Annex O – MSC – MILITARY VEHICLE SIMULATION WITH ADAMS: MOBILITY AND BEYOND

Note: This Annex appears in its original format.

Military Vehicle Simulation with Adams Mobility and Beyond

Presentation For NG-NRMM CDT
AVT 308

Eric Pesheck, PhD, USA

MSC Software 50 Years of CAE

1965 NASA Contracts MSC to develop Nastran

1971 First Commercial Version of Nastran

1987 NASA uses MSC Nastran

1999 MSC Acquires Marc (Nonlinear FEA)

2002 MSC Acquires MDI (Mechanical Dynamics)

2011 MSC Acquires FFT (Acoustics)

2012 MSC Acquires e-Xstream engineering (Materials)

2014 MSC Announces MSC Apex

2015 MSC Acquires Simufact Engineering (Manufacturing Process)

2016 MSC Acquires Cradle (CFD)

2017 MSC Acquires VIRES

2017 Hexagon Acquires MSC Software

1960 – 2000

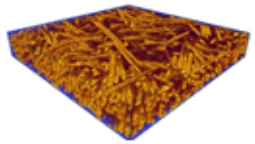
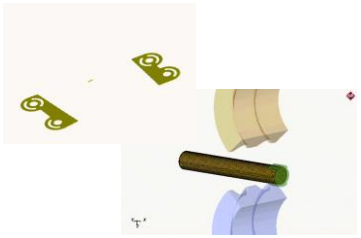
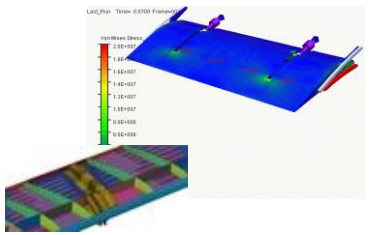
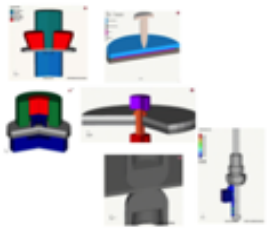
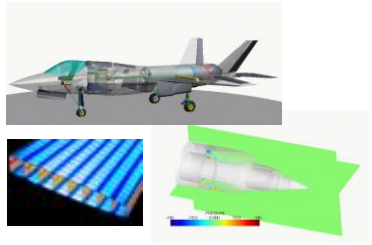
2000 - 2018

- **1300 Employees in 35 Offices**
- **Annual Revenue ~$230 million**

Every NASA Mission uses MSC

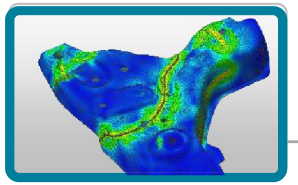
Virtually every auto, aero & heavy machinery OEM is a customer

MSC Product Portfolio

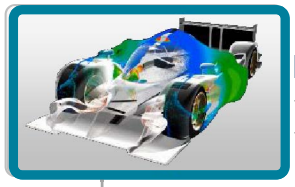
Materials	Fabrication	Parts	Assembly	Systems
				
Digimat	Digimat Additive Manufacturing	MSC Apex	Simufact welding	MSC Nastran
Digimat-VA	Simufact Additive Manufacturing	Marc	Simufact joining	Actran - Acoustics
Digimat-AM	Simufact.forming			MSC Apex
MaterialCenter				SC/Tetra - CFD
				Adams
				Virtual Test Drive
		SimManager		

- NG-NRMM work has used the Adams product portfolio.
- Work performed by MSC Consulting services organization
- Real-Time model leveraged for VTD

MSC Vehicle Solutions

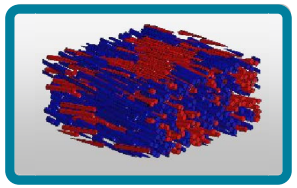


Manufacturing
- ✓ Joining process simulation
- ✓ Sheet metal forming

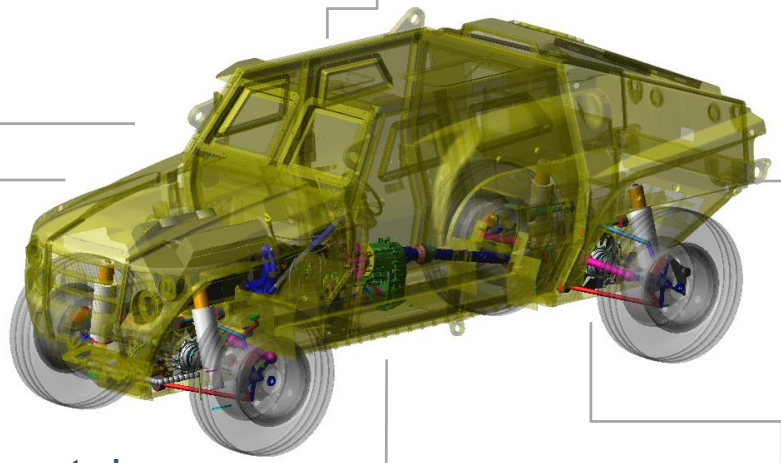


Body & Interior
- ✓ Wind noise & Road noise
- ✓ Door Closing Effort

Simulation Process & Data Management

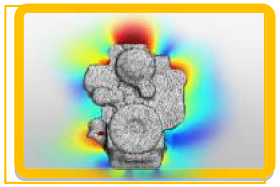


Material
- ✓ Advanced material modeling
- ✓ Material management

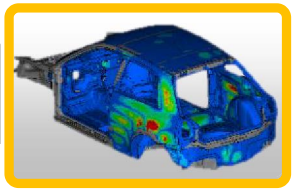


Chassis & Vehicle Dynamics
- ✓ Handling & Steering
- ✓ Ride & Comfort
- ✓ Terrain interaction

Primary CDT Analysis Events



Powertrain
- ✓ Powertrain torque delivery
- ✓ Gear noise
- ✓ Exhaust Noise
- ✓ Battery thermal management



Durability & NVH
- ✓ Road loads generation
- ✓ Fatigue study
- ✓ Offroad Impact

Autonomous Driving
- ✓ Simulator (HIL) Integration
- ✓ ADAS & Controls evaluation
- ✓ Perception & validation

Secondary CDT Contributions

MSC Software

MSC AVT-308 Activities - Overview

Adams/Car Parametric Vehicle Model Architecture

Validation

Validated Model

Real-Time Model

Virtual Test Drive

Complex Terramechanics

- Drawbar
- Traverse

(with EDEM)

Simplified Terramechanics

- Drawbar
- Sand Climb
- Traverse

Uncertainty Quantification

Rigid Road

- Handling
  - Lane-change
  - Cornering
- Ride
  - RMS roads
  - Halfrounds
- Obstacles

- Mapping
- Route Selection

(with Luciad)

MSC Software

Rigid Road Events

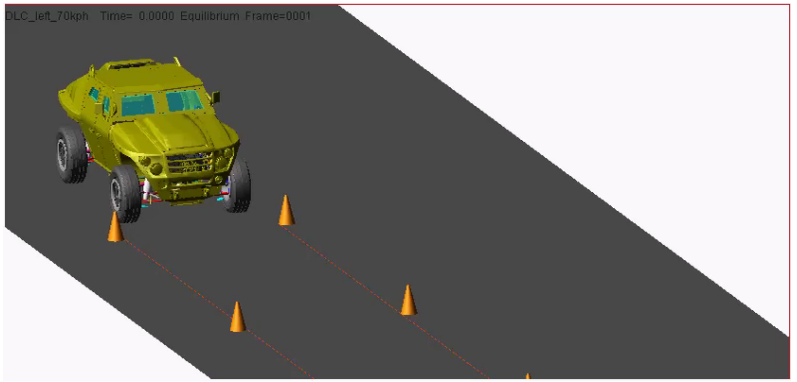
Events

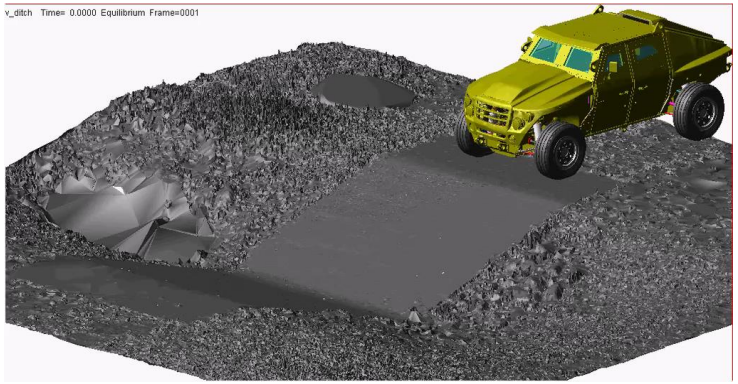
- Double Lane Change
- Cornering
- Halfrounds
- RMS courses
- V-Ditch
- Step Climb
- Acceleration
- Braking
- Grade Climb
- Side Slope

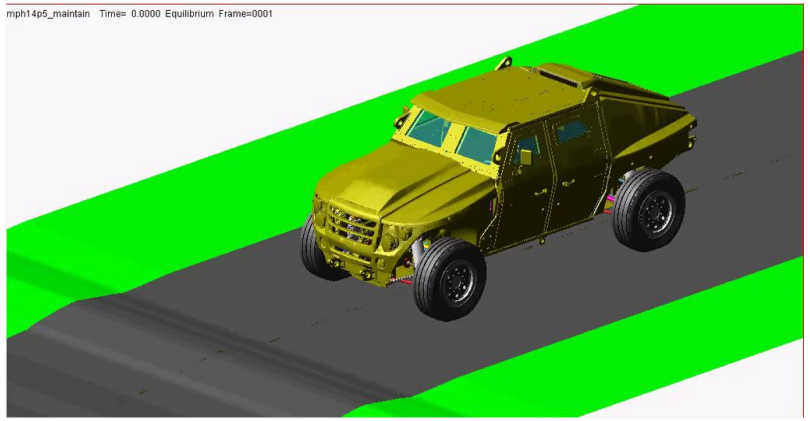
Methods

- Driver Strategies
- Tire fidelity
- Detailed driveline
- Specialized dampers
- Road Contact Models

Results







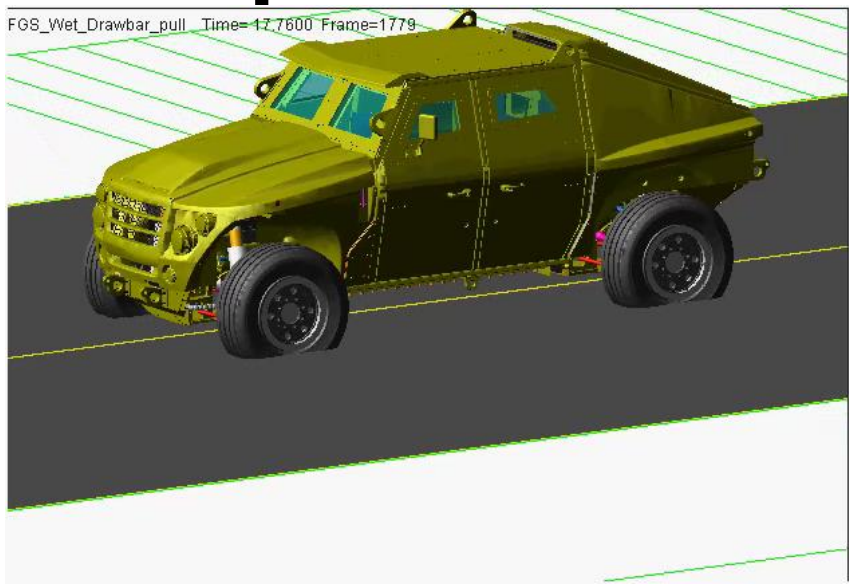
Simplified Terramechanics

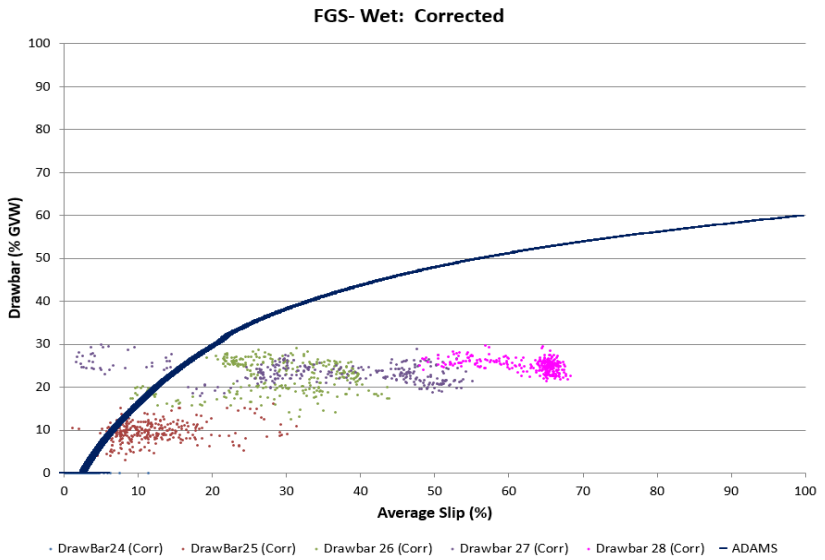
Events

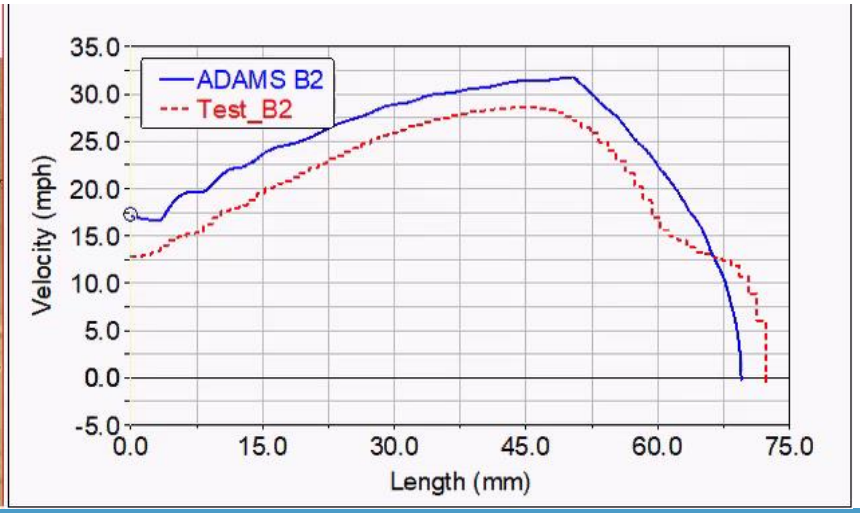
- Drawbar
- Hill Climb
- UQ DOEs
- Traverse

Methods

- Bekker-Wong Soft road
- Scripting
- Scanned mesh roads







Complex Terramechanics

Events

- Calibration
- Drawbar
- Traverse

Methods

- EDEM Configuration
- Soil Bed Preperation
- Cosimulation

Cosimulation Process

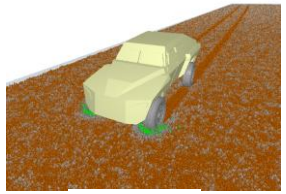
Adams

High Fidelity MBD Model

Tire Soil Contact forces

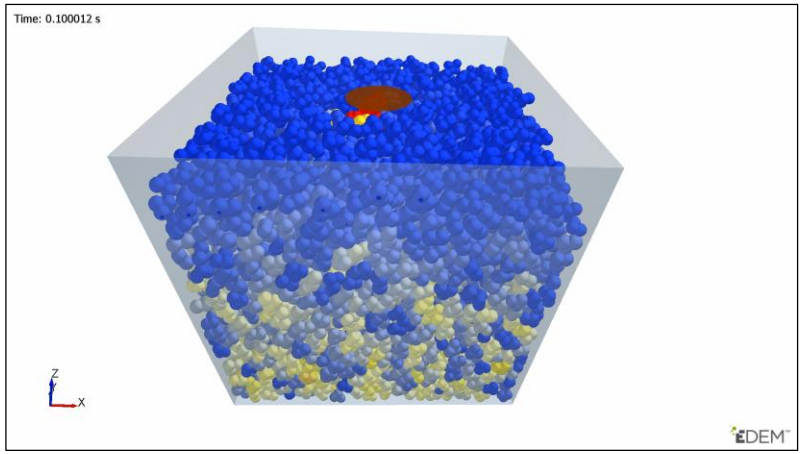
Tire Position/ velocity

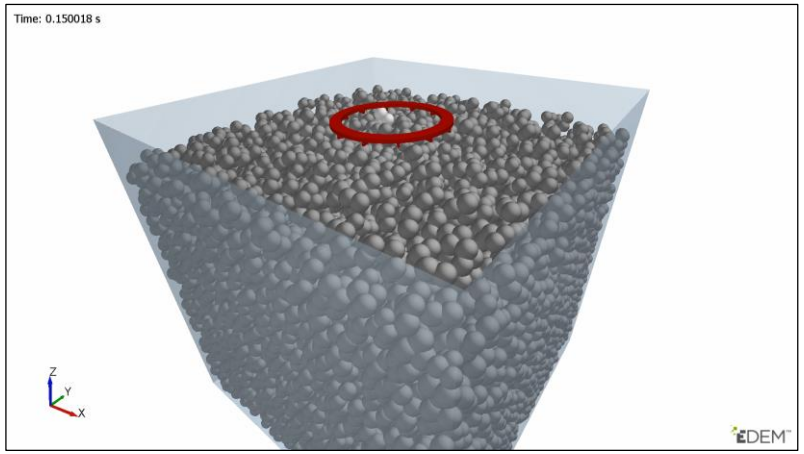
Soil-Tire Interactions



EDEM

Results





Time: 0.600045 s

Time: 0.50002 s

Traverse: Sand Bed Cornering and Acceleration

Adams Real-Time / Virtual Test Drive integration

Export Real-Time model

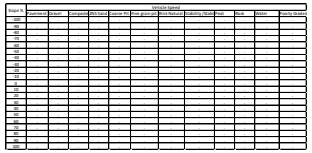
Create VTD 3D vehicle model

Publish KRC terrain for VTD scenario

VTD runs Adams vehicle plant (Different Vehicle and scenario shown)

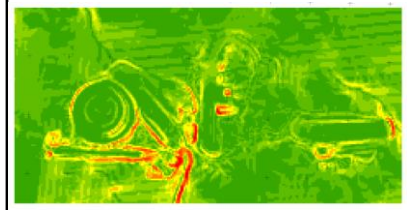
Applying Modern Mapping Frameworks

Inputs



Vehicle Capabilities

Soil Data

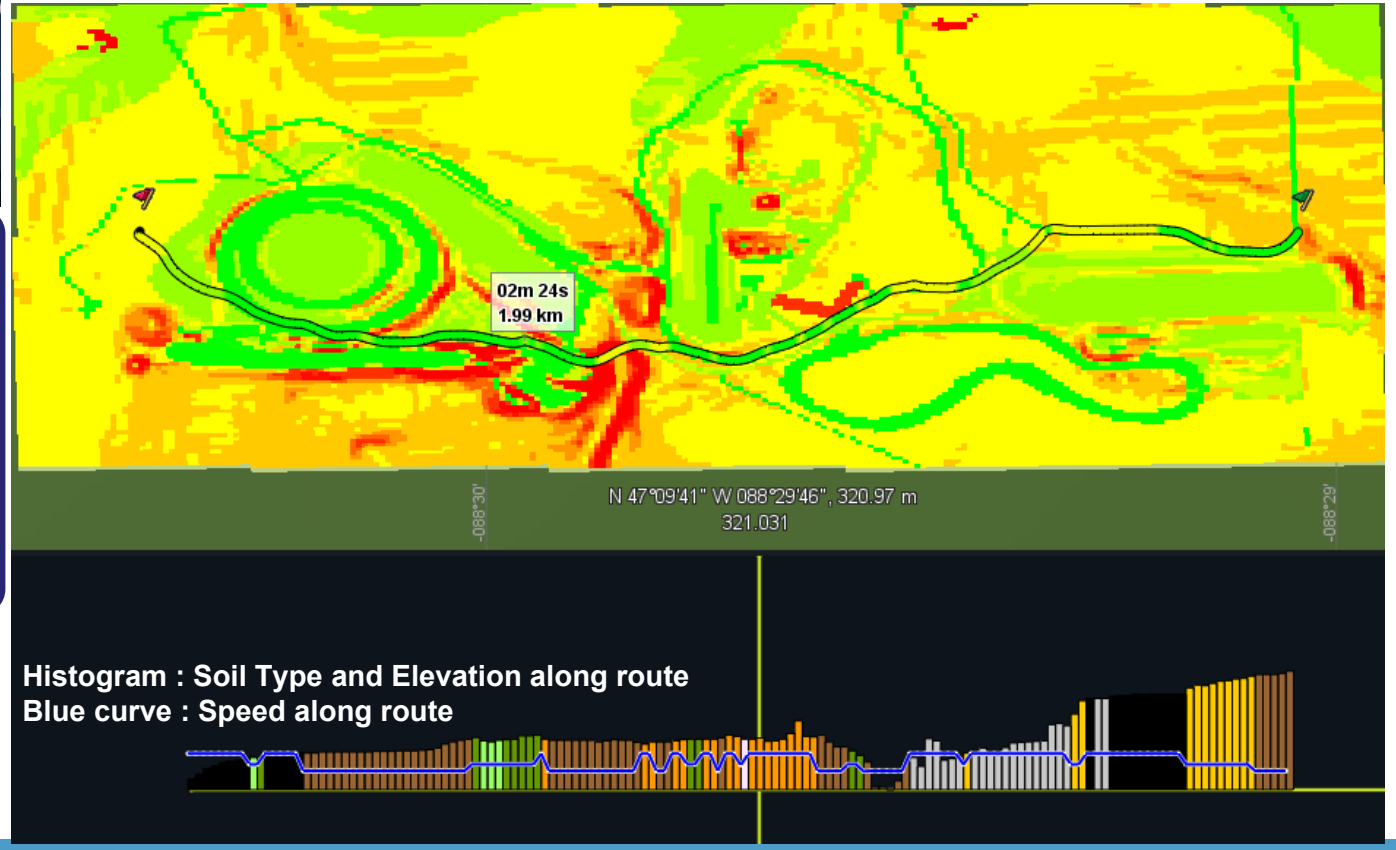


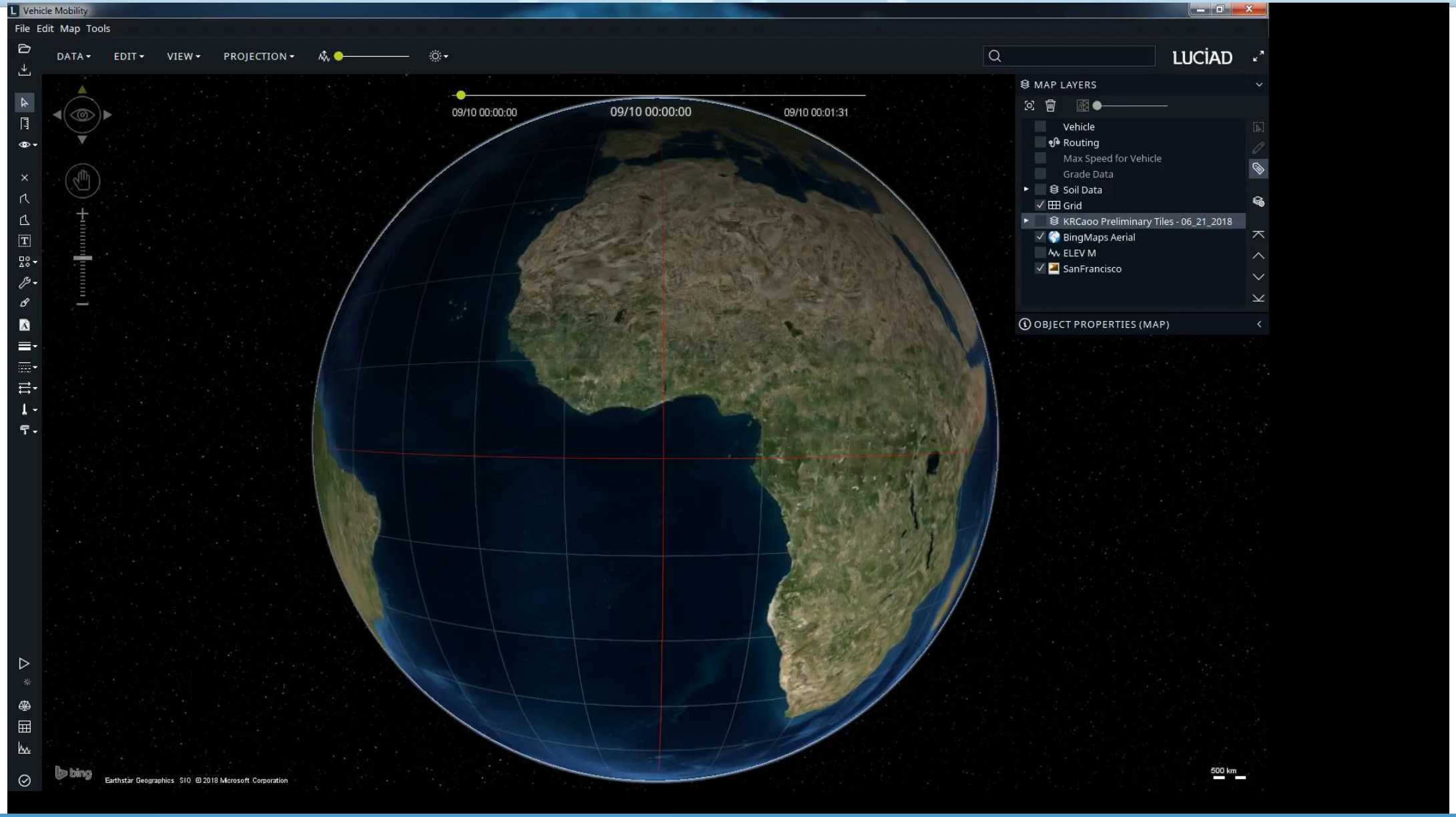
Elevation

- Custom App in Lucy Framework
- Custom Map Layers
- Generate Go/No-Go
- Custom Routing Algorithm

HEXAGON GEOSPATIAL

Mapping, Visualization, Route planning Environment



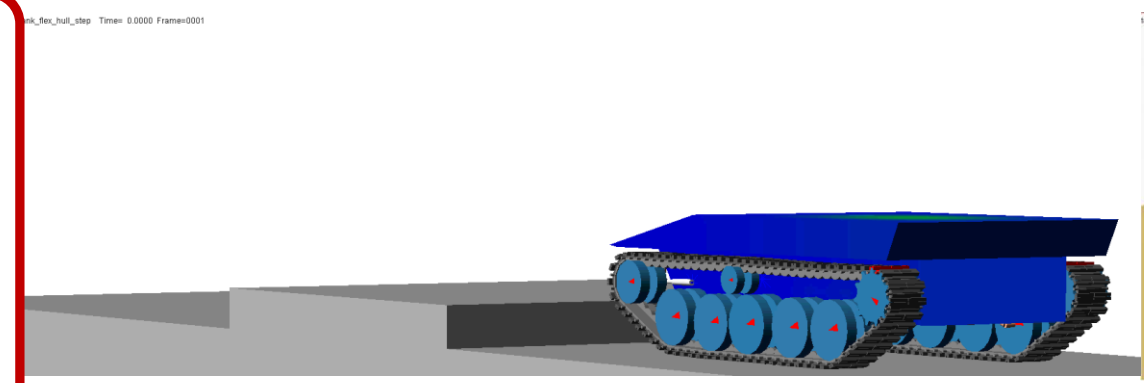

Vehicle Mobility
File Edit Map Tools
DATA
EDIT
VIEW
PROJECTION
LUCiAD
09/10 00:00:00
09/10 00:00:00
09/10 00:01:31
MAP LAYERS
Vehicle
Routing
Max Speed for Vehicle
Grade Data
Soil Data
Grid
KRCaoo Preliminary Tiles - 06_21_2018
BingMaps Aerial
ELEV M
SanFrancisco
OBJECT PROPERTIES (MAP)
bing
Earthstar Geographics SIO © 2018 Microsoft Corporation
500 km

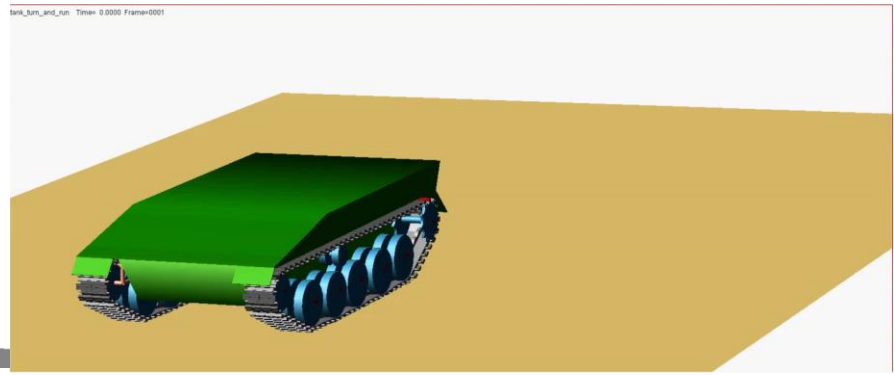
What About Tracks?

MSC Software

Adams Tracked Vehicle (ATV) toolkit

- **Detailed track modeling**
- **Rigid or soft-soil ground**
- **Automated track wrapping**
- **Extensible template-based approach**
- **Global user-base:**
  - Defense
  - Construction
  - Sport





What Next?

- **Continuous Improvement …**
  - Terrain issues – Formats, vegetation
  - Soil characterization:
    - Testing at vehicle-scale loads and geometry
    - Simplified terramechanics: theory vs practice
    - Complex terramechanics: characterization, scaling
  - Tire Details – soil/obstacle interaction
  - Methods maturity for terramechanics

- **To Discuss leveraging MSC technology for your Mobility Requirements:**

Eric Pesheck, PhD Eric.Pesheck@mscsoftware.com,
MSC Simulation Services: **734-546-4634**

MSC Software

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