



**RDECOM**



*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*

# **US Army TARDEC Ground Vehicle Mobility: Dynamics Modeling, Simulation, & Research**

P. Jayakumar @ JPL 24 Oct 2011

# Report Documentation Page

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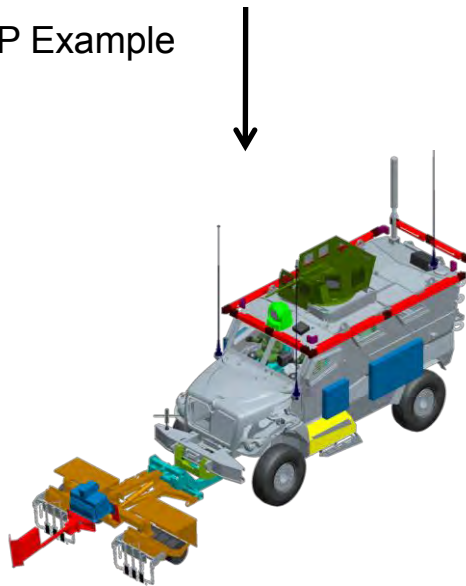
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## System Level Analysis



MRAP Example



- Mobility / Automotive Performance Analysis**
  - 
  - 
  - 
  - 
  - 
  -
- Blast / Crash / Ballistic Analysis**
  - 
  - 
  -
- Thermal / Signature / Aerodynamic Analysis**
  - 
  -
- Durability / Reliability Analysis**
  - 
  -

High Performance Computing Infrastructure

## Life Cycle Modeling & Simulation Support

- Acquisition Support
  - Construct Virtual Technology Demonstrators
  - Develop automotive performance requirements
  - Write M&S content of the Request For Proposal
  - Participate in the Source Selection Evaluation Board
- Field System Support
  - Configuration changes
  - Waiver requests
  - Safe Use Range of Operation
  - Field failures

## Research

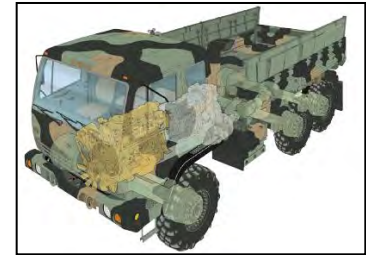
- Internal and External



ASV



MRAP



FMTV



FTTS



HMMWV



GCV



JLTV



M2



M915



Small Robot



APD

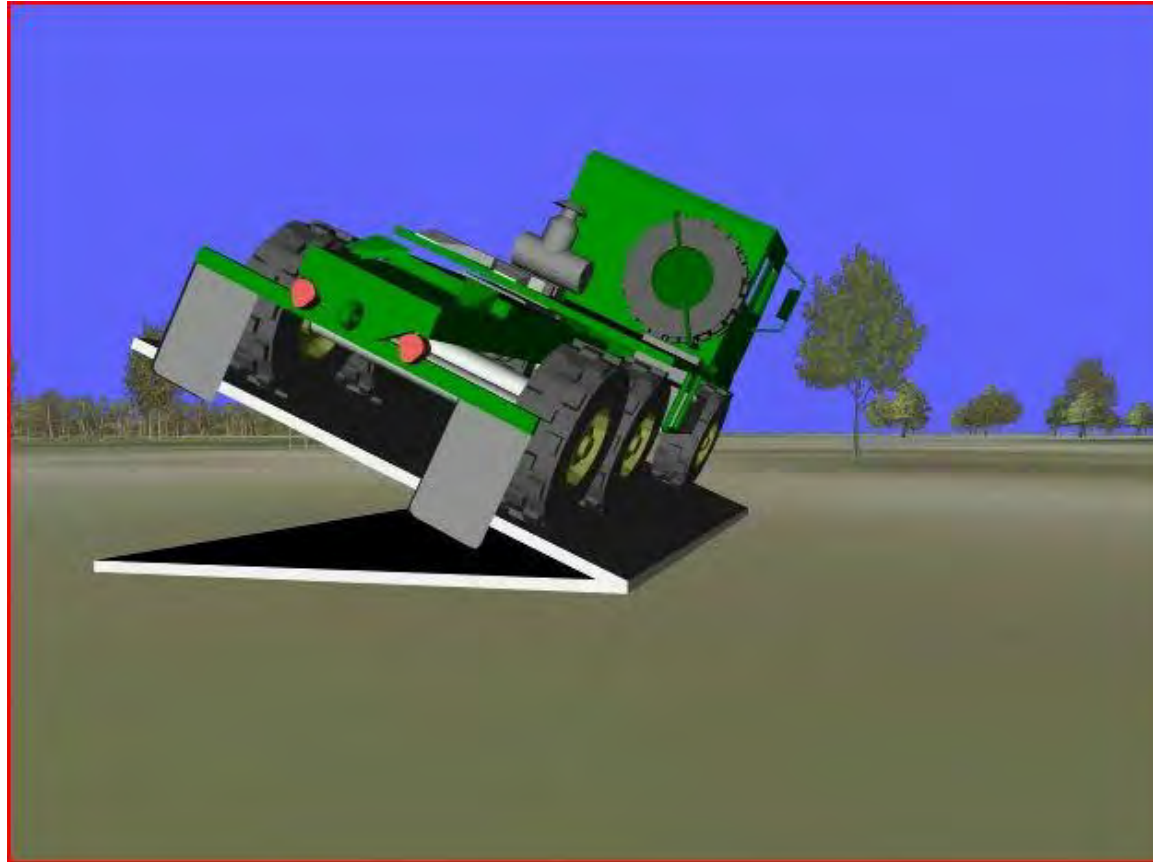
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- Vehicle stability
- Ride quality
- Durability
- Steerability
- Obstacle maneuverability
- Design sensitivities



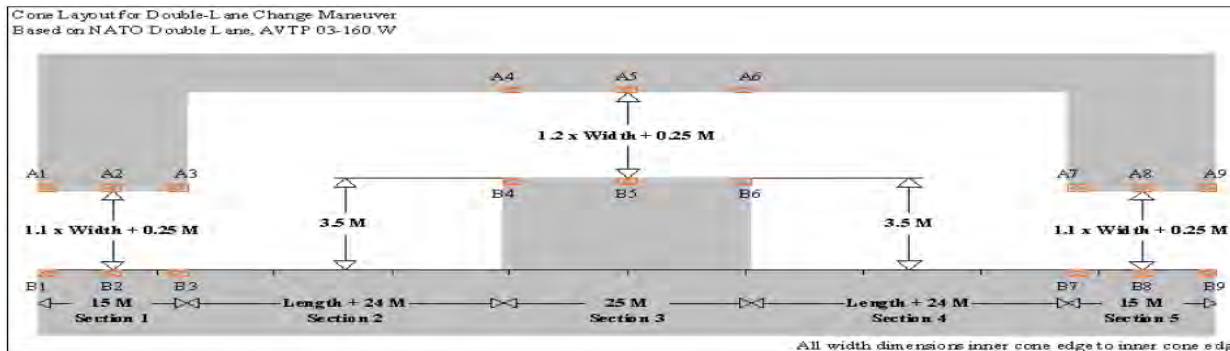
Multi-Body Vehicle Dynamics



TiltTable-Standard.wmv



tan16700a-frontview.wmv

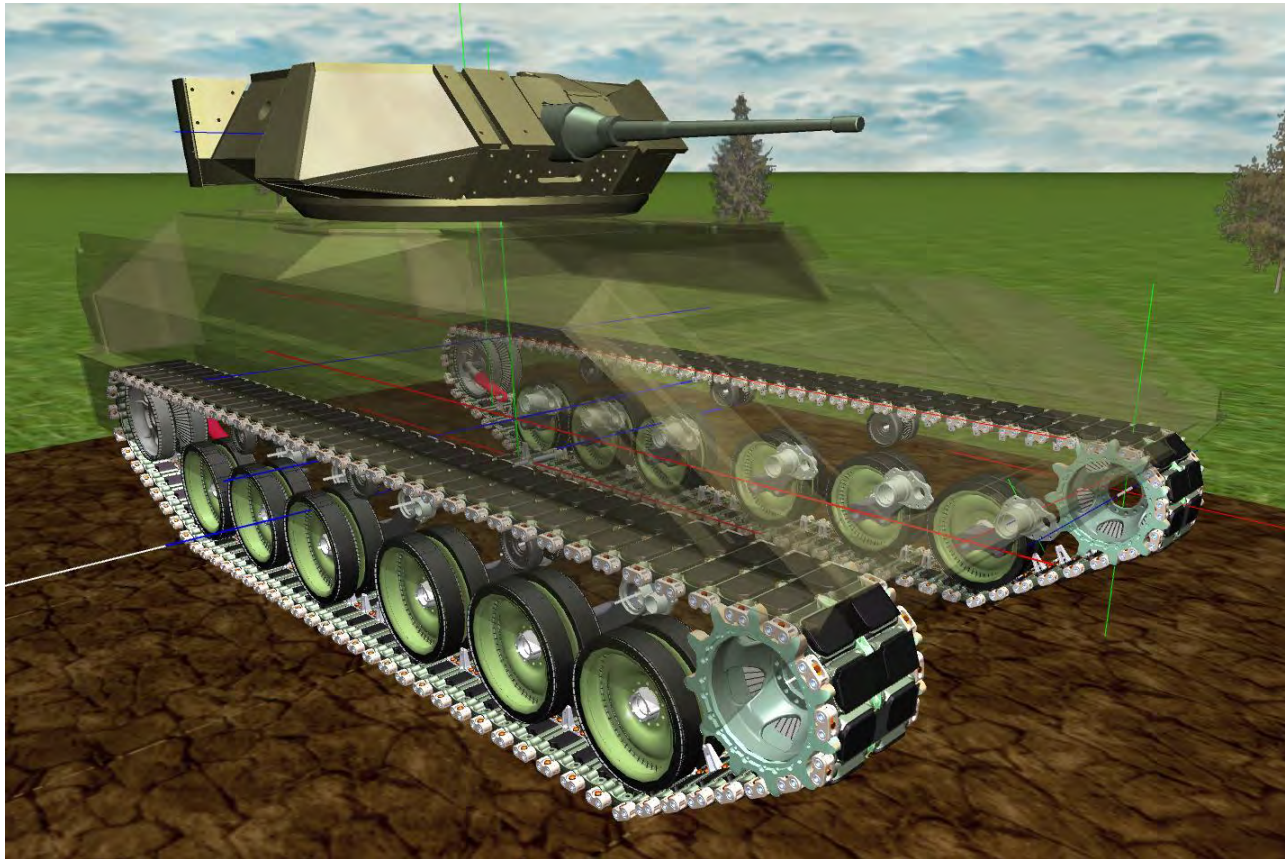






ah32big.wmv

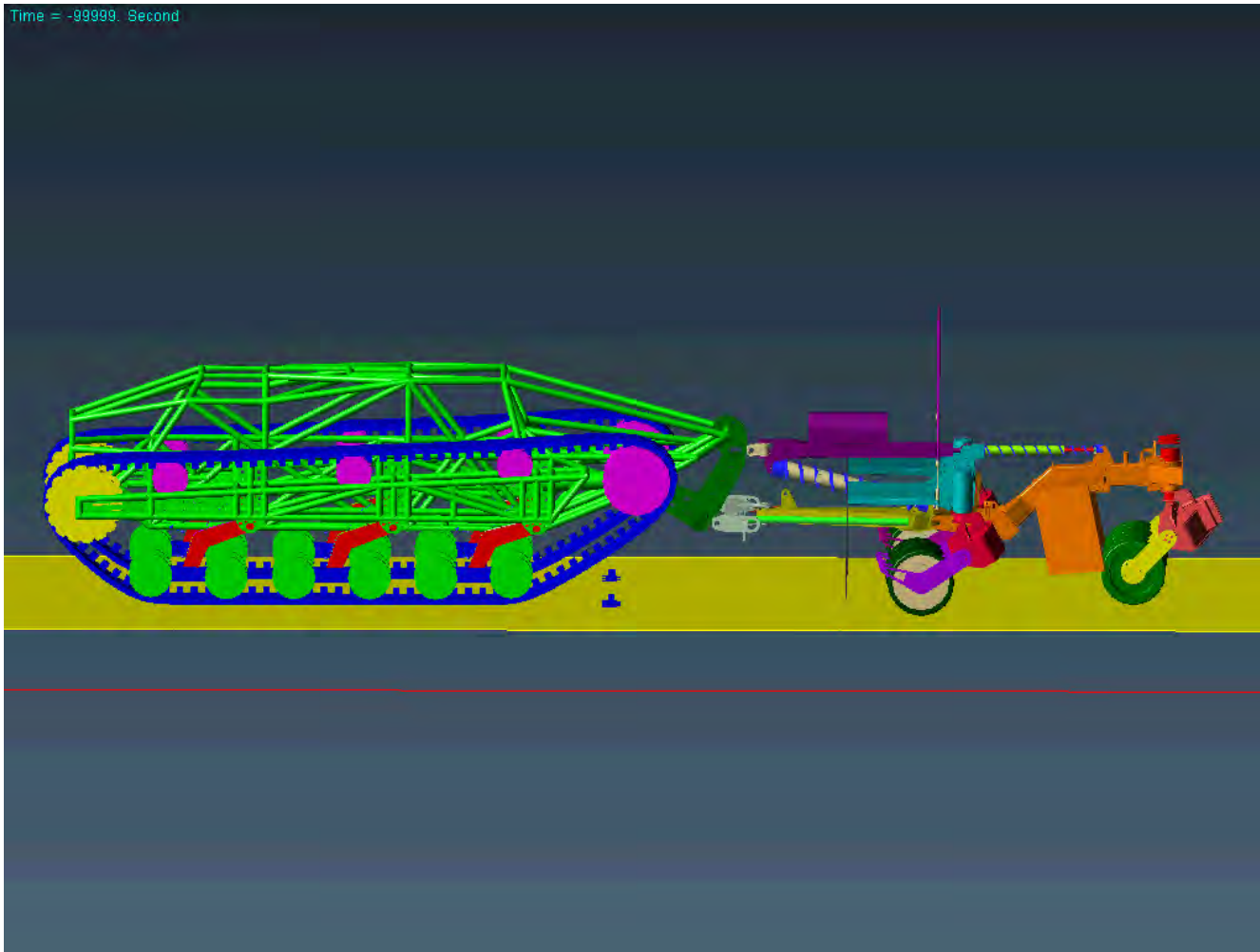
## FE-Based Vehicle Dynamics



OPSEC\_SegmentedTrack.avi



Brake-LSAC-40mph.wmv



*Click on the image*

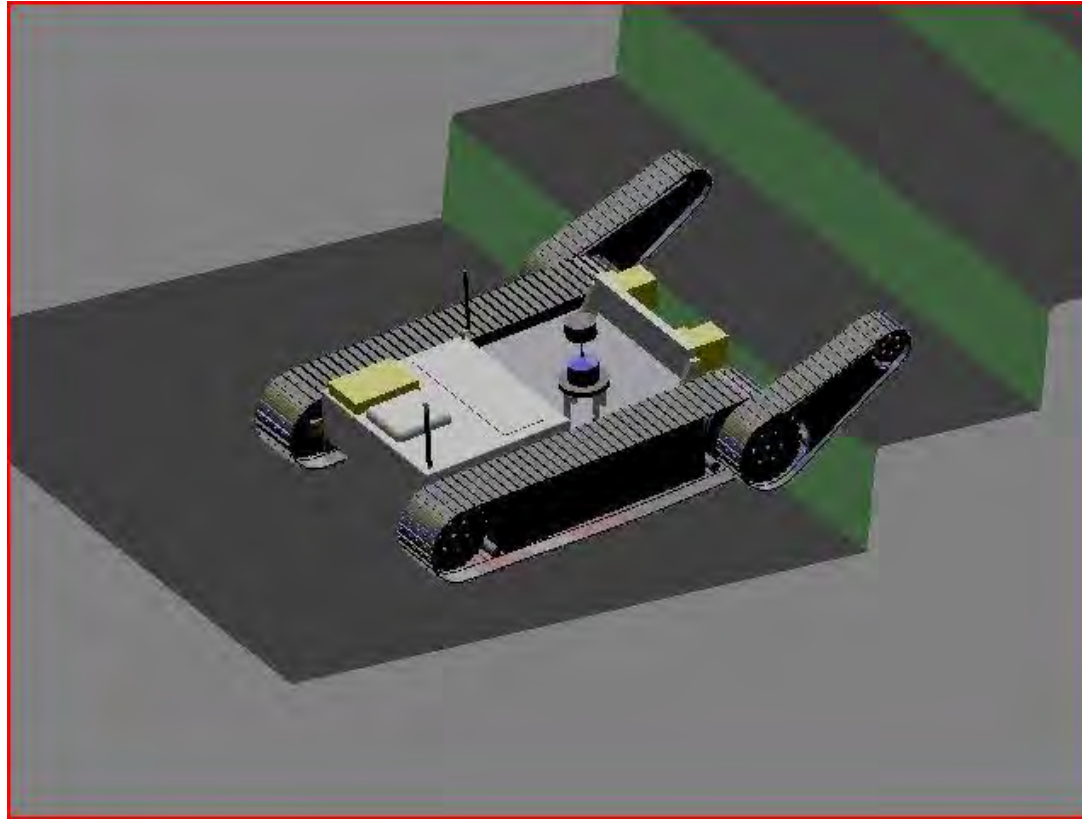


## Fluid-Structure Interaction



OPSEC\_TankerTruck\_LaneChange.avi

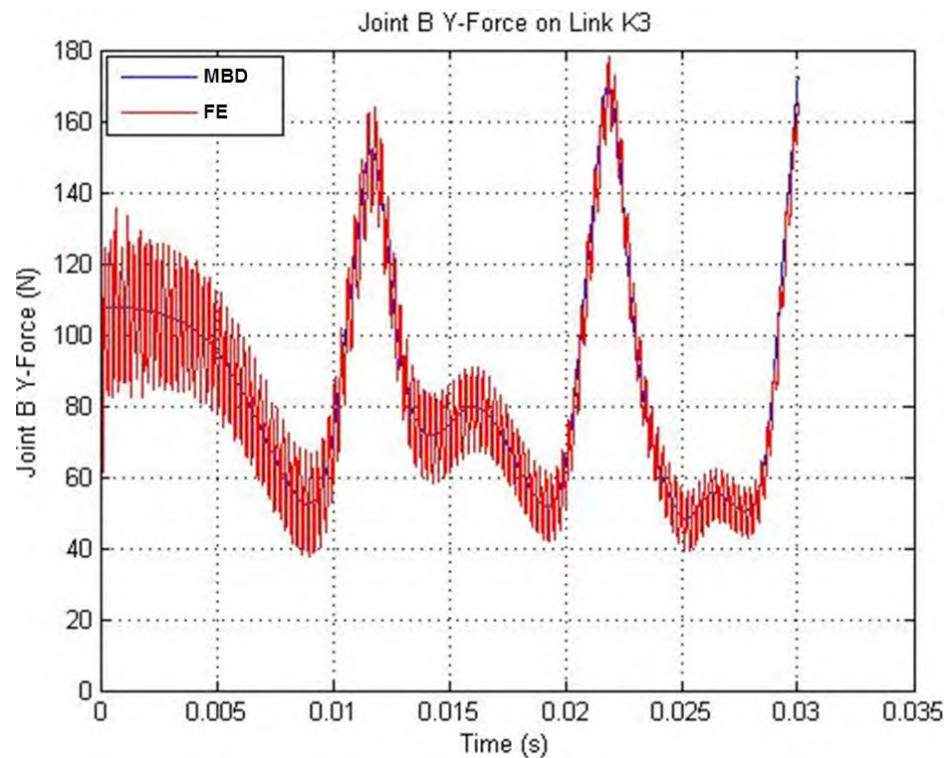
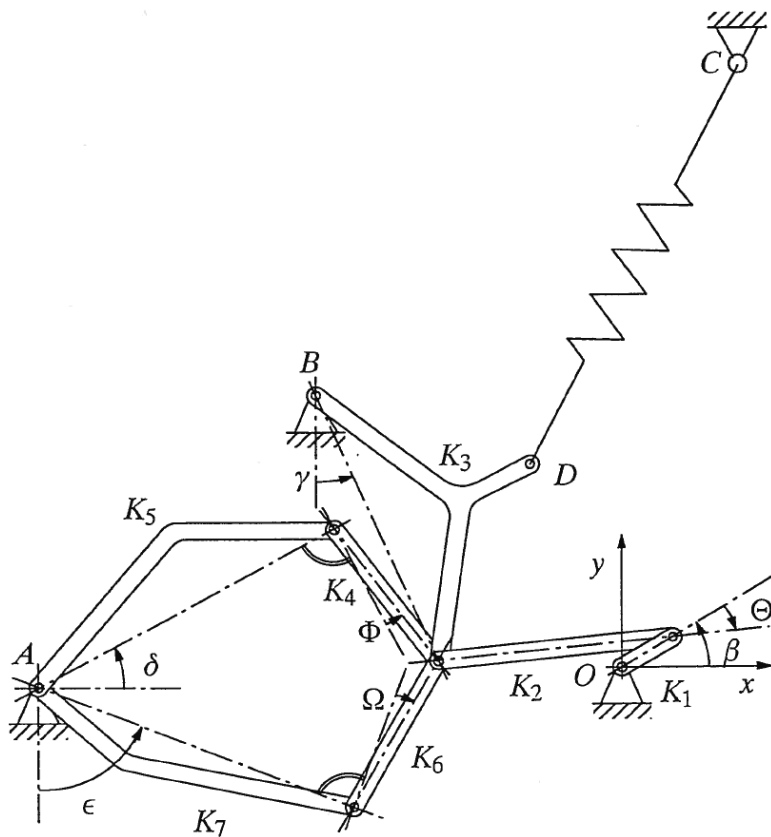




Urbie\_final\_rear.avi

$$d_i = \dot{x}_{p1} - \dot{x}_{p2}$$

## Joint Force Comparison

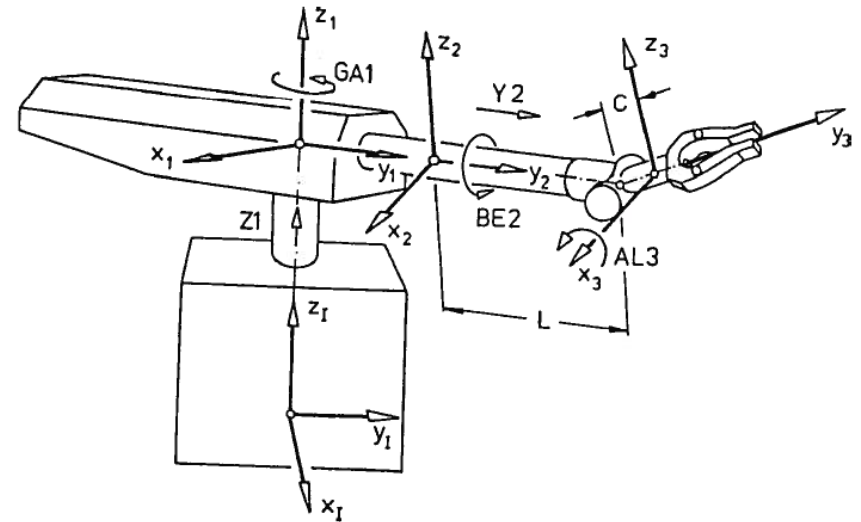
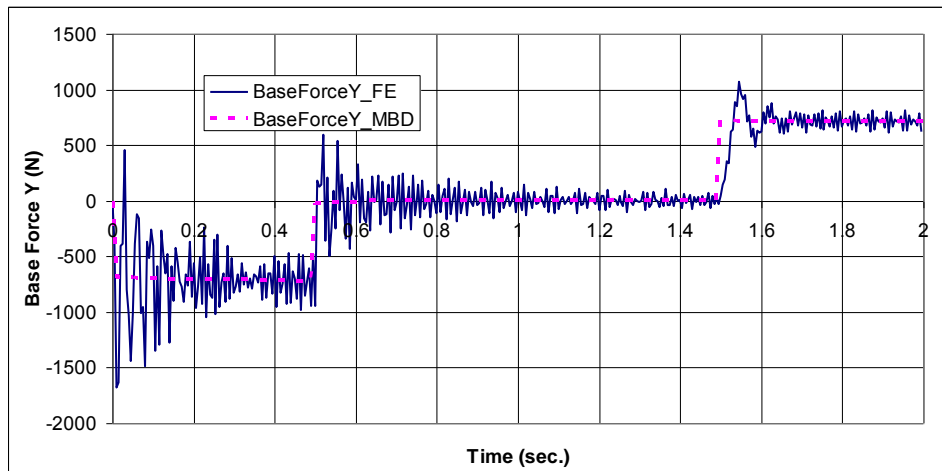
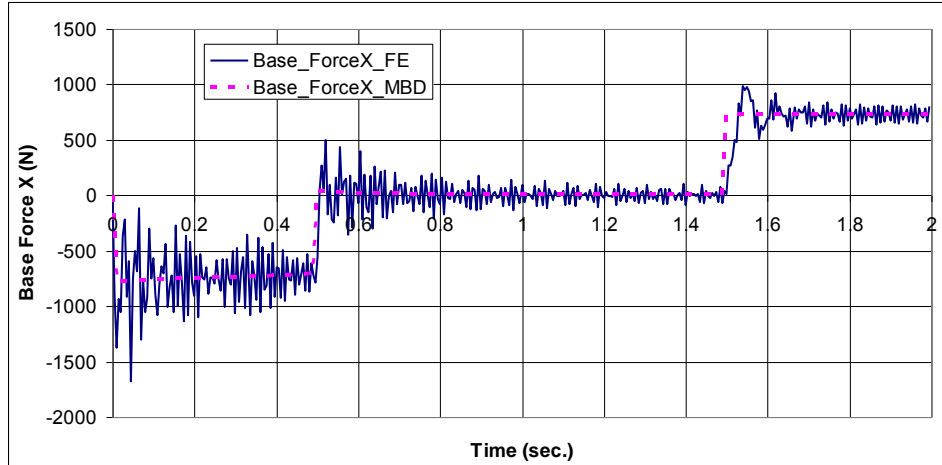


OPSEC\_MBD\_Benchmark\_Mechanism.avi

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$$d_i = \dot{x}_{p1} - \dot{x}_{p2}$$

## Manipulator Force Comparison



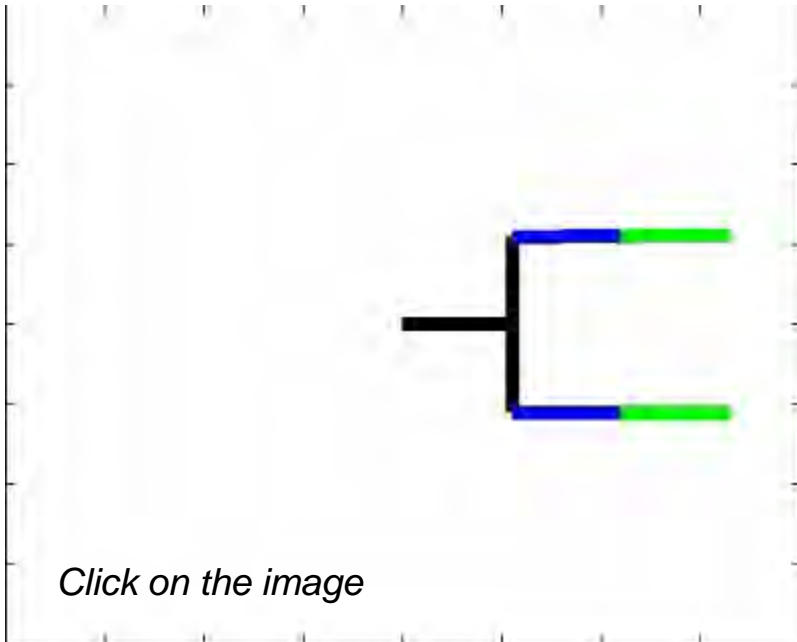
OPSEC\_MBD\_Benchmark\_Robot.avi

## M113



*Click on the image*

## ANCF Finite Elements



## Tracked Vehicle



$$\begin{bmatrix}
 \mathbf{M}_{rr} & \mathbf{M}_{rf} & \mathbf{0} & \mathbf{0} & \mathbf{C}_{q_r}^T \\
 \mathbf{M}_{fr} & \mathbf{M}_{ff} & \mathbf{0} & \mathbf{0} & \mathbf{C}_{q_f}^T \\
 \mathbf{0} & \mathbf{0} & \mathbf{M}_{aa} & \mathbf{0} & \mathbf{C}_{q_a}^T \\
 \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{C}_s^T \\
 \mathbf{C}_{q_r} & \mathbf{C}_{q_f} & \mathbf{C}_{q_a} & \mathbf{C}_s & \mathbf{0}
 \end{bmatrix}
 \begin{bmatrix}
 \ddot{\mathbf{q}}_r \\
 \ddot{\mathbf{q}}_f \\
 \ddot{\mathbf{q}}_a \\
 \ddot{\mathbf{s}} \\
 \lambda
 \end{bmatrix}
 =
 \begin{bmatrix}
 \mathbf{Q}_r \\
 \mathbf{Q}_f \\
 \mathbf{Q}_a \\
 \mathbf{0} \\
 \mathbf{Q}_c
 \end{bmatrix}$$

## Integrates

- rigid motion (r)
- flexible deformation (f)
- very flexible deformation (a)



