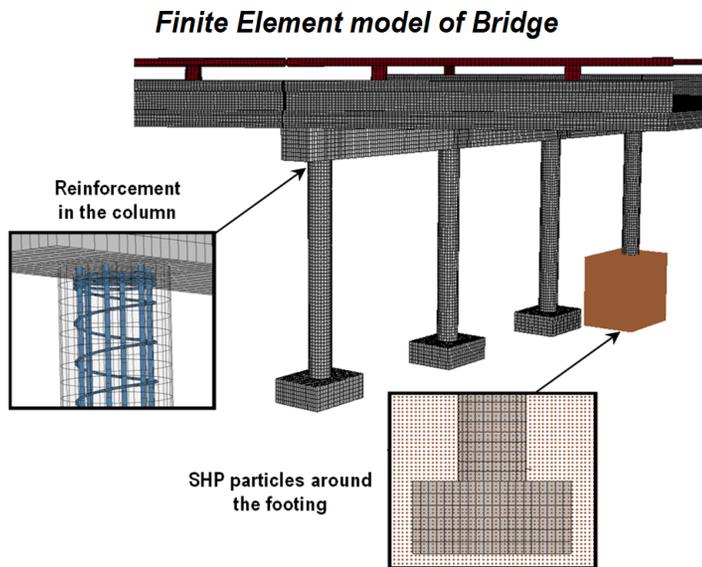
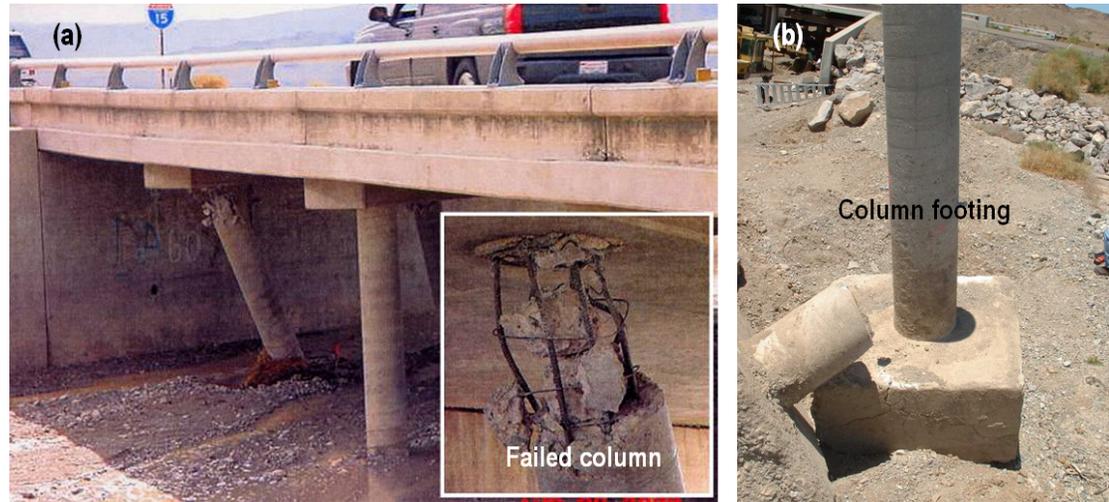
TRACC: Multi-purpose high fidelity bridge models

- Integrated analysis
- Traffic load on bridges
- Wind forces on deck and cables
- Dynamic interaction with vehicles

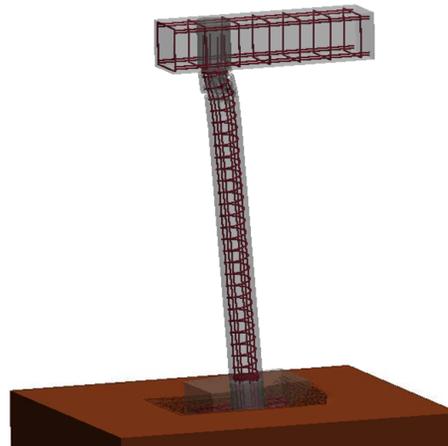


TRACC: Soil-Structure Interaction Example

- Develop simulation capabilities for modeling bridge pier failure during riverbed scour that occurs during flash floods



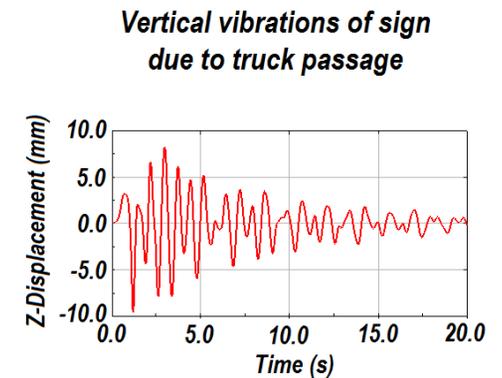
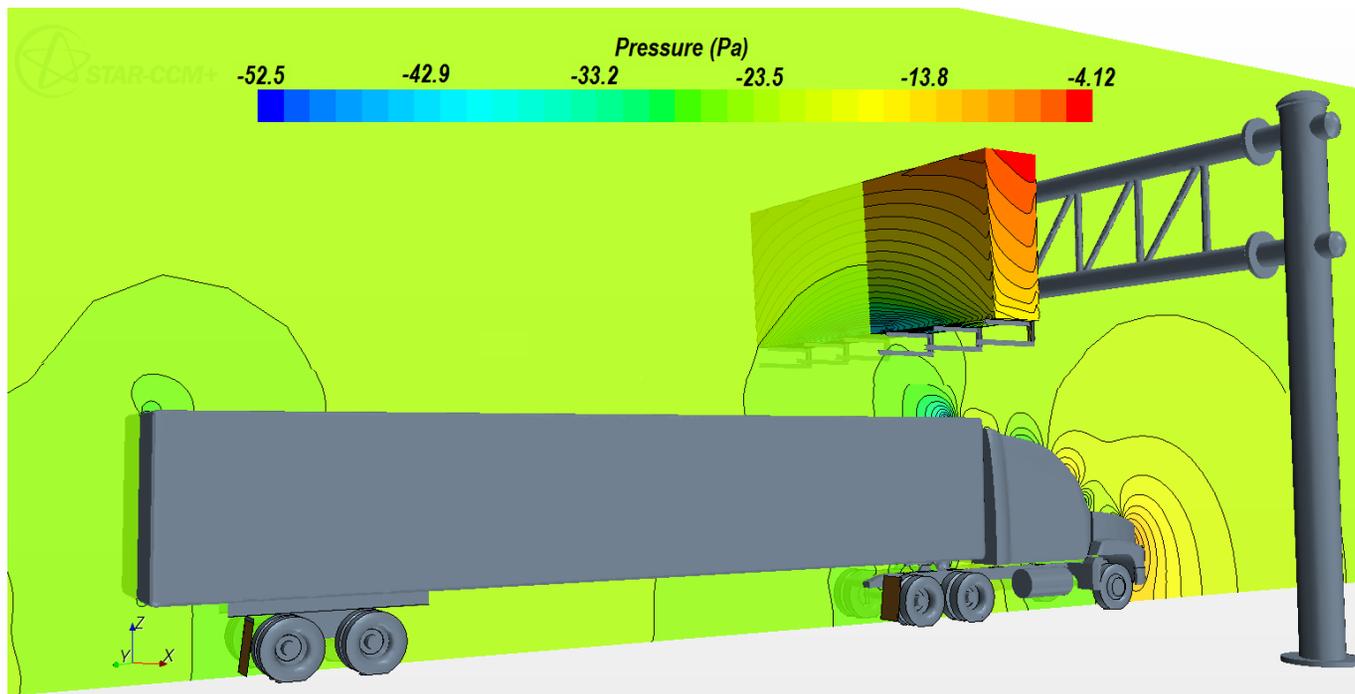
Failed column due to lateral load



- Use hybrid formulations (Lagrangian plus Smooth Particle Hydrodynamic) to simulate the failure of a bridge pier to hydraulic loading during flood events
- Soil-structure interaction treatment with large deformations

TRACC: Road Sign vibration due to truck passage CFD and CSM coupling example

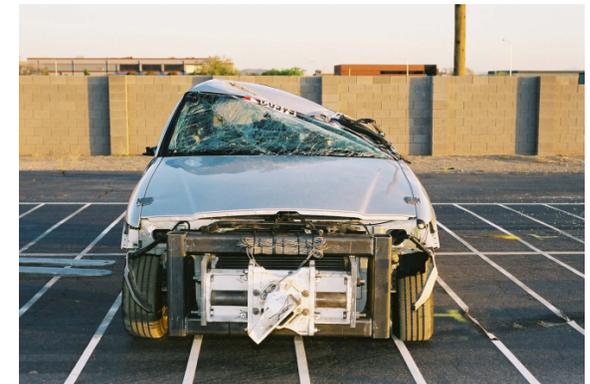
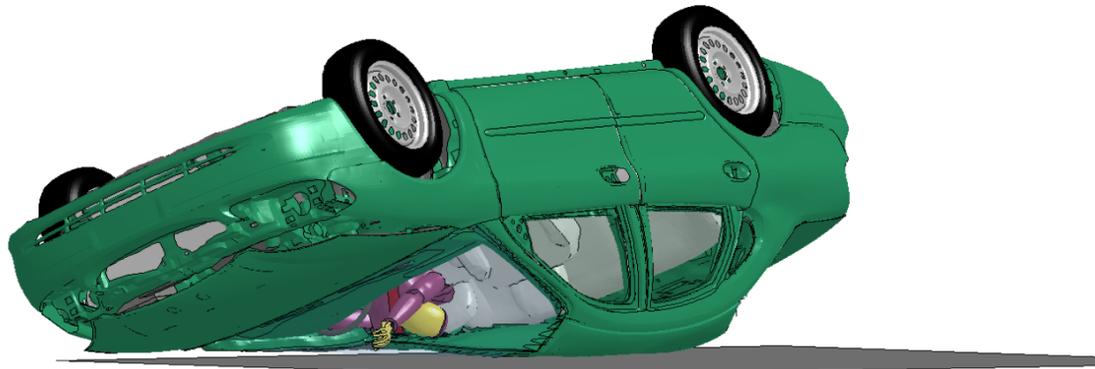
- Developing coupling methods between STAR-CCM+ (fluid mechanics code) and LS-DYNA (structural code) for fluid-structure interaction (FSI) problems
- Analyze transient vibration of signs due to the passage of trucks



TRACC Users' work: NHTSA - Controlled Rollover Impact System

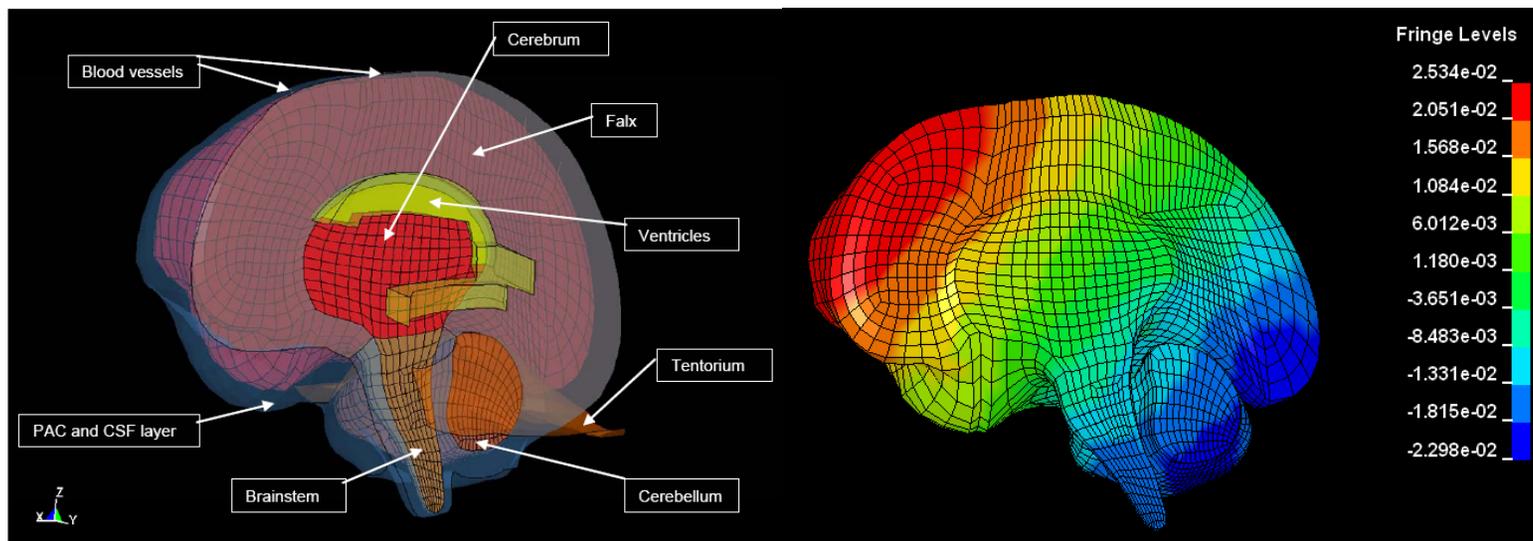
- CRIS provides a repeatable test technique for evaluating roof-to-ground impact in a vehicle rollover event
- NHTSA is using TRACC resources to supplement expensive experiments with multiple crashworthiness simulations

THOR dummy inside Ford Taurus FE model



TRACC Users' work: NHTSA - Traumatic Brain Injury (TBI)

- Motor vehicle crashes remain one of the major causes of TBI in the US only second to falls.
- Finite element models have proven to be viable tools to better understand the biomechanics of TBI.
- Probabilistic analyses are being performed to identify important random variables and their effect on response distributions.
- Defining Characteristic: Small FE model, short compute time but hundreds of runs.



Computing, Networking, and Training and Collaborative Facilities



In cooperation with the U.S. Department of Transportation

TRACC High-Performance Cluster Computers



Zephyr

Item/Cluster	Zephyr	Phoenix
Nodes	92	128
Processors per node	2	2
Total Processors	184	256
Processor Type	AMD 6273, 16 core, 2.3 GHz	AMD 2378, quad core, 2.4 GHz
Cores per Processor	16 (8 modules each capable of executing 2 integer or 2 floating point operation)	4 cores each capable of executing 1 integer or 1 floating point operation
Total Cores	2944	1024
RAM per node	88 nodes at 32 GB, 2 at 64 GB, & 2 at 128 GB	124 nodes at 8 GB and 4 at 32 GB
RAM Speed	1600 MHz	667 MHz
Disk storage per node	One TB	200 GB
Login Nodes	2	3
Administrative Nodes	2	2
Application Node (Sandbox)	1	0
Statistics Gathering Node	1	1
I/O Nodes	1	4
Ethernet Interconnect	Gig-E/Dual 10 Gig uplink	Gig-E/Dual 10 Gig Uplink
Infiniband Interconnect	QDR 40 Gbps	DDR 20 Gbps
File System Usable Storage	Lustre-based, 120 TB/RAID6 storage	GPFS-based, 90TB formatted capacity
OS	CentOS/Linux 6.2	Red Hat Enterprise Linux 4.8
Tape Storage and Backup	Shared 160 TB Tape Library	

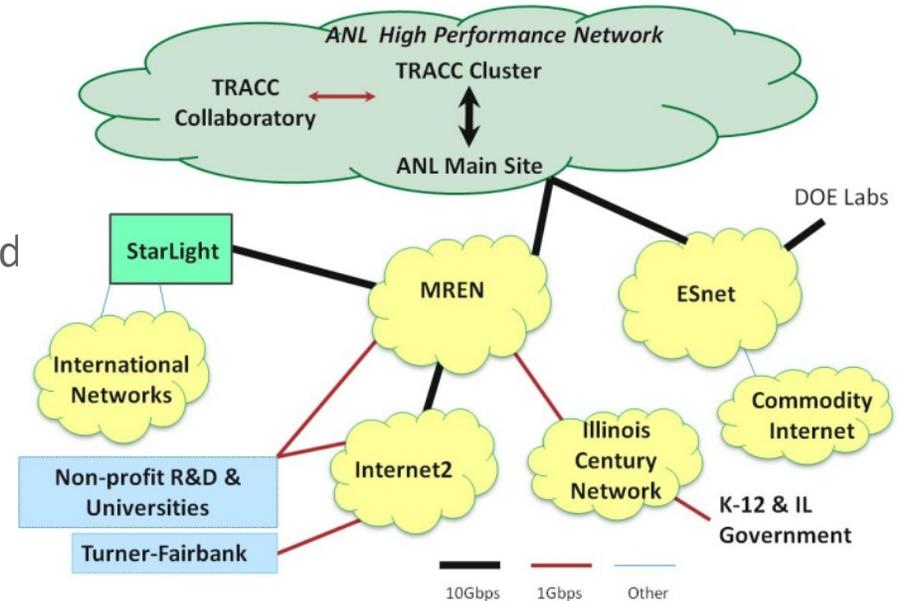


Phoenix



TRACC Network Connectivity

- TRACC is a part of the Argonne advanced fiber optic-based network



- TRACC, via the Argonne network, has network access to university, federal, state and local, and commercial transportation research centers world-wide via:
 - The Department of Energy network (ESnet)
 - The Metropolitan Research and Education Network (MREN)
 - The research and education network, Internet2
 - StarLight, an international network connection point



TRACC Training and Collaboration Facilities

Collaborative conferences, meetings and training with geographically distributed participants utilizing:

- High-speed network access to global research and education networks
- Video Teleconference systems
 - Web conferencing
 - High-Definition multi-point video and data sharing
- Large (60 person) Demonstration and Collaborative Training area
- Multimedia and Videoconferencing enabled conference room
- Two units, each capable of providing eight-site videoconferences





The TRACC Team



- Management
 - Hubert Ley (Director), Penny Kolpacki
- Operations
 - Larry Amiot, Joe Reitzer
- System Administration
 - Waldemar Nowakowski, Bob Schmitt
- Current Targeted Technical Disciplines
 - *Structural Mechanics*
 - Cezary Bojanowski
 - *Fluid Dynamics, Aerodynamics*
 - Steve Lottes,
 - *High Fidelity Transportation Simulations*
 - Vadim Sokolov, Michael Hope, Kuilin Zhang, Joshua Auld, Bei Zhou, Bo Xu

- Key USDOT Partners
 - Federal Highway Administration (FHWA)
 - Office of Planning (OoP)
 - Turner-Fairbank Highway Research Center (TFHRC)
 - National Highway Traffic Safety Administration (NHTSA)

