A Comprehensive Simulation-Based Framework for Design of Army Ground Vehicles

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2007 SAE World Conference

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Report Documentation Page

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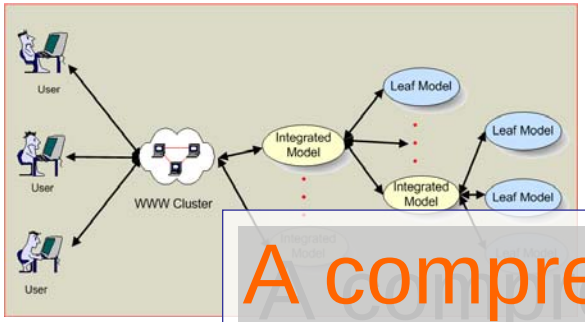
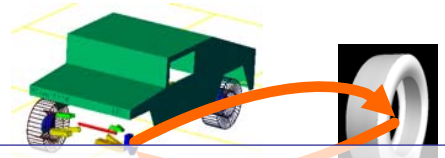
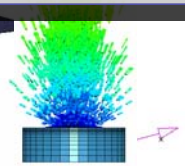
Presentation Overview



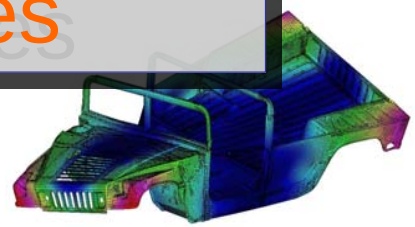
Distributed Simulation & Design Platform (DSDP)



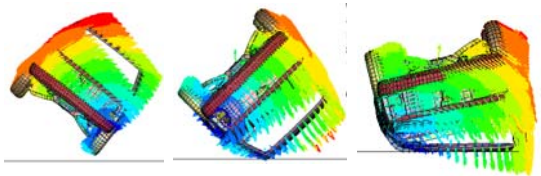
A comprehensive framework for supporting analysis and design of Army's current and next generations of tactical vehicles



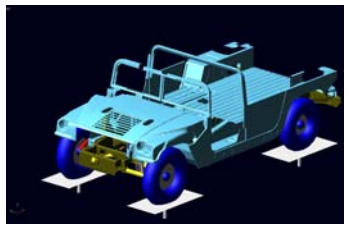
Blast



Durability and Ride

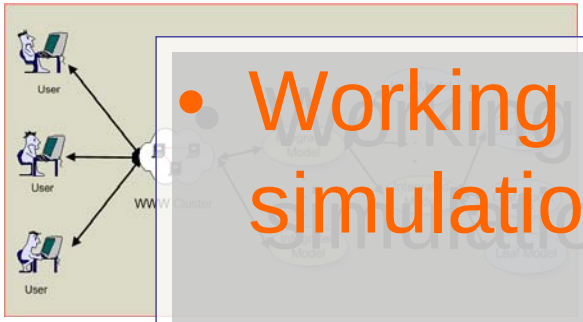


Crash

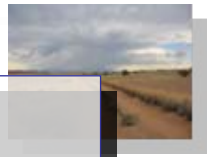


Rollover

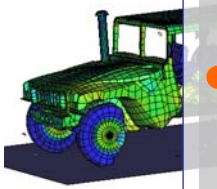
Presentation Overview



Distributed Simulation & Design Platform (D-Sim)



Tire-Terrain Interaction



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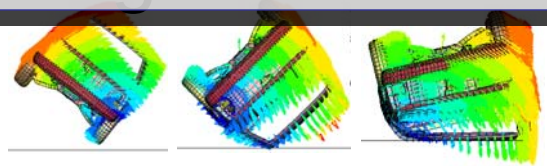
- Working capability for distributed simulation across multiple domains
- New modeling capability for rapid configuration of HMMWV variants
- New modeling techniques for accurate, efficient simulation and design



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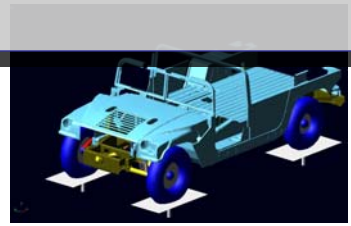


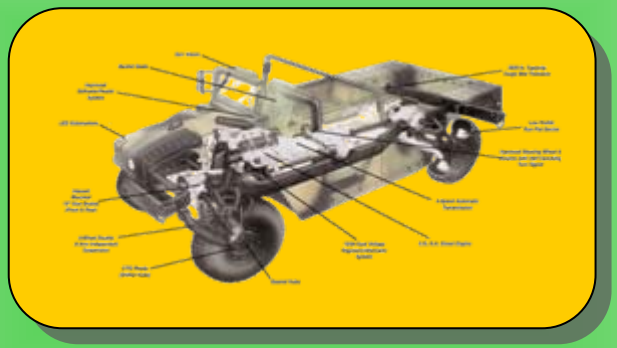
Rollover

Durability and Ride

Research Objectives

- Develop an integrated simulation and design capability to support:
  - Modularized product development of current and future vehicle families

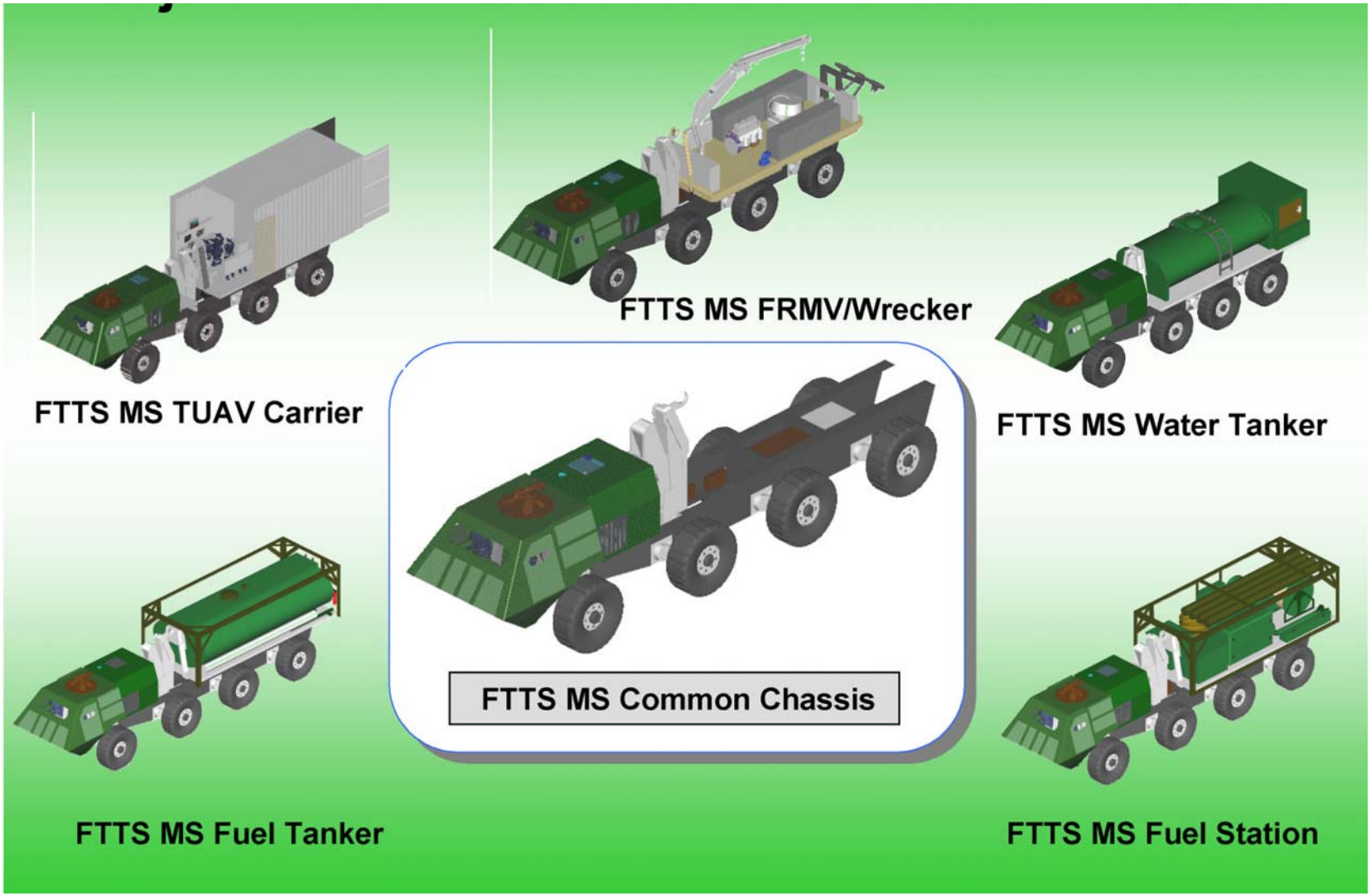
The HMMWV Family



Research Objectives

- Develop an integrated simulation and design capability to support:
  - Modularized product development of current and future vehicle families
  - Innovative vehicle concepts in support of Army transformation

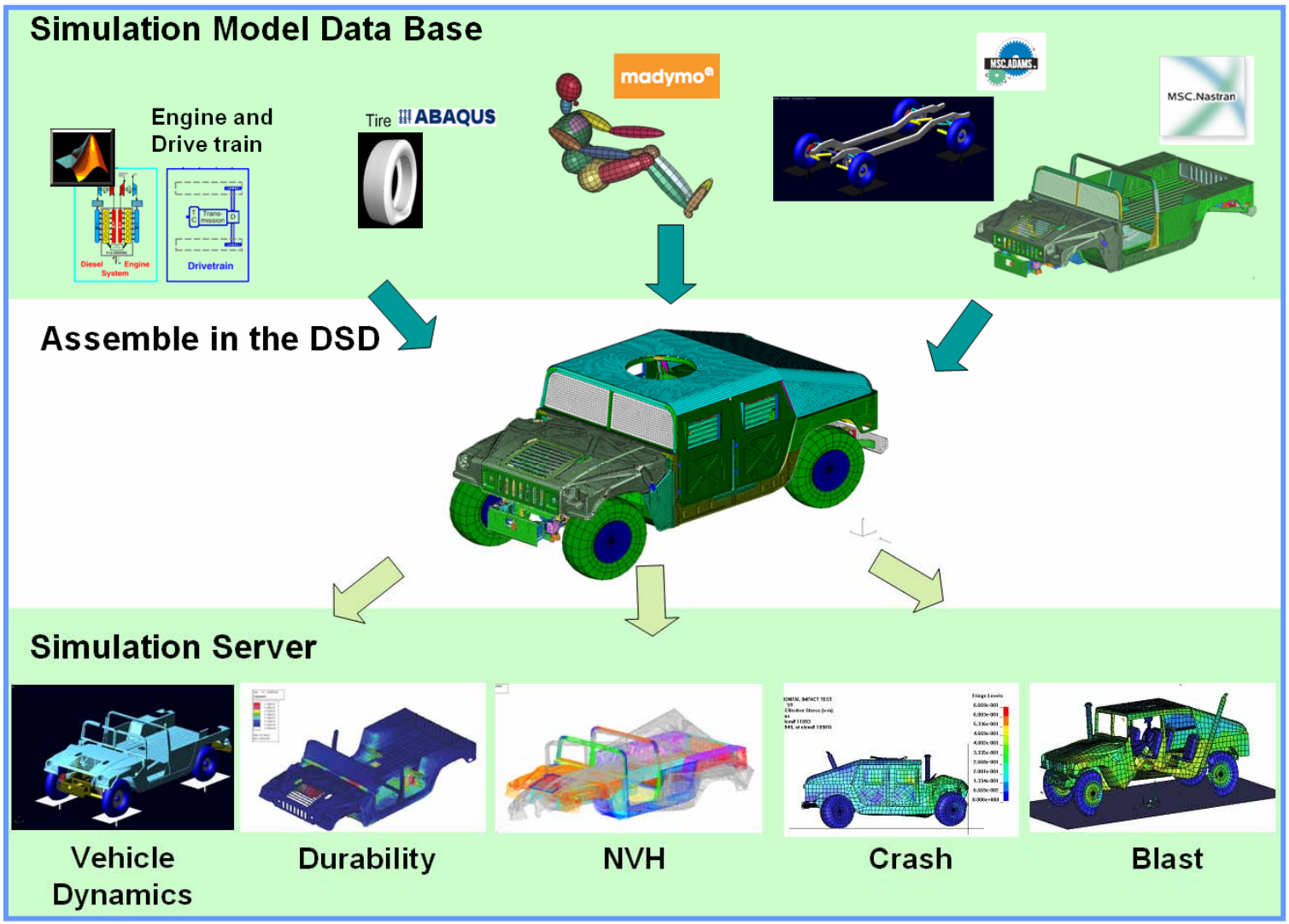
Future Tactical Truck System



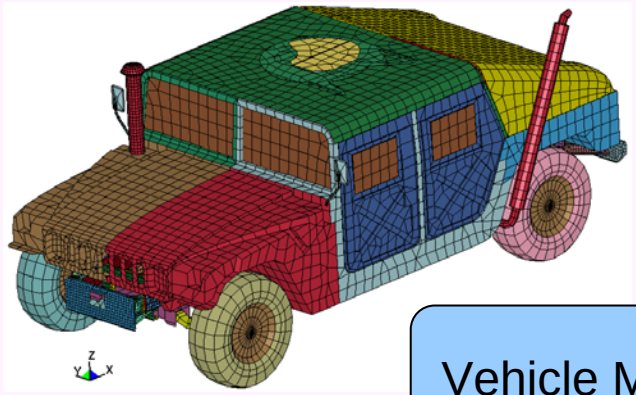
Research Objectives

- Develop an integrated simulation and design capability to support:
  - Modularized product development of current and future vehicle families
  - Innovative vehicle concepts in support of Army transformation
  - Efficient integration of distributed models, simulation codes, and new design methodologies for commercial and military applications

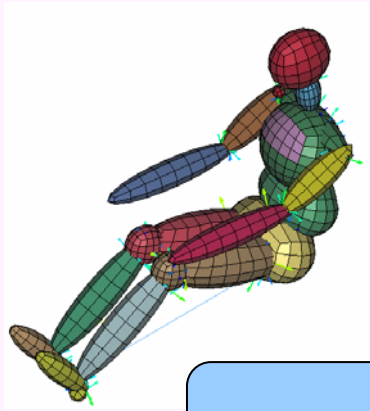
Vision of Distributed Simulation and Design



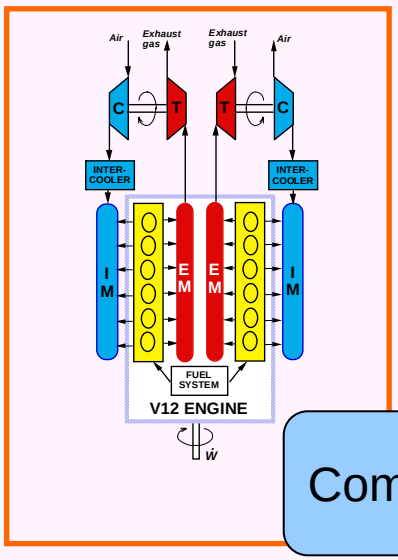
Requirement: Multi-Domain Simulation



Vehicle Model

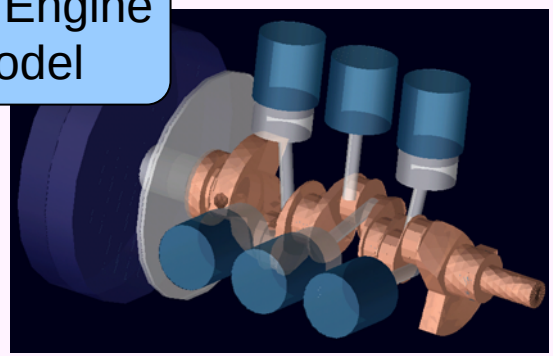


Human Model

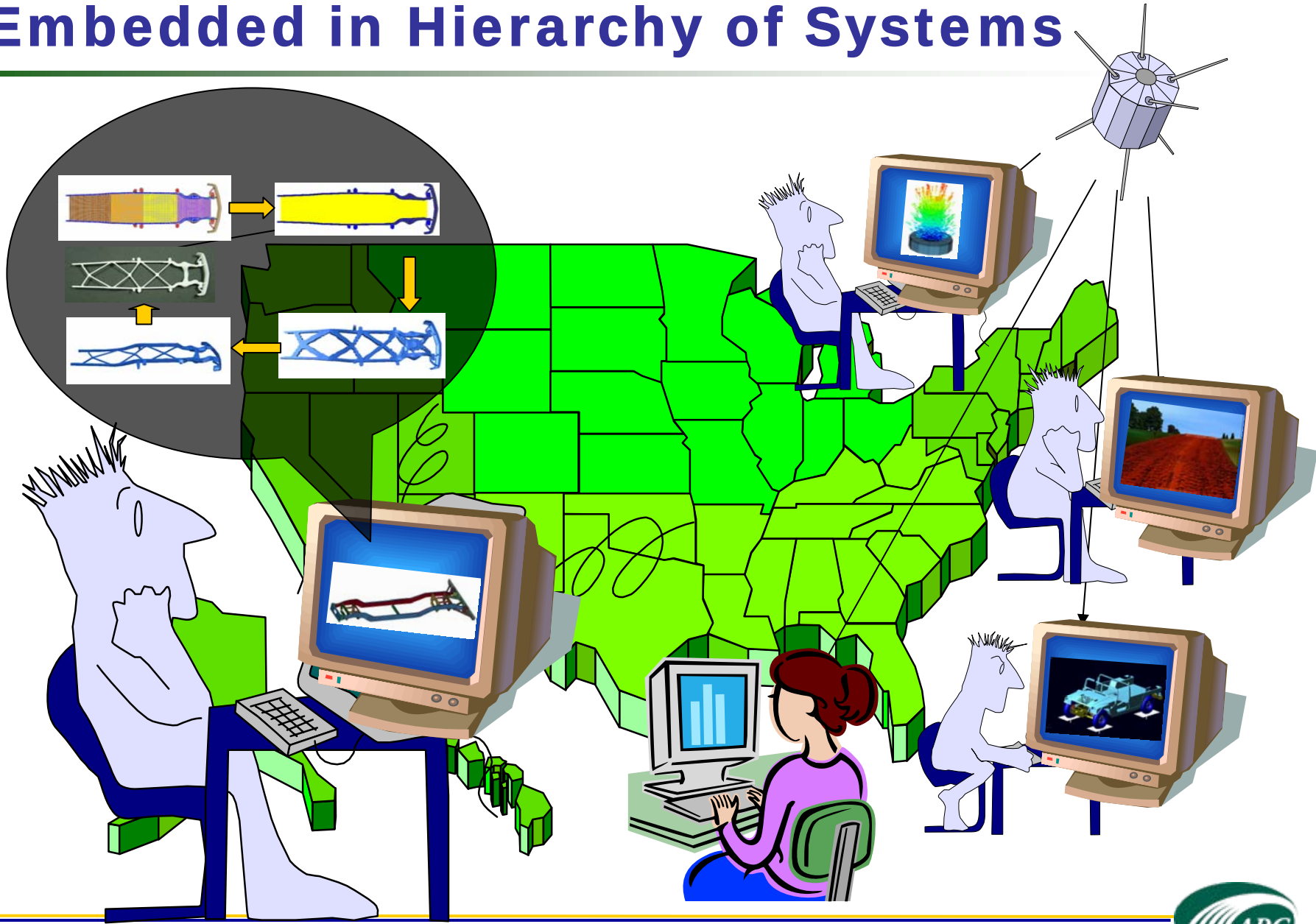


Combustion Model

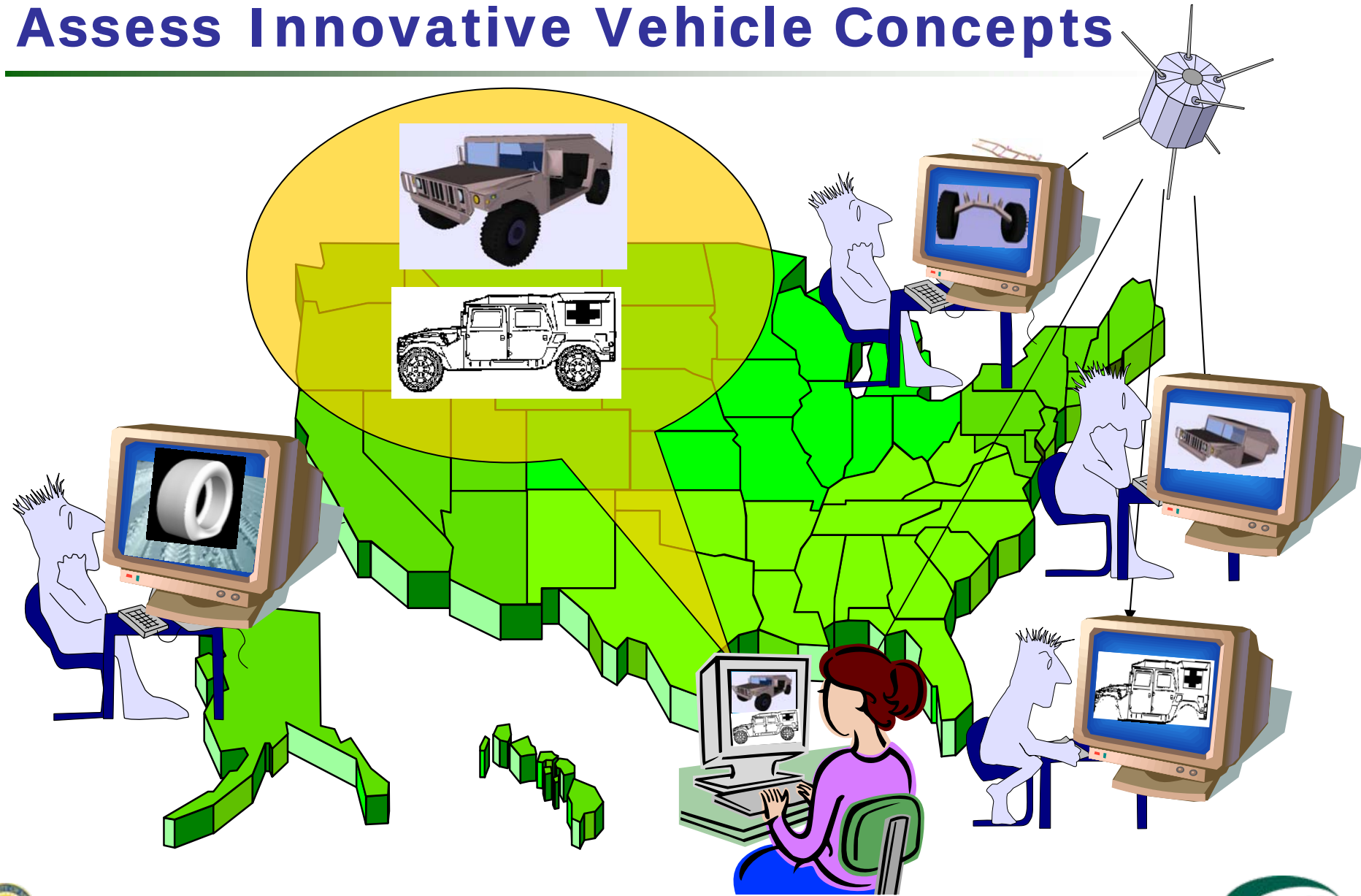
MBD Engine Model



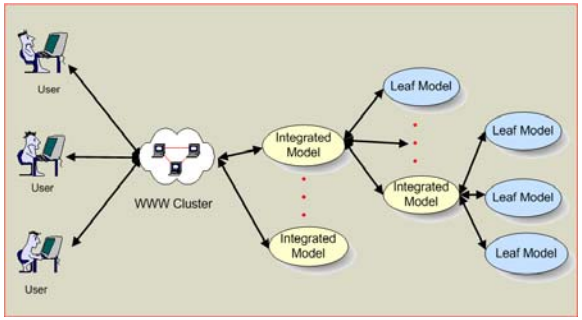
Requirement: Subsystem Design Embedded in Hierarchy of Systems

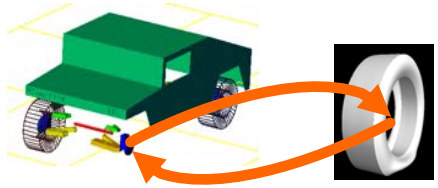


Requirement: Rapid Configuration to Assess Innovative Vehicle Concepts



Overview





Tire-Terrain Interaction

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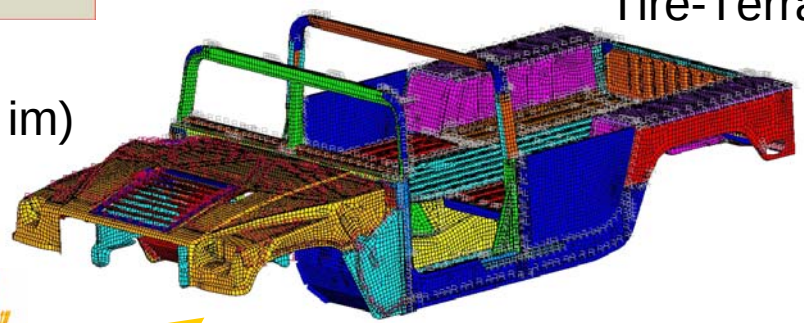
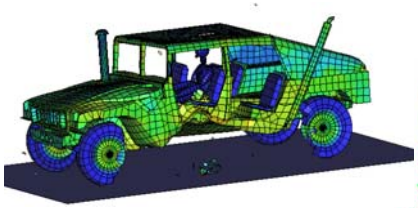
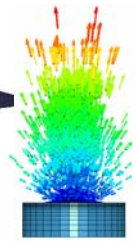
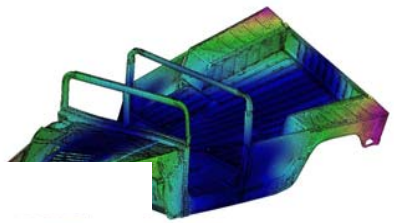




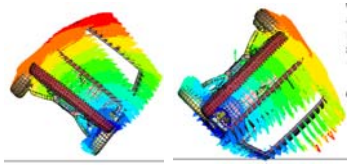
Blast

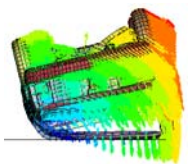


Distributed Simulation & Design Platform (D-Sim)



Durability and Ride



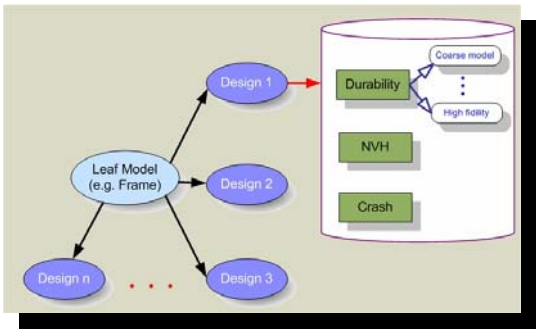


Crash

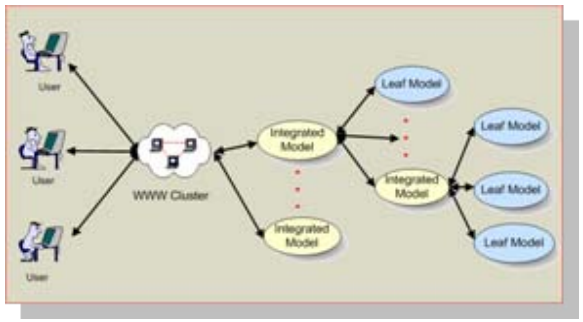
Rollover

Major Components of D-Sim

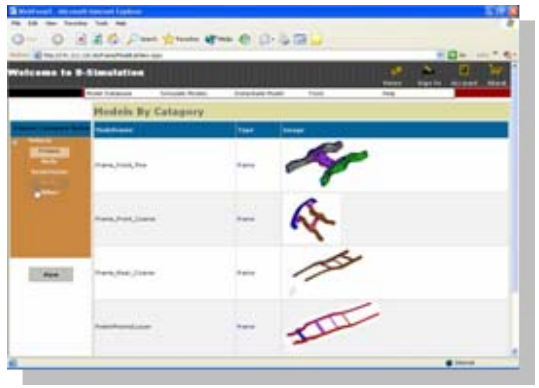
Model Database

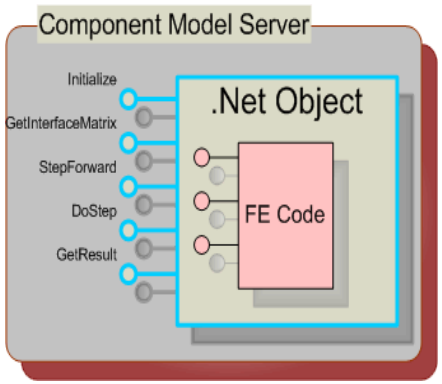


Distributed Architecture

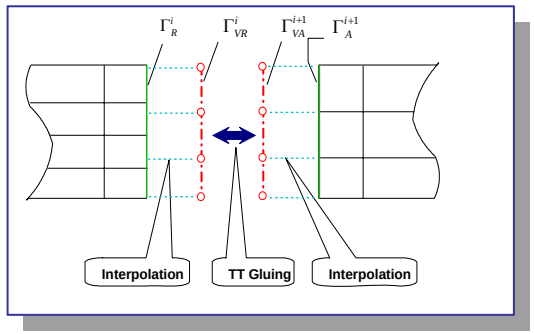


Web-based Interface

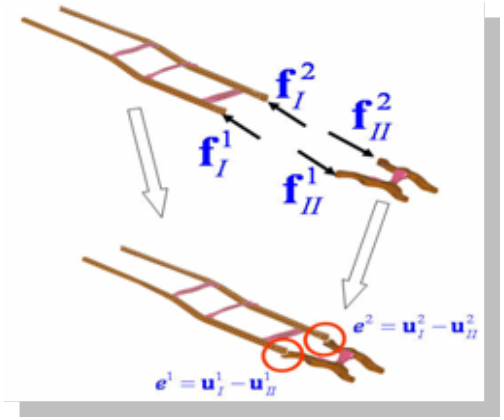




Simulation Code Wrapper



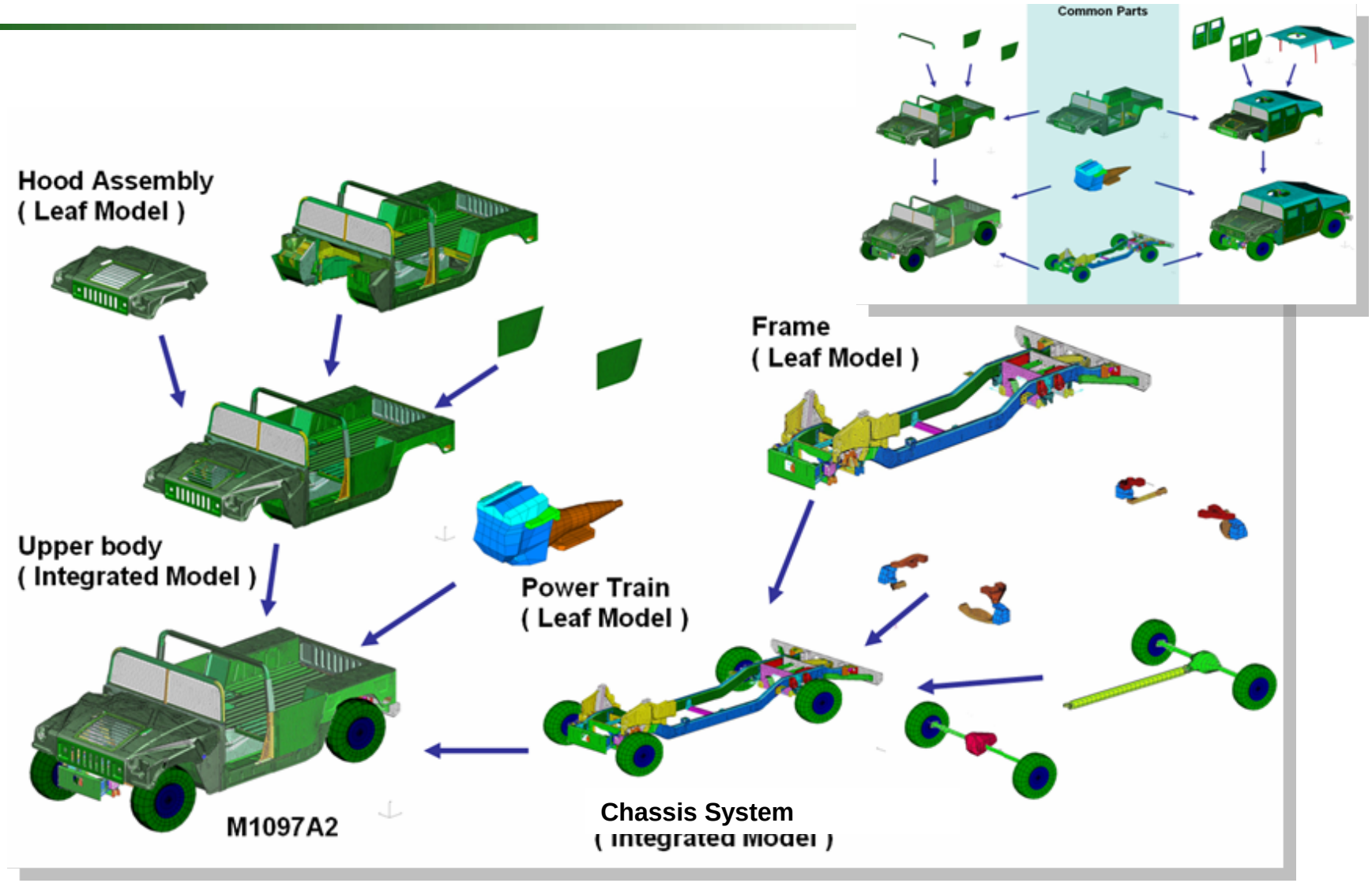
Non-matching Interfaces



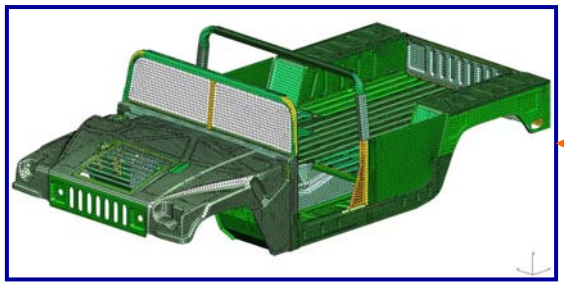
Gluing Algorithm

Collection of HMMWV Subsystem Models

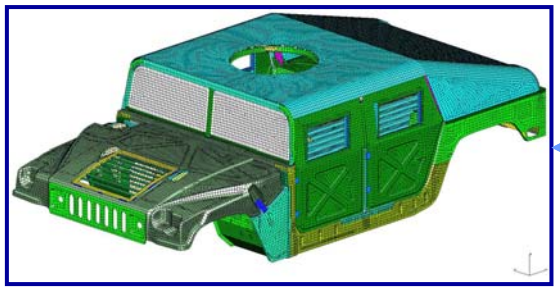
Integrated Systems Approach



Rapid Configuration of Different Vehicles



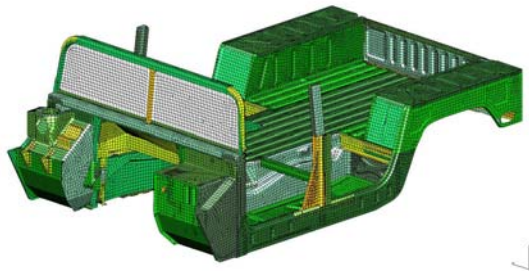
M1097A2 UPPER BODY



M1025 UPPER BODY

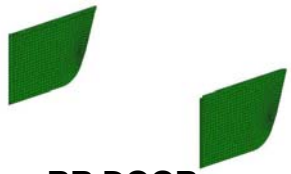
Common Parts

HOOD ASSEMBLY



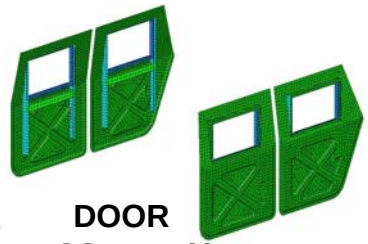
HMMWV BASE UPPER BODY

B-PILLAR
CROSS MEBER



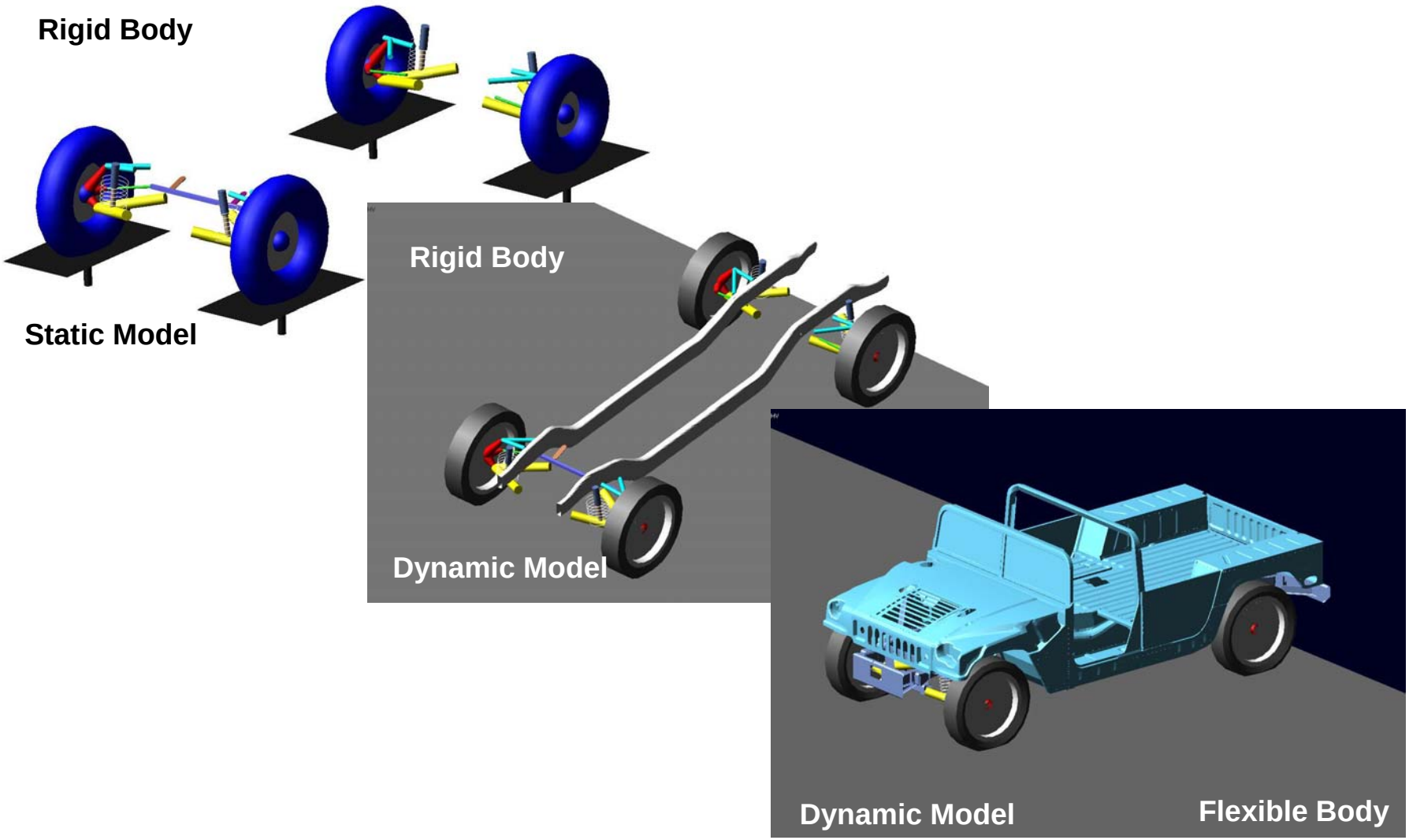
RR DOOR

ROOF ASSEMBLY



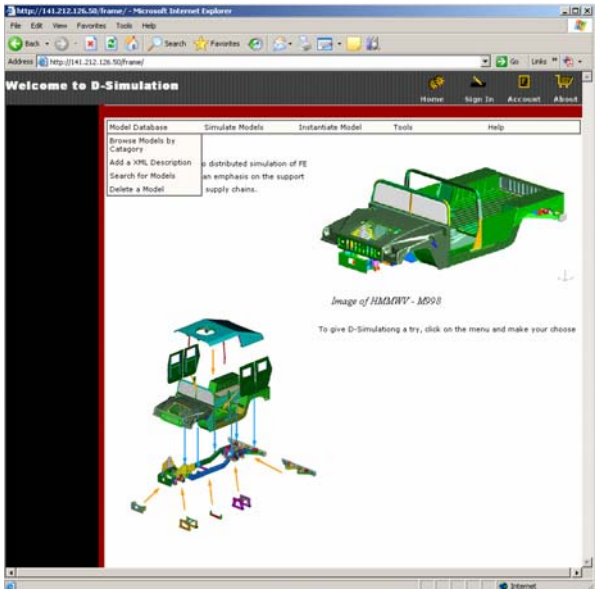
DOOR
ASSEMBLY

Rapid Substitution of Different Fidelity Models

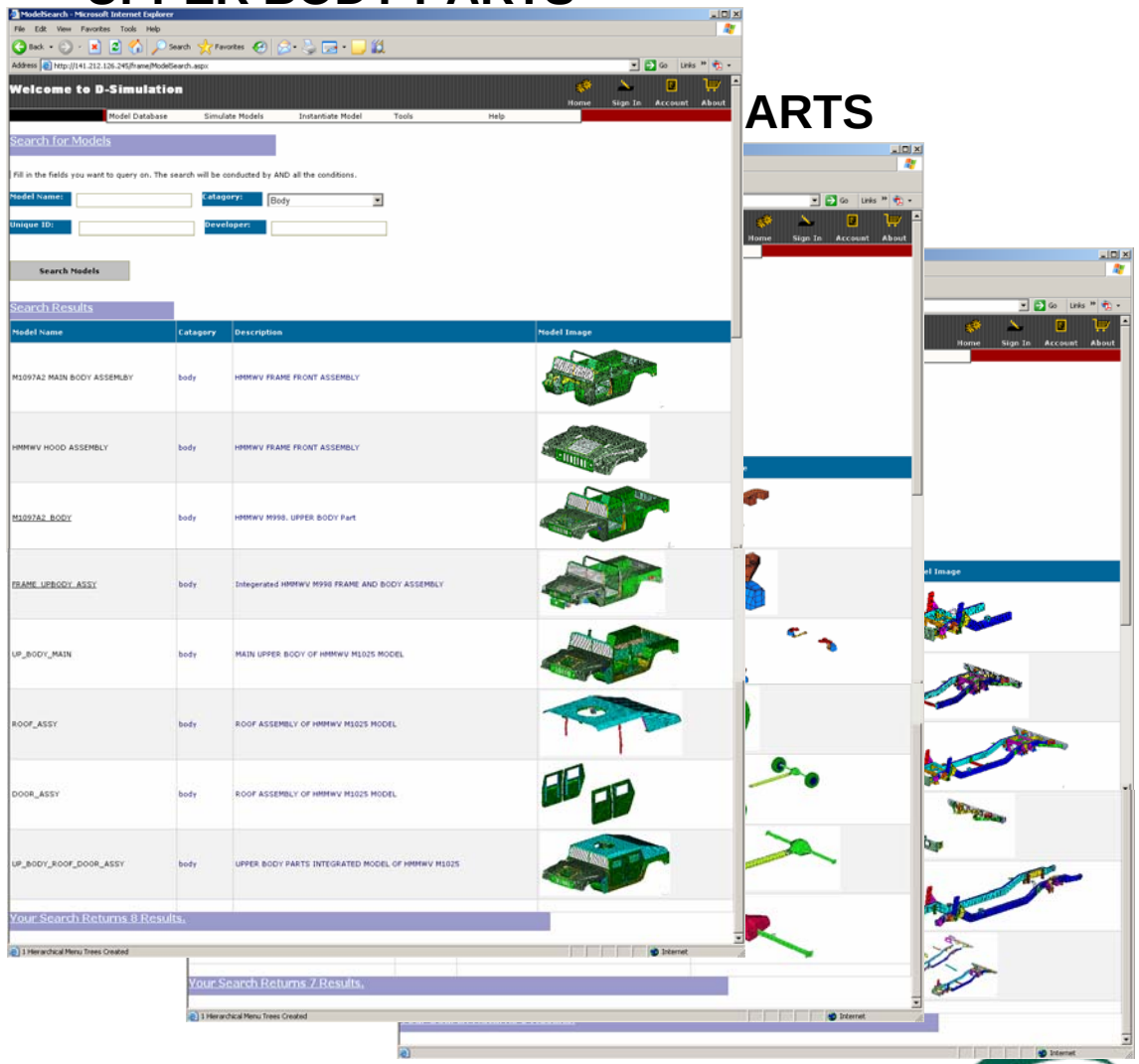


Web-Based Interface

Main Web Page for D-Simulation



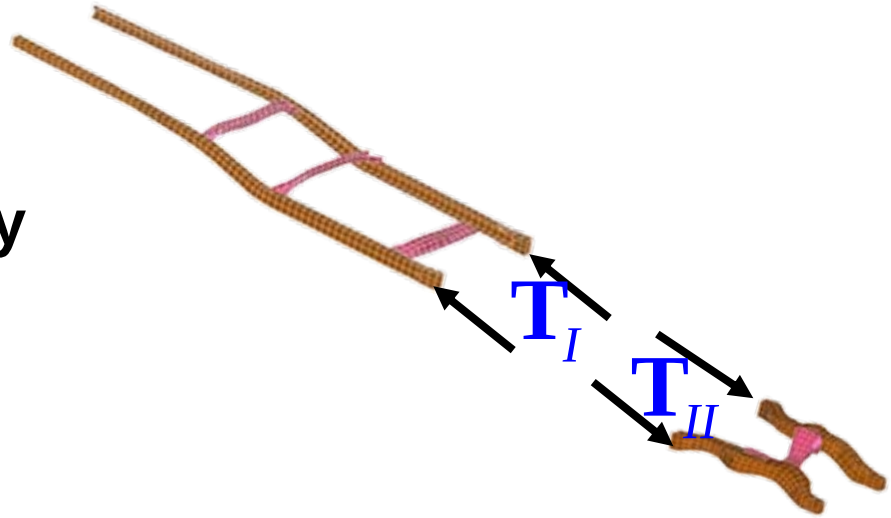
UPPER BODY PARTS

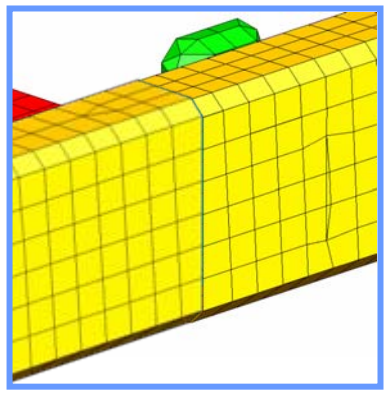


- Search multi-layered model database
- Define interfaces for model integration
- Generate new distributed simulation and design models

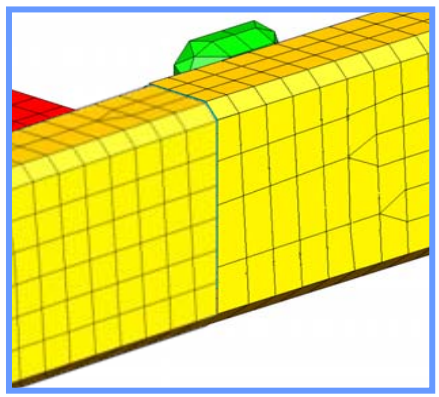
Gluing Algorithm and Non-Matching Interfaces

- Enables multi-platform, multi-layered plug and play capability
- Standardizes model interfacing
- Protects proprietary data / models



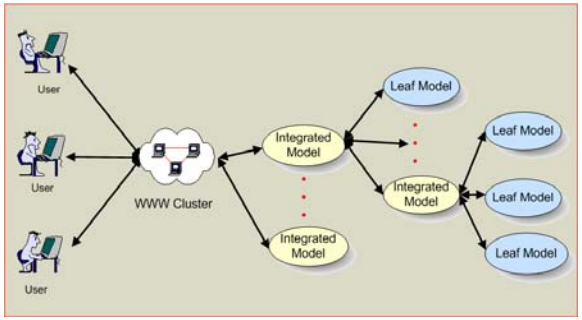


Matching

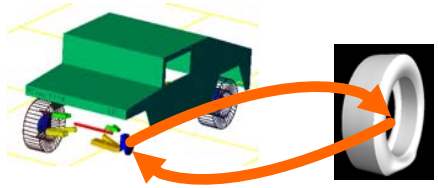


Non-Matching

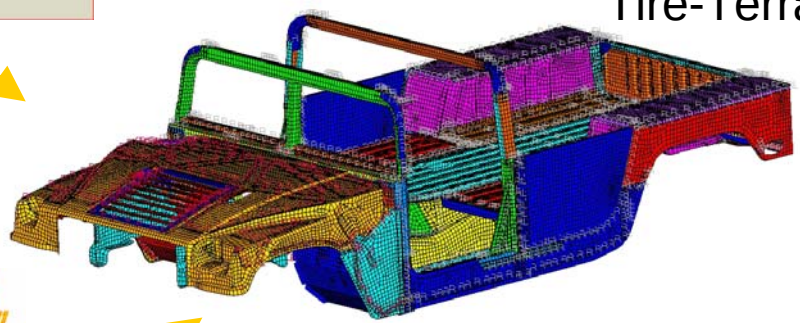
Overview

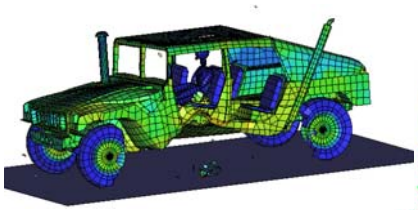


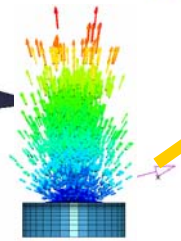
D-Sim



Tire-Terrain Interaction

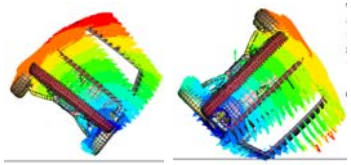


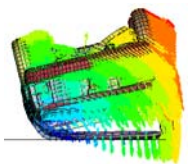




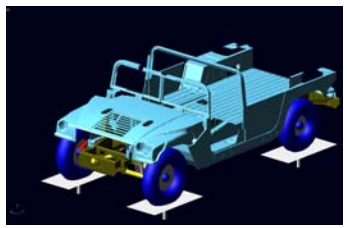
Blast

Durability

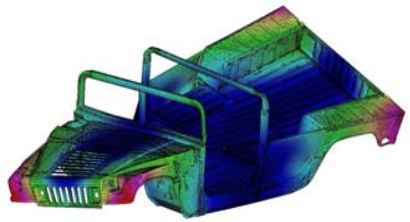




Crash



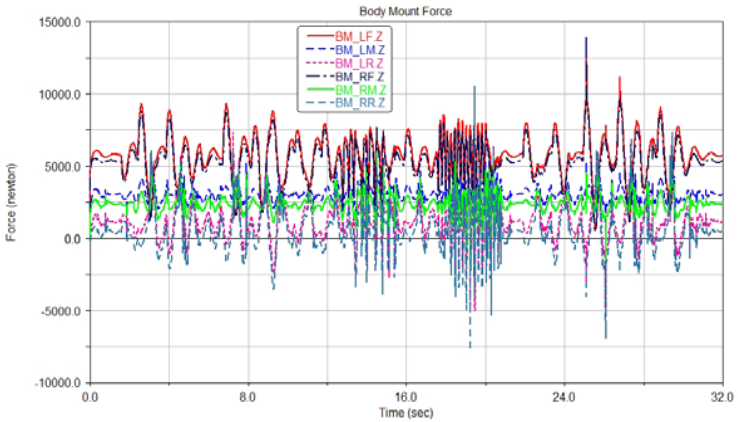
Rollover



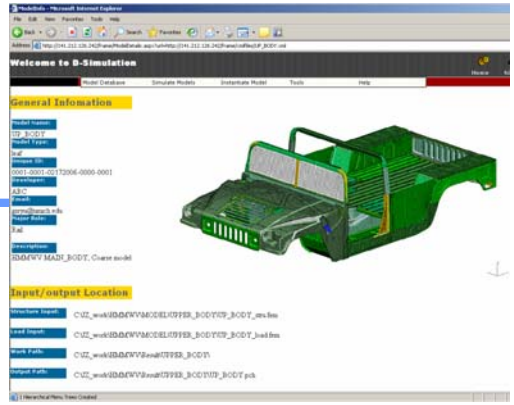
Durability Road Simulation

Durability Road

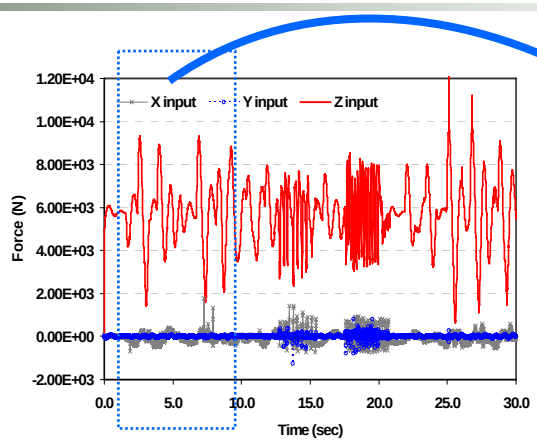
Computed Body Mount Forces



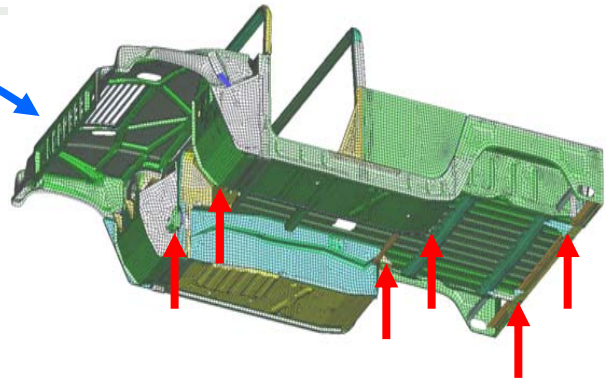
Gluing Algorithm for Durability



Assembly of Main Body and Hood



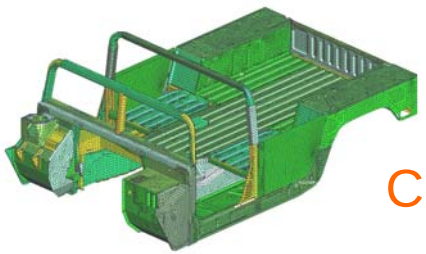
Forces computed using ADAMS



Apply external force at 6 body mounts

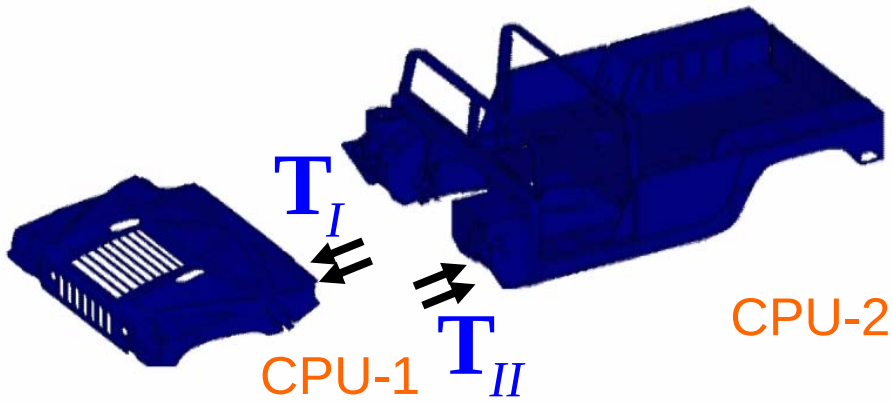
CPU-1

HOOD ASSEMBLY



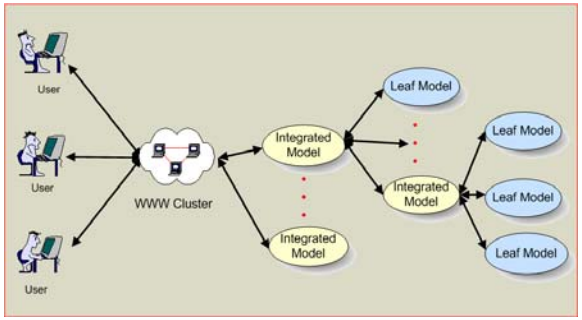
CPU-2

MAIN BODY ASSEMBLY

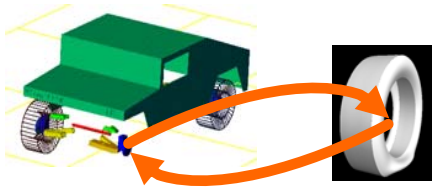


D-Sim Results
(coupled simulation)

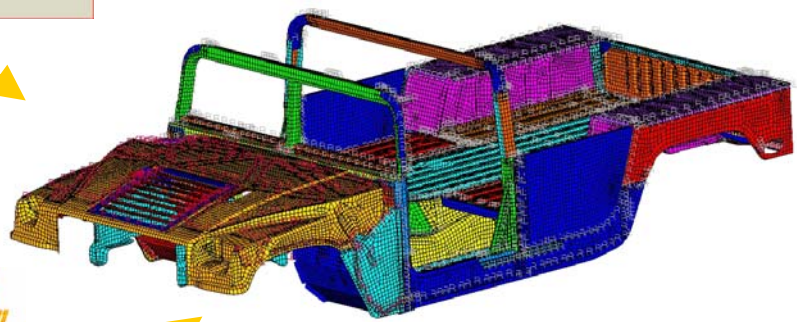
Overview

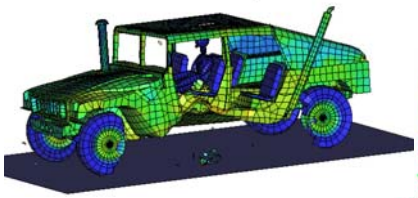


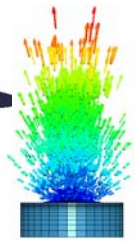
D-Sim

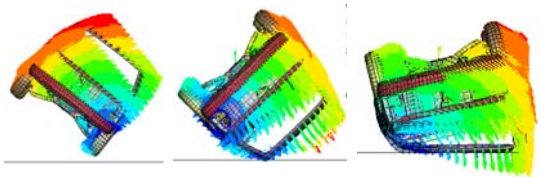


Terrain Interaction

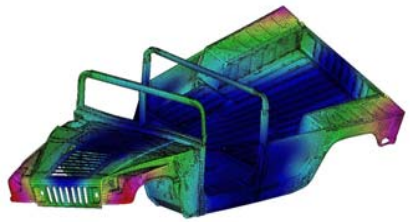








Safety



Durability and Ride

Safety Applications

Rollover

Crash

Blast

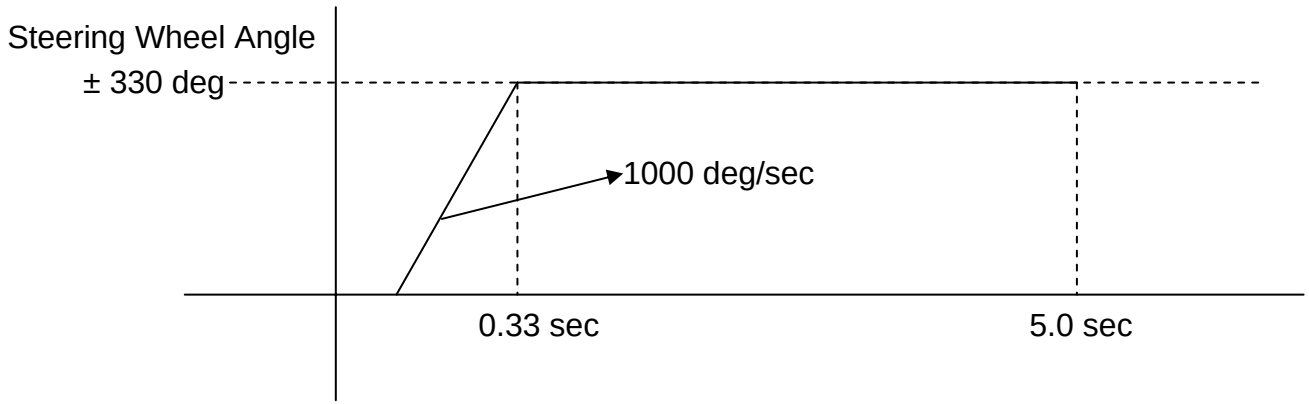
Extreme Terrain

HMMWV Rollover

J-Turn Rollover Simulation (Flat Ground)

Driving Conditions

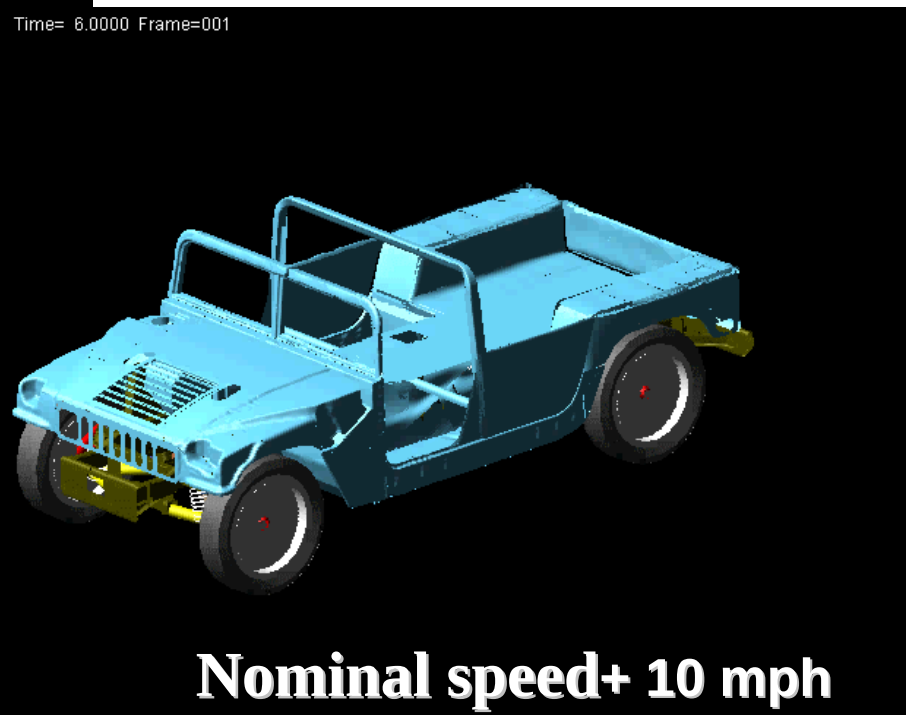
- Modified test protocol
- Initially driven in a straight line
- Initial speed: 10 mph and up
- Test runs for 5 seconds



J-Turn (Rigid Body Model)

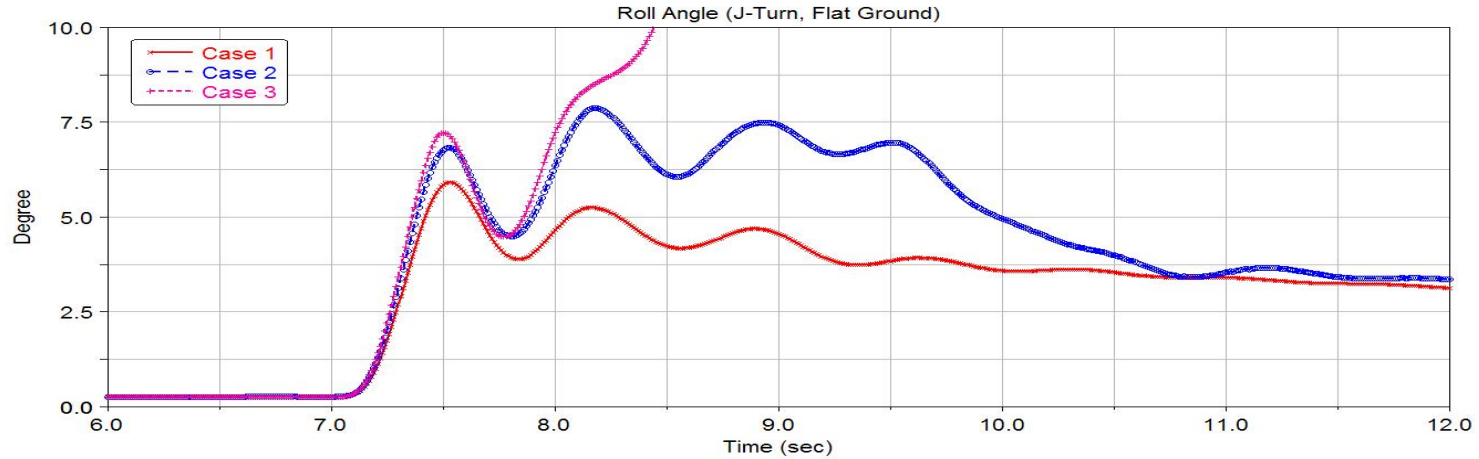
Nominal speed

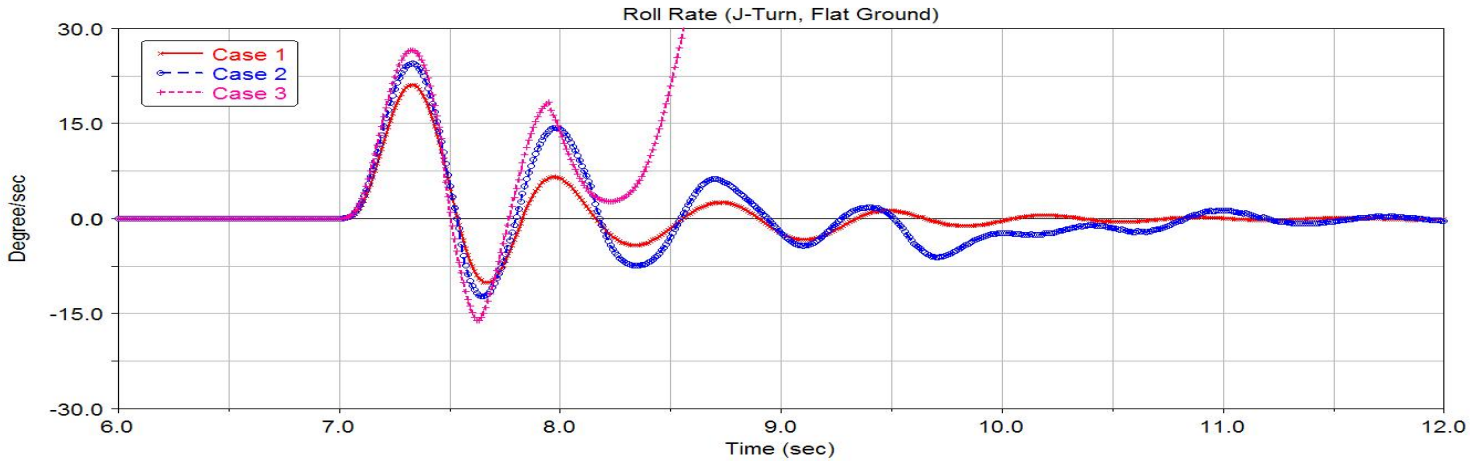
- Predict critical speed range
- Study rollover behavior
- Assess effect of up-armor system
- Design for rollover prevention



Nominal speed+ 10 mph

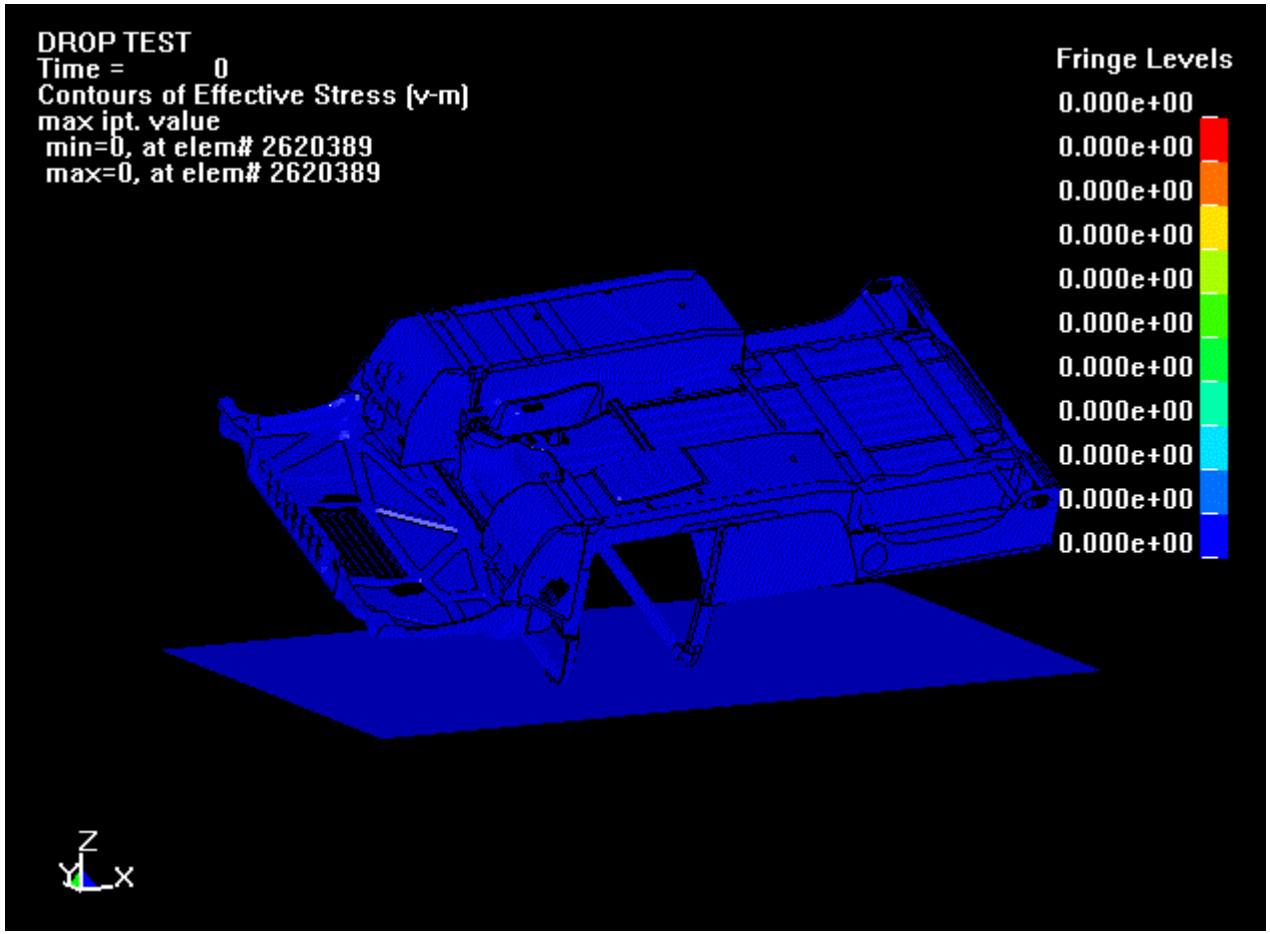
J-Turn Analysis Results



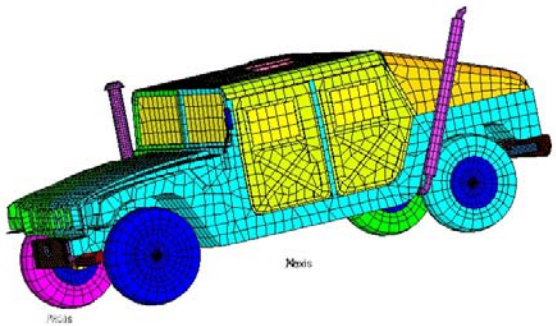


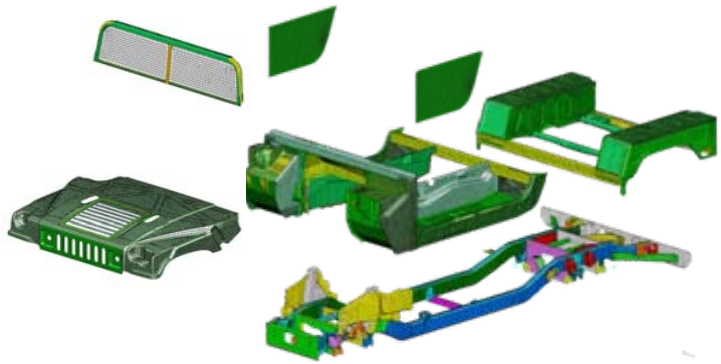
Roof Strength Analysis

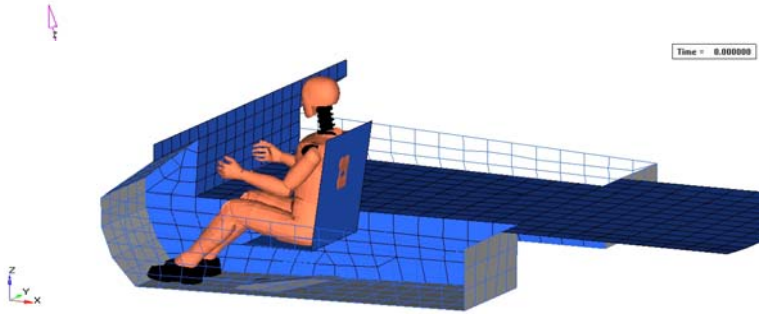
- Drop Test

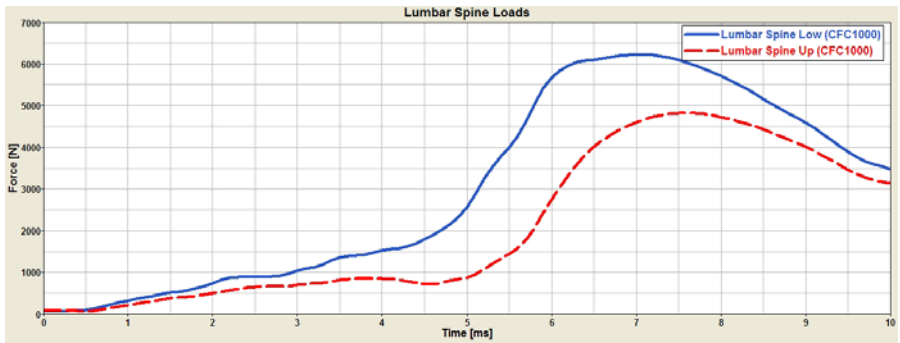


Simulating the Response of Structures and Occupants to Blast Loads



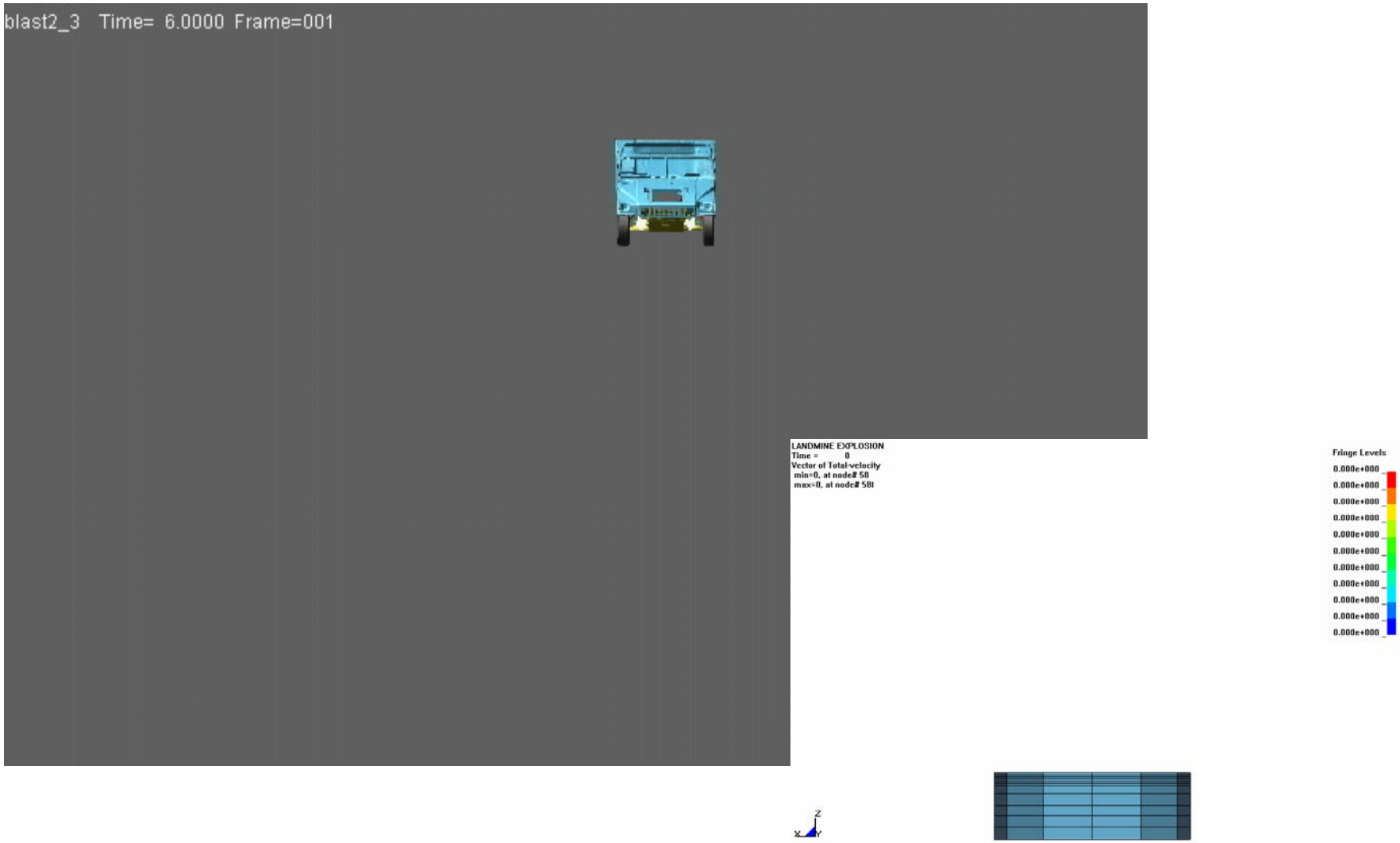




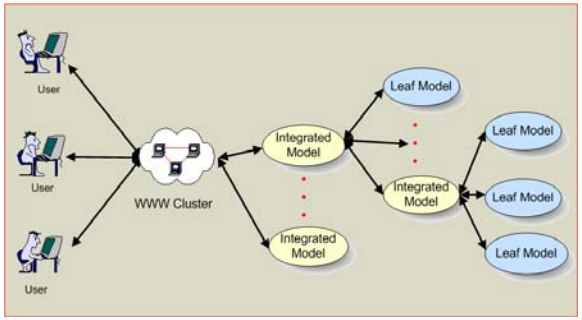


Response of vehicle floor and occupant under blast

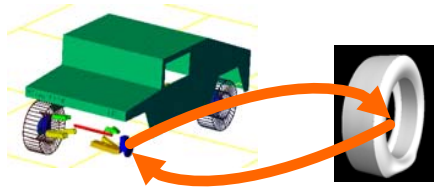
J-Turn Rollover under a Blast

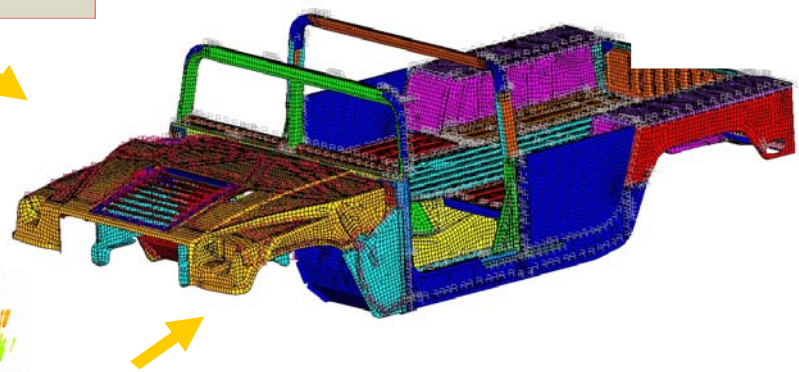


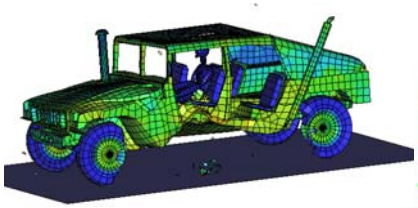
Overview

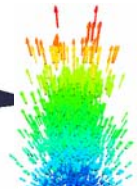


D-Sim



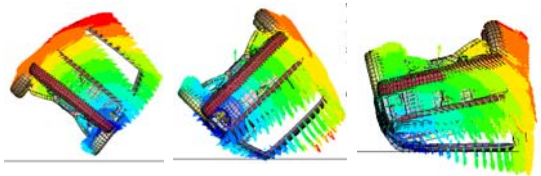






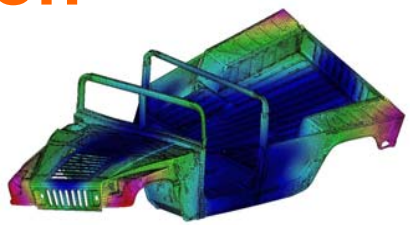
Blast

Tire-Terrain Interaction



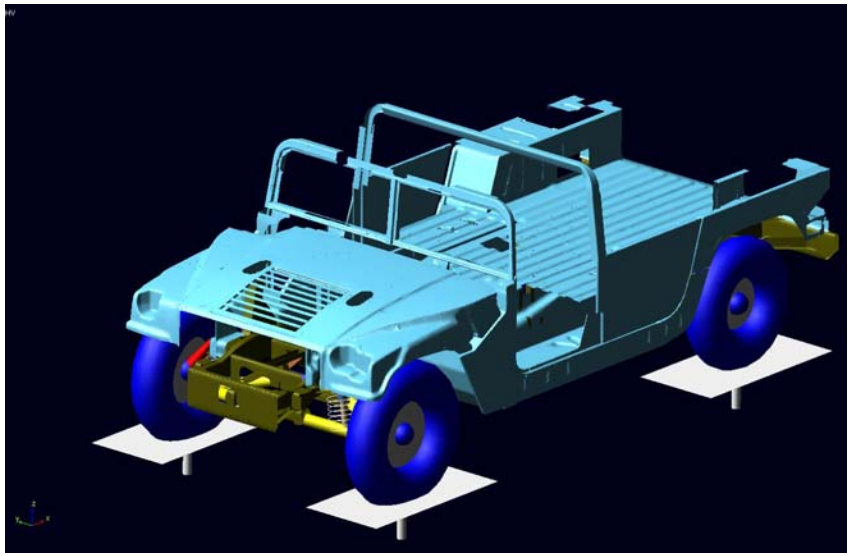
Crash

Rollover



Durability

Extreme Terrain



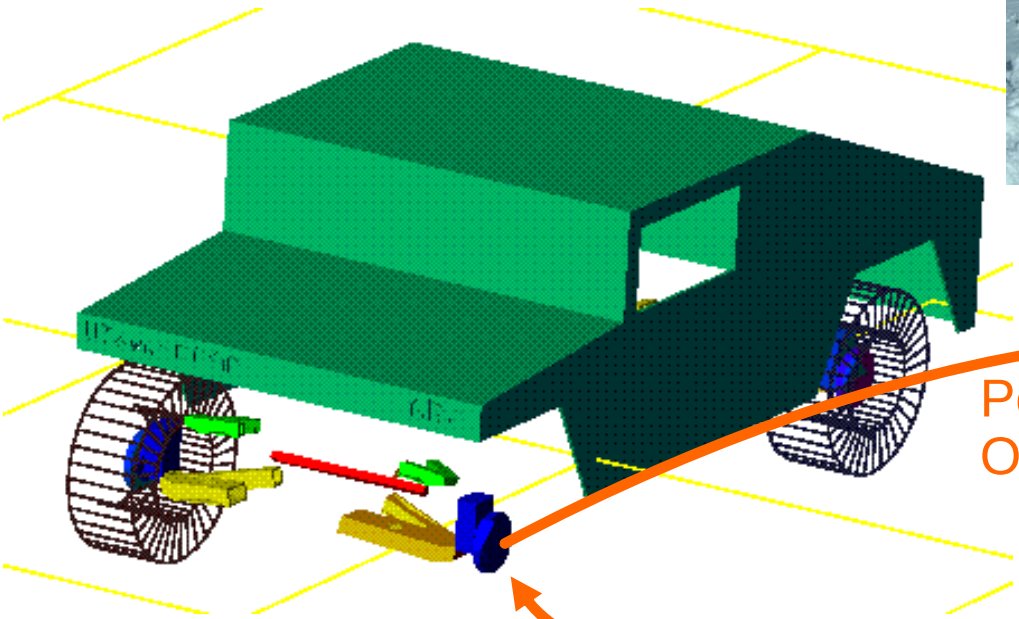
Sand

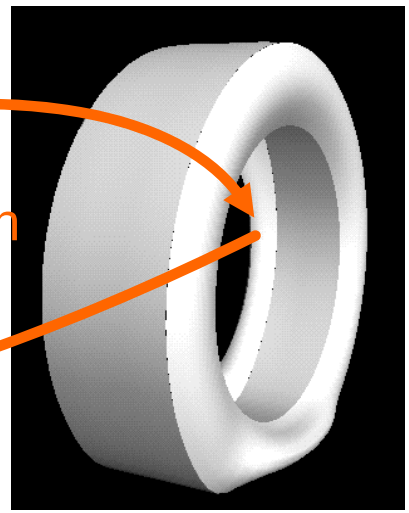
Ice

Snow

Tire-Terrain Interaction

- Tire passes forces / moments to vehicle
- Vehicle passes hub position / orientation to tire

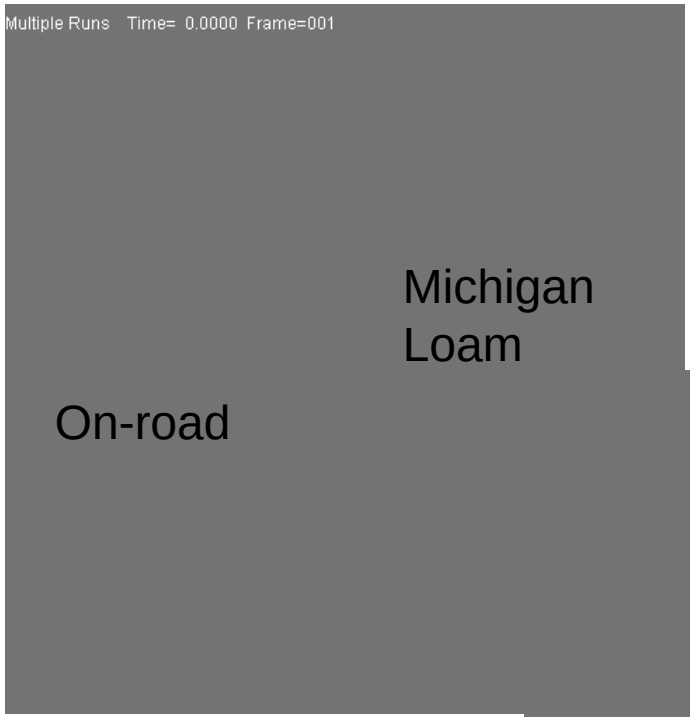


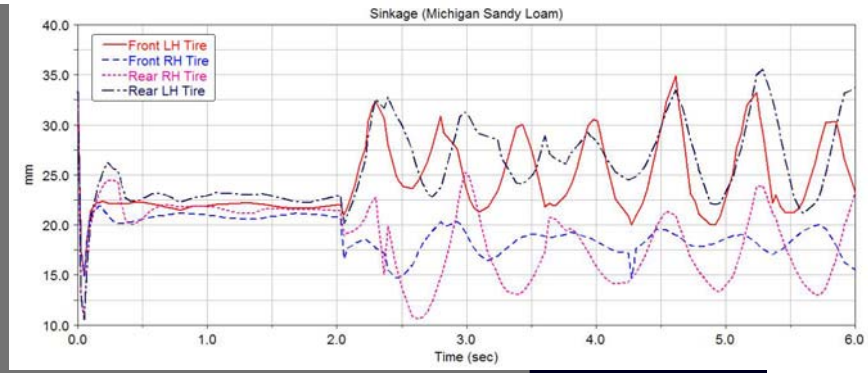


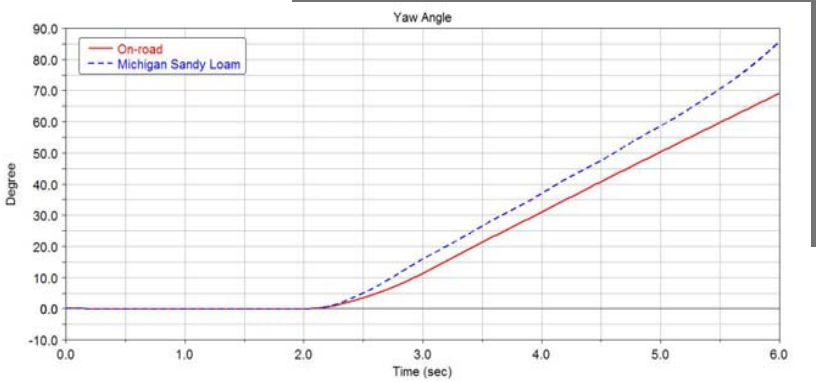
Position / Orientation

Forces/Moments

Vehicle Performance for Off-Road Events





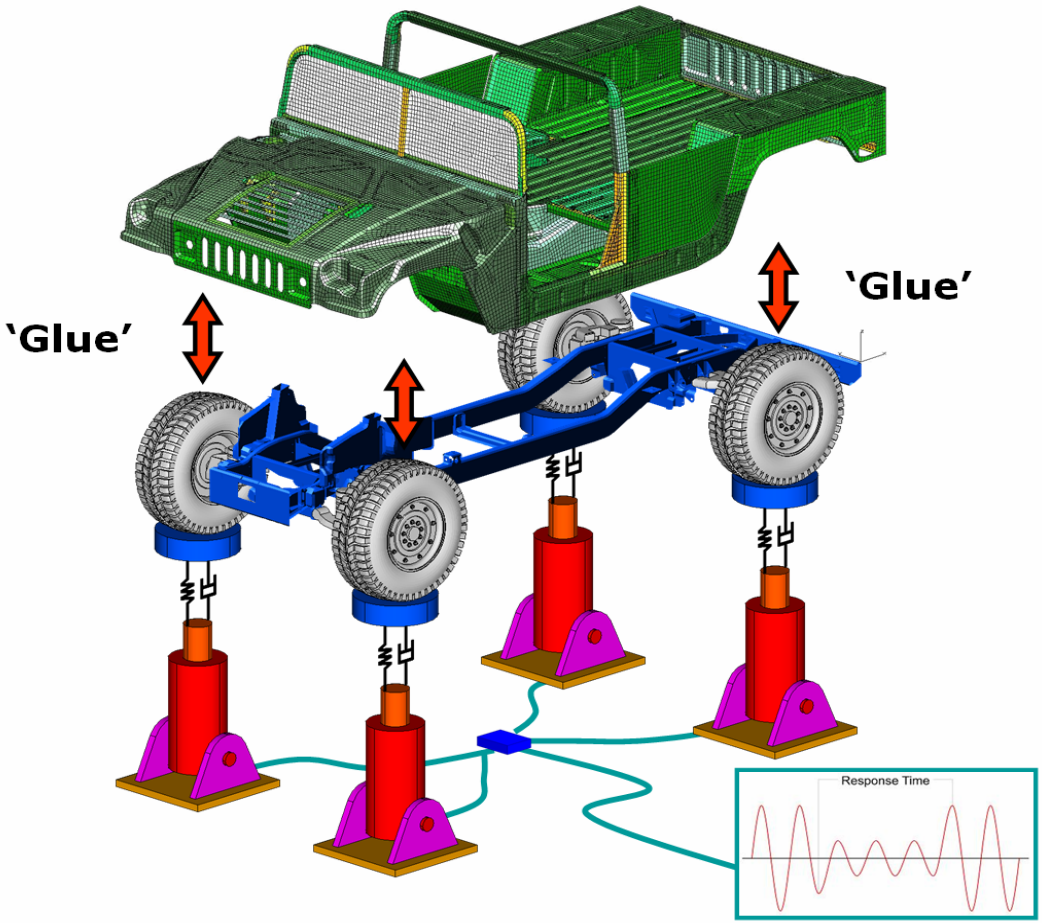


Off-road Maneuver

Summary

- Comprehensive, integrated platform for analysis and design to support current and next generation vehicles
- Enabling technologies:
  - General, functional simulation framework
  - Algorithms for coupling different models and simulation codes
  - Algorithms for coupling non-matching interfaces

Future Developments

- Continue development of model database
- Incorporate human models
  - Driver perception
  - Assess safety systems
- Expand integration with commercial software
- Verify, validate and update model database using instrumented vehicles
- Simulation-based certification

Future Developments