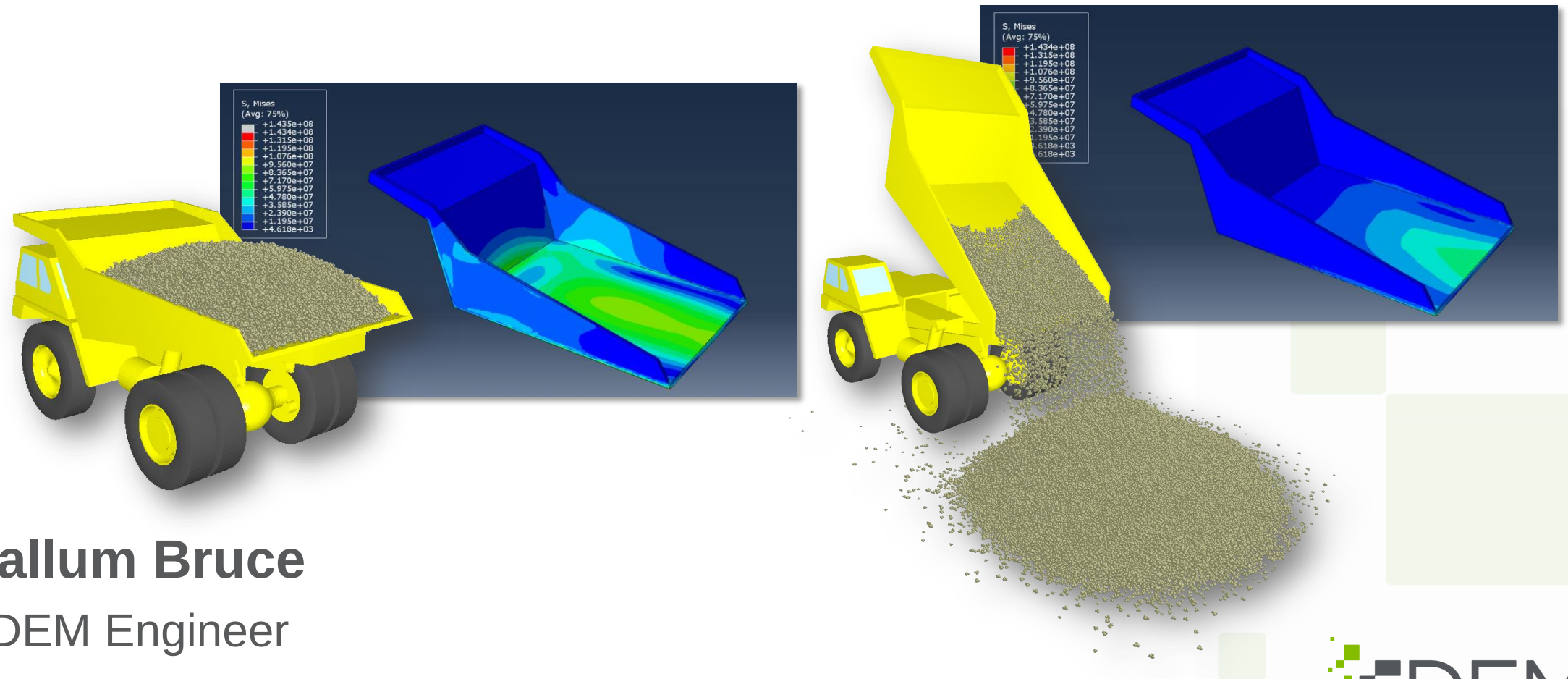




Simulate material. Deliver results.

# Abaqus-EDEM Coupling: Virtual Equipment Design using Realistic Bulk Material Loads

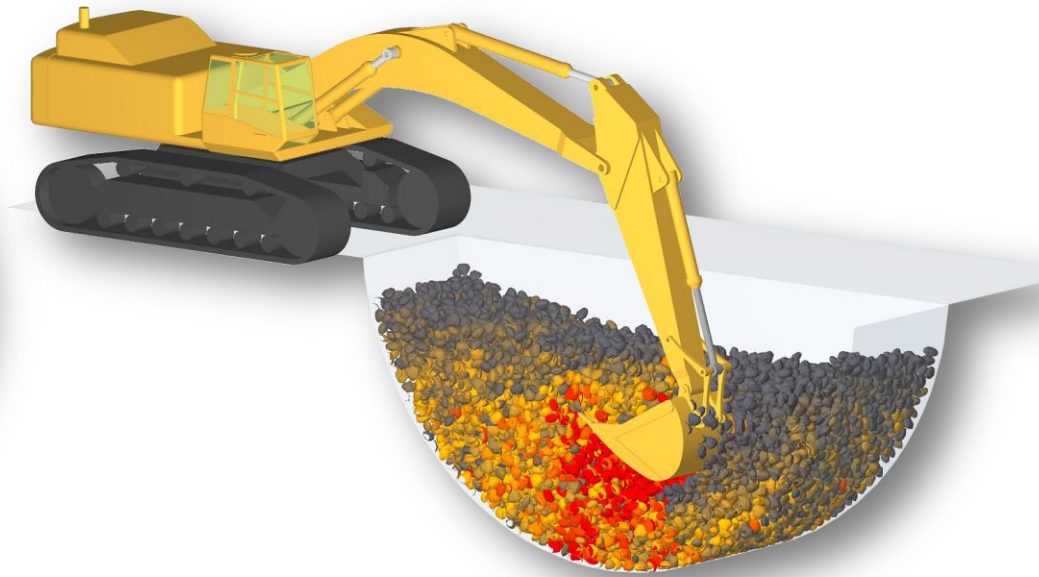
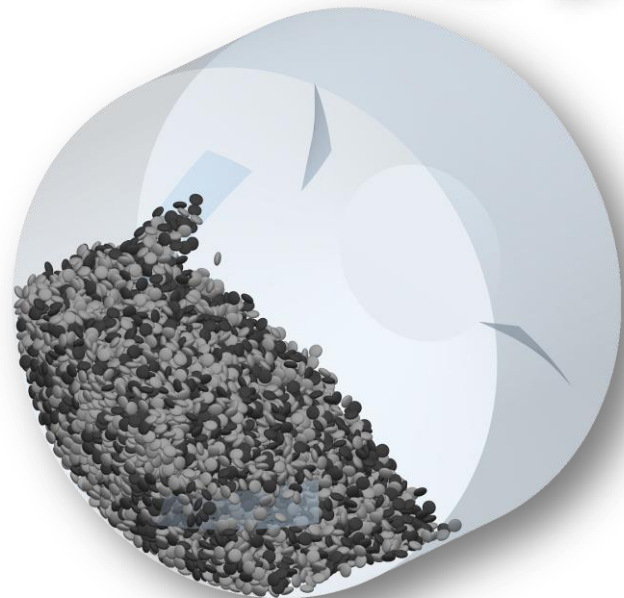


**Callum Bruce**  
EDEM Engineer

# What is EDEM?



- Bulk material **simulation** software
- Powered by **Discrete Element Modelling** (DEM) technology
- Used for **virtual testing** of equipment design

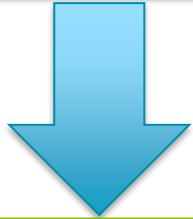


# A World of Bulk Materials



# The Challenge of Bulk Materials

Material type and behavior  
results in forces on equipment

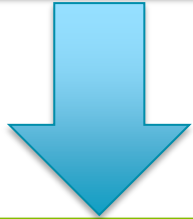


Material force cause stresses  
and strains in the system,  
influencing structural integrity  
and performance



# The Challenge of Bulk Materials

Material type and behavior  
results in forces on equipment



Material force cause stresses  
and strains in the system,  
influencing structural integrity  
and performance



# The Challenge of Bulk Materials



**Large Lumps -  
Limestone**



**Dry Fine -  
Sand**

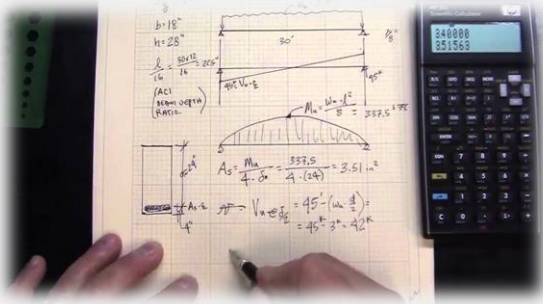


**Stick, Cohesive -  
Mined ores, Clay**



# Designing for Bulk Materials

## Hand Calculation, Experience



### Equipment Loads:

- Estimate material loads
- Low-fidelity, especially over time dependent events

## Incorporate Test Data



### Equipment Loads:

- Loads from experiments
- Constant or variable loads
- Requires suitable physical test

**How to get accurate loads for complex materials and different operating conditions?**



### Skid Steer Loader

Courtesy of DSIM Technologies



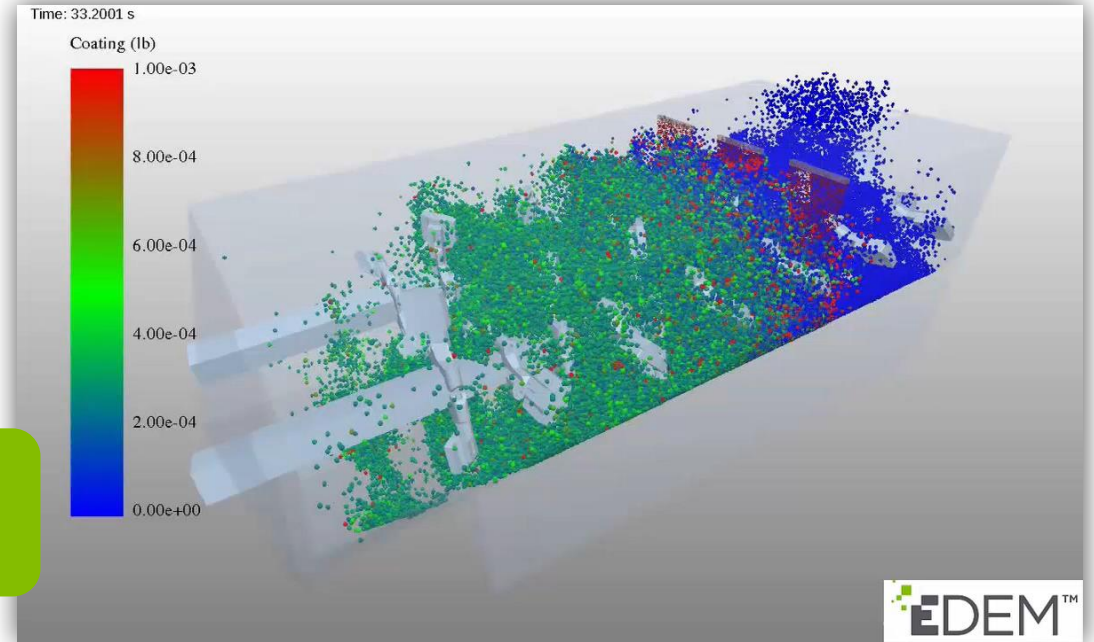
Gravel



Woodchips

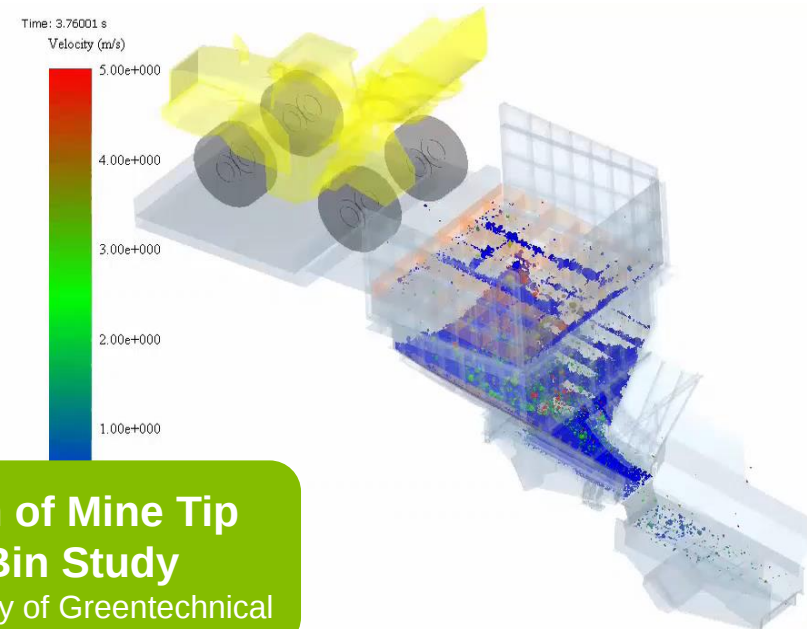
### Asphalt Coating

Courtesy of Astec Industries



### Run of Mine Tip Bin Study

Courtesy of Greentechnical



# EDEM: Realistic Bulk Materials Simulation



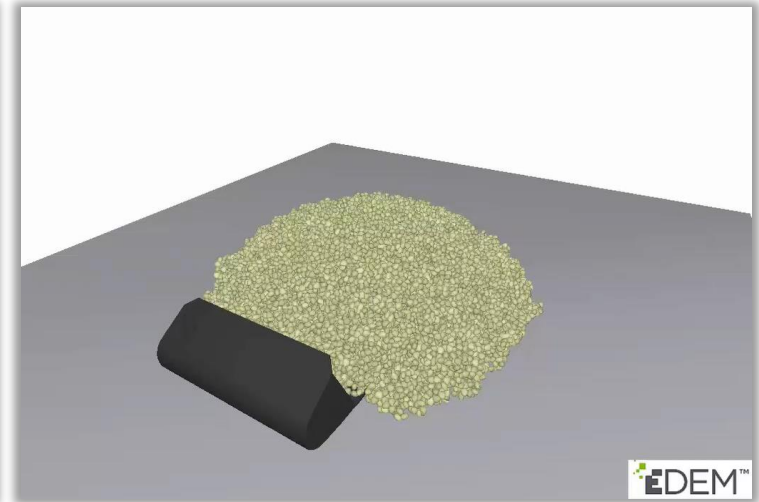
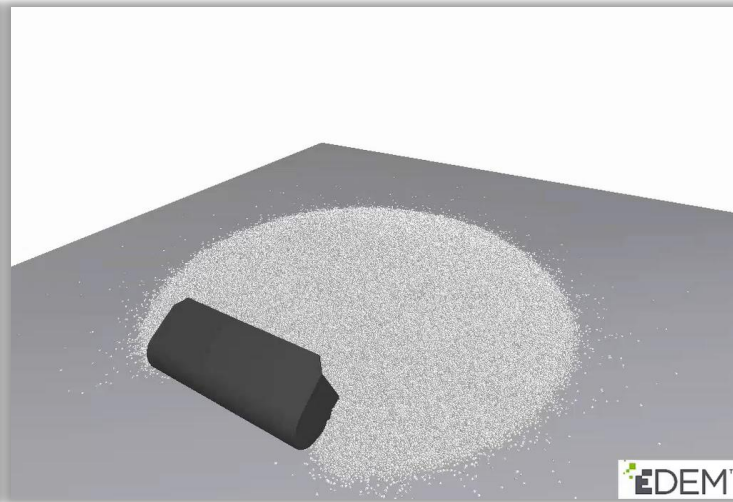
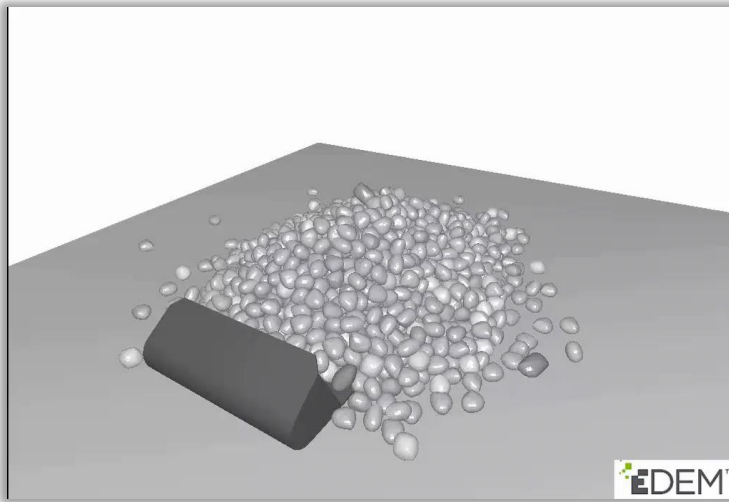
Large Lumps, Rough



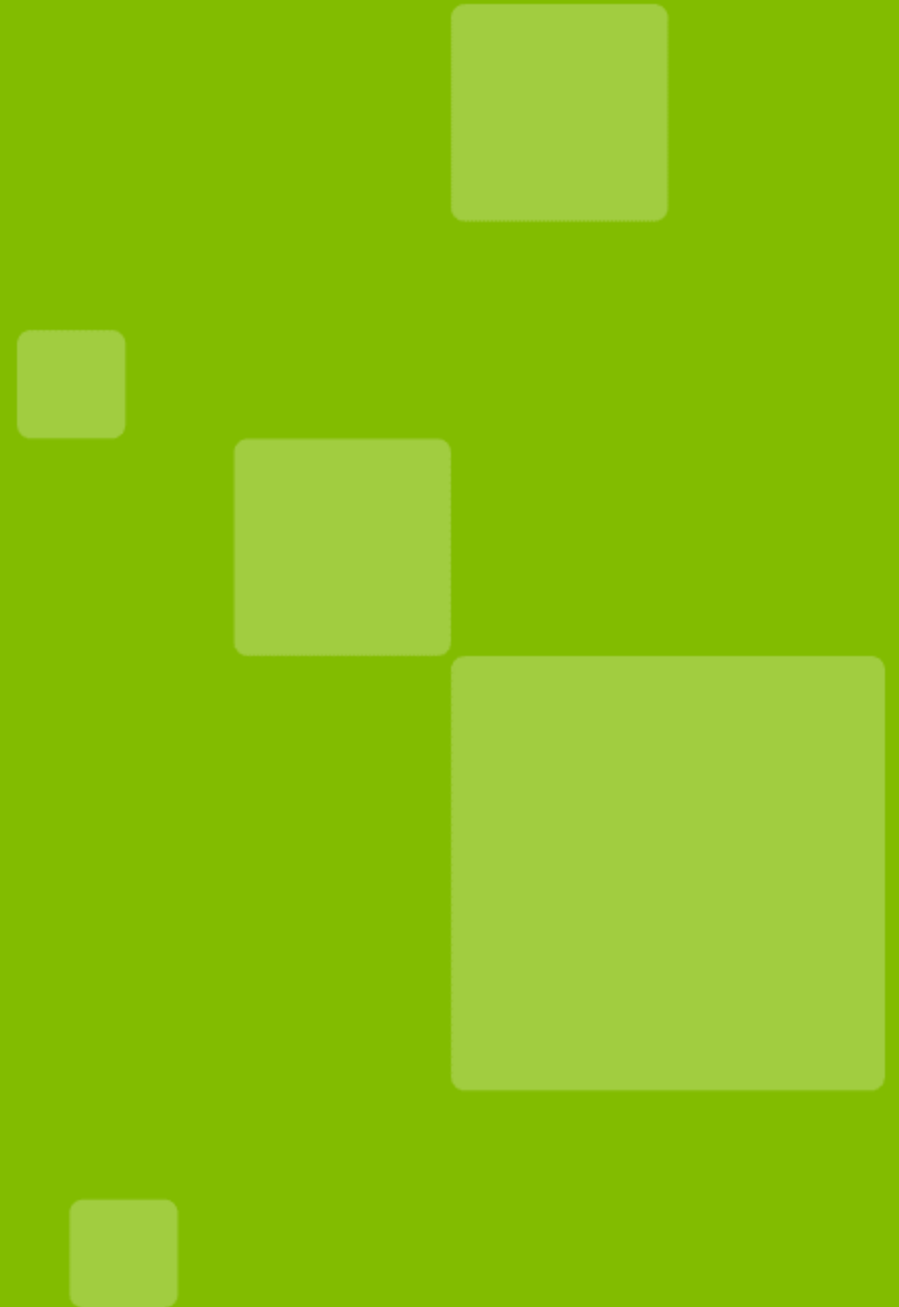
Fine grade, Loose



Sticky, Cohesive, Resistant

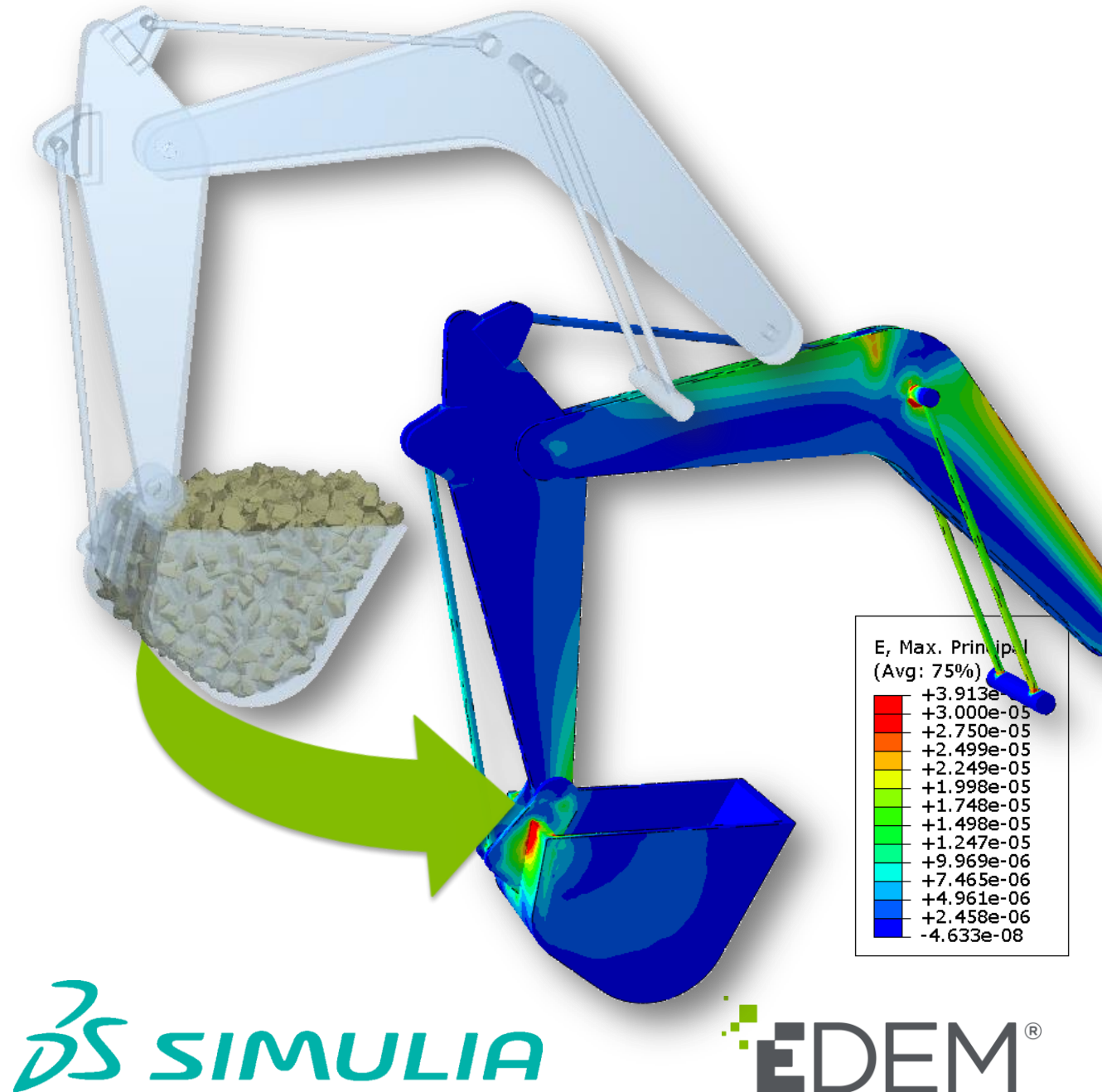


# Introducing EDEM-Abaqus Coupling



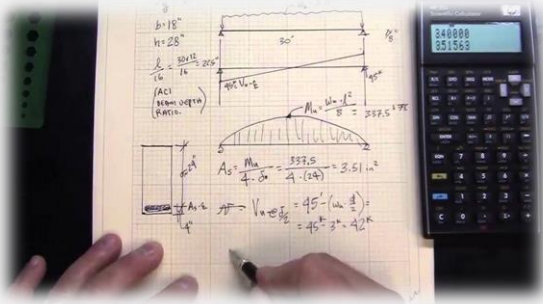
# EDEM-Abaqus Coupling

- Enables realistic EDEM material forces acting on equipment to be used in Abaqus FE analysis
- Replaces need for rough estimates of material loads
- Streamlined workflow - automatically call Abaqus from inside EDEM
- Perform realistic design analysis early in the design cycle



# EDEM-Abaqus Coupling: CAE Based Design Approach

## Hand Calculation, Experience



### Equipment Loads:

- Estimate material loads
- Low-fidelity, especially over time dependent events

## Incorporate Test Data



### Equipment Loads:

- Loads from experiments
- Constant or variable loads
- Requires suitable physical test

## CAE Based Design

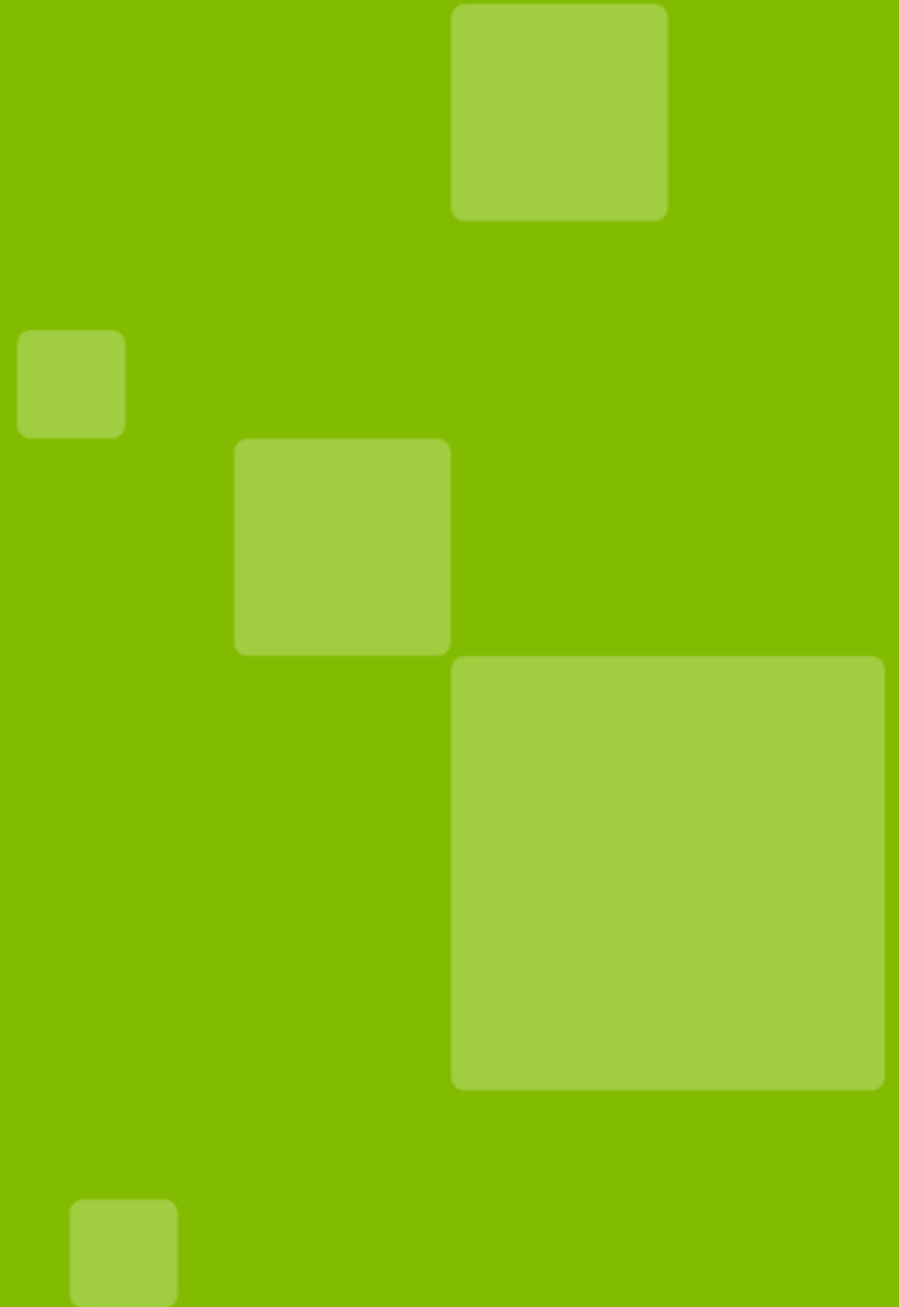


### Equipment Loads:

- Realistic material loads without physical testing
- Design for a range of materials
- Broad 'what-if' analysis

# **Workflow:**

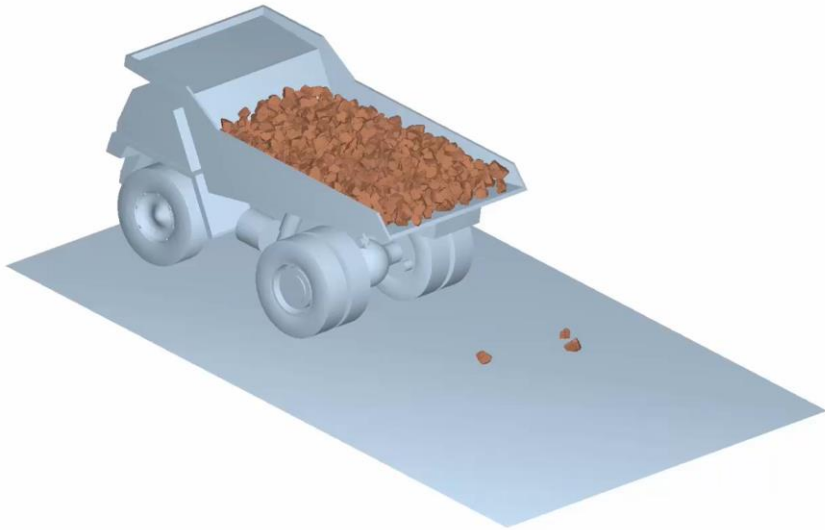
## **EDEM-Abaqus Coupling**



# Workflow

## 1. Set-up and run EDEM simulation

Time: 10.5009 s



Import your CAD equipment



Define bulk material



[www.edemsimulation.com/gemm](http://www.edemsimulation.com/gemm)



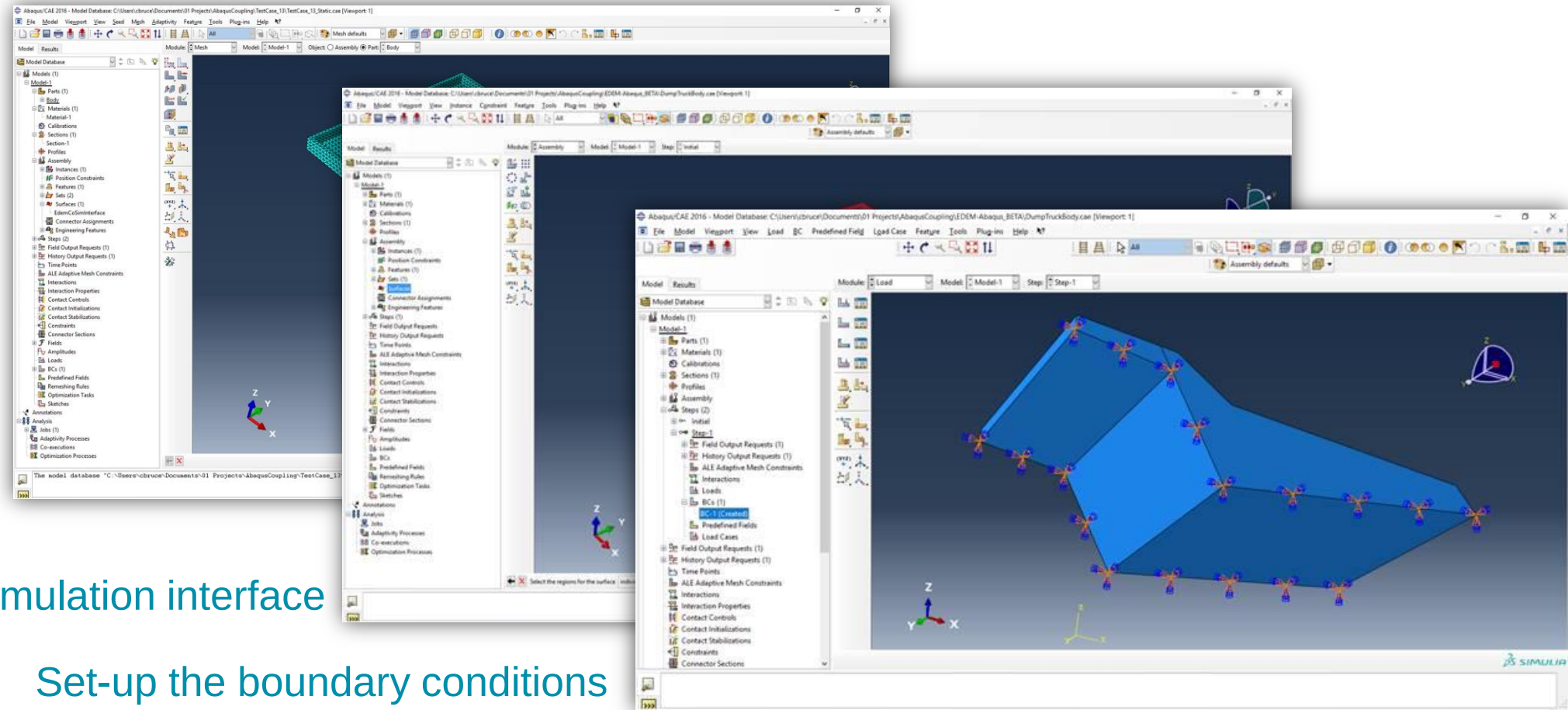
# Workflow

## 2. Set-up the Abaqus simulation

Mesh the parts

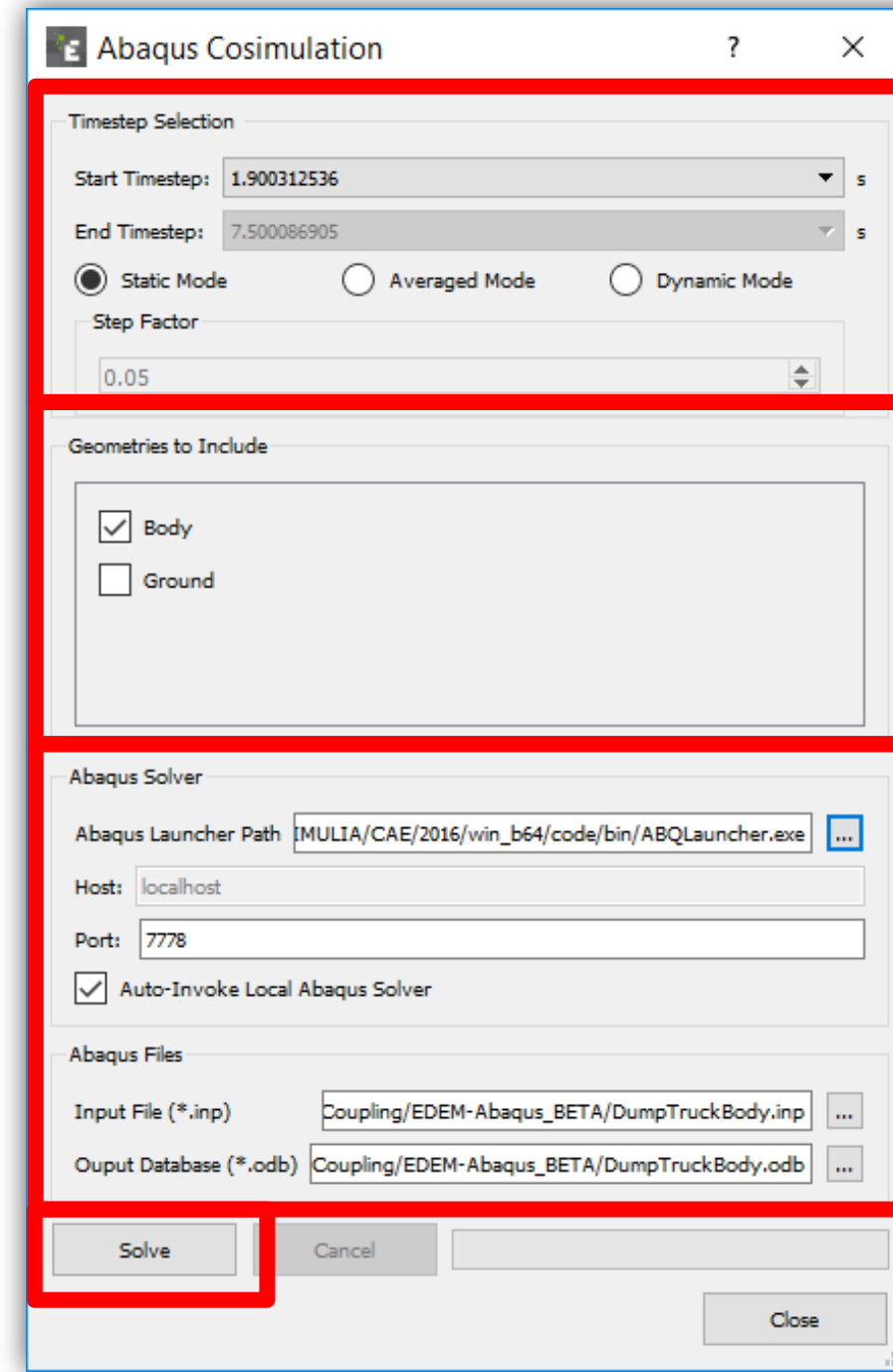
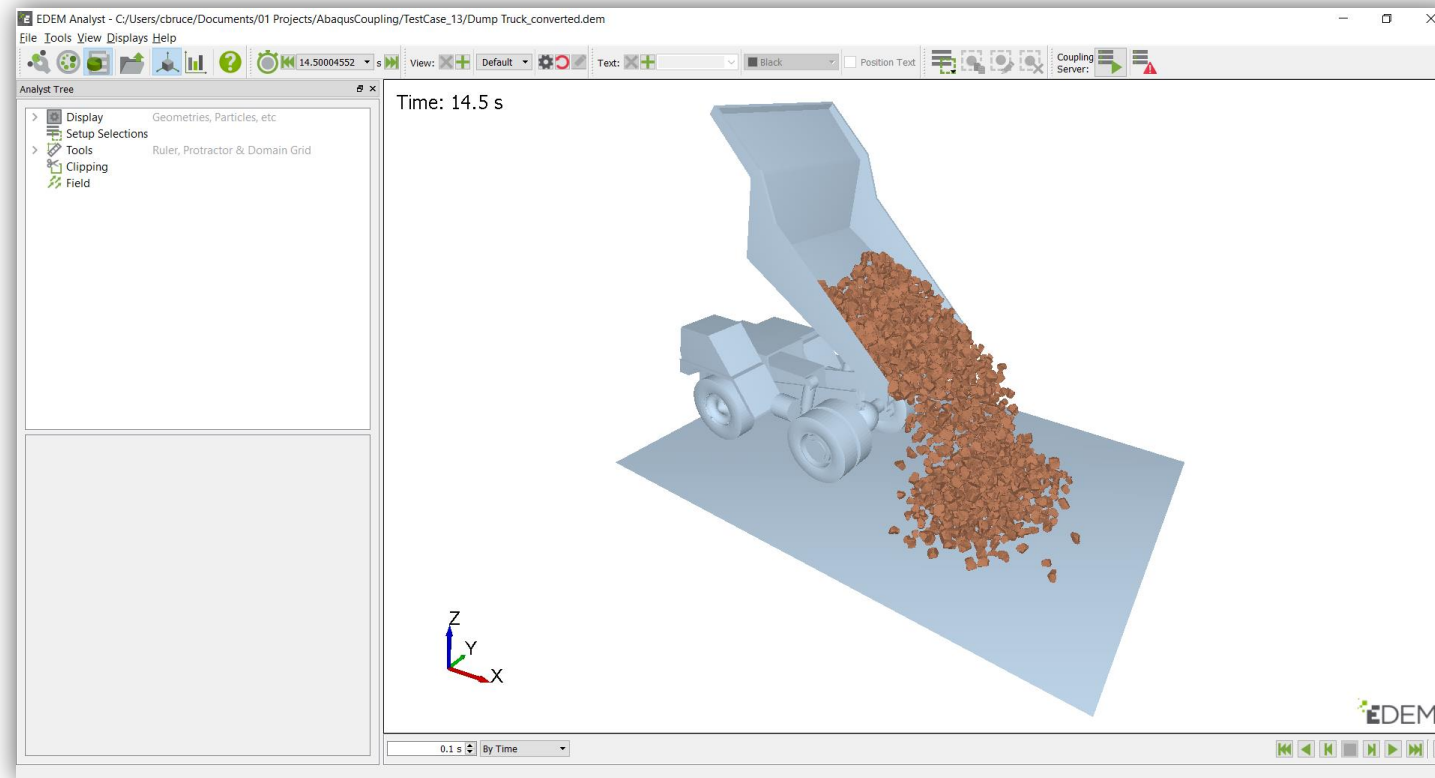
Define the co-simulation interface

Set-up the boundary conditions



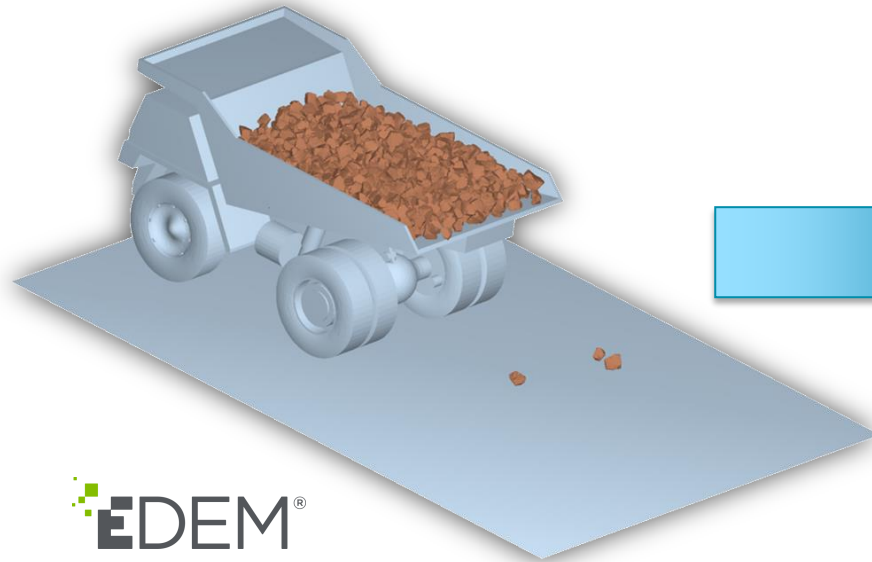
# Workflow

## 3. Choose EDEM data to transfer into Abaqus

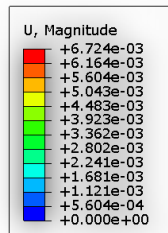
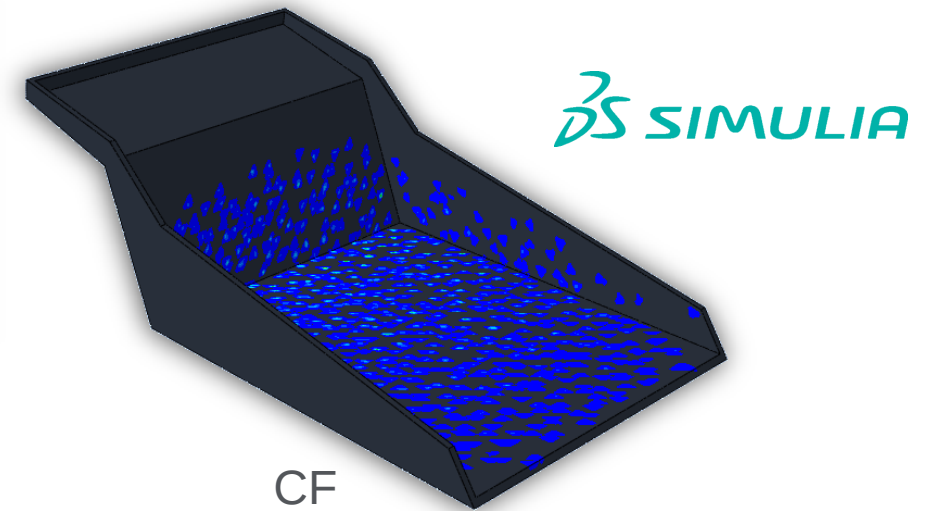
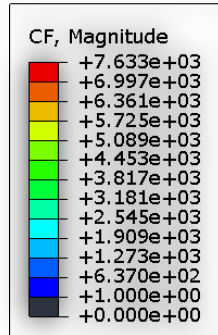


# Workflow

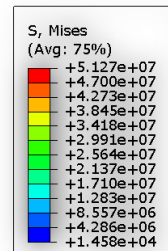
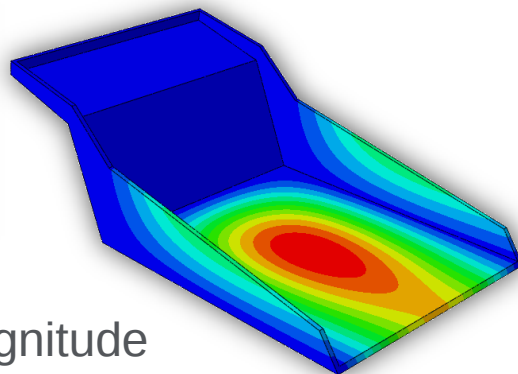
## 4. Solve!



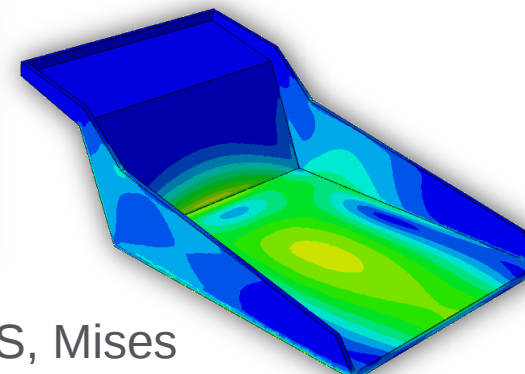
Contact forces mapped onto Abaqus mesh



U, Magnitude



S, Mises

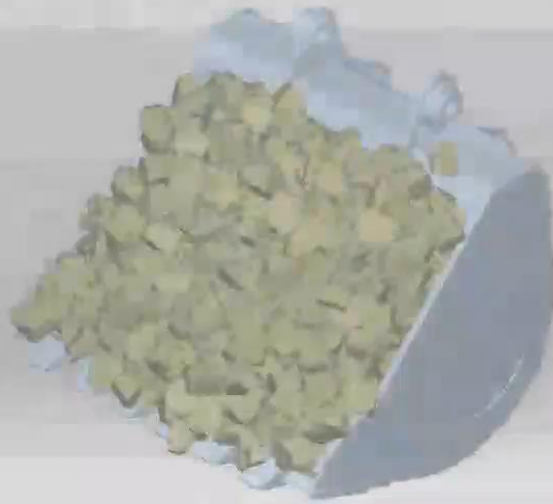


## Examples:

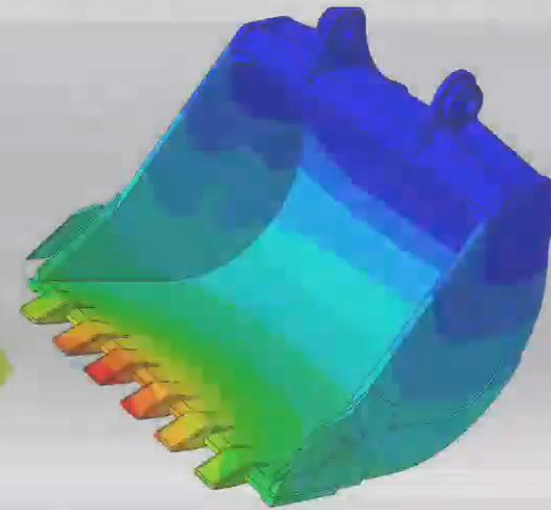
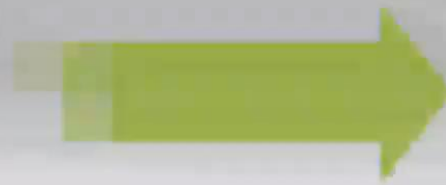
- **Excavator**
- **Mini-Dozer**

# Excavator

Analysis of an  
under Realistic

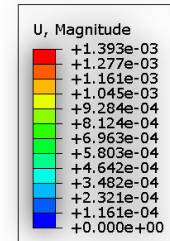
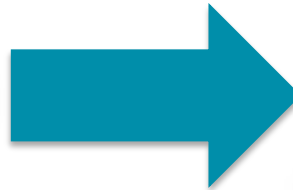


 **EDEM**<sup>TM</sup>

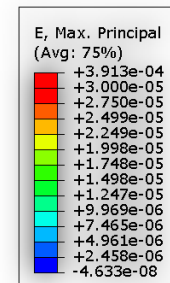
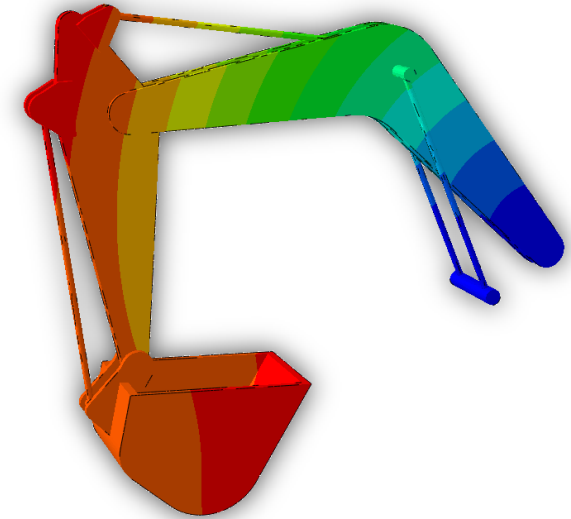


 **SIMULIA**

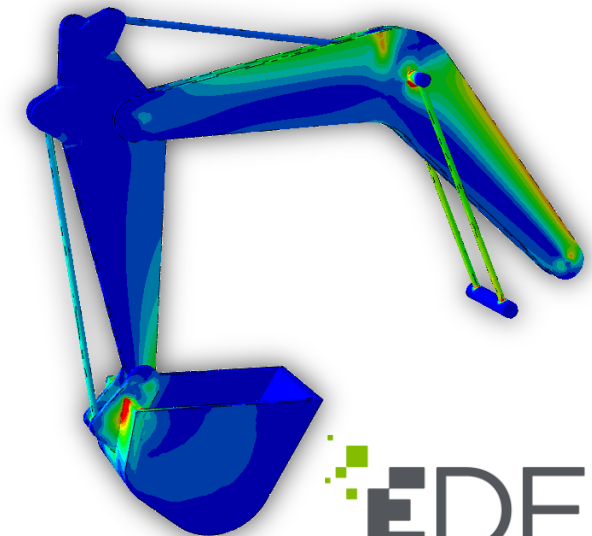
# System Analysis: Excavator



U, Magnitude

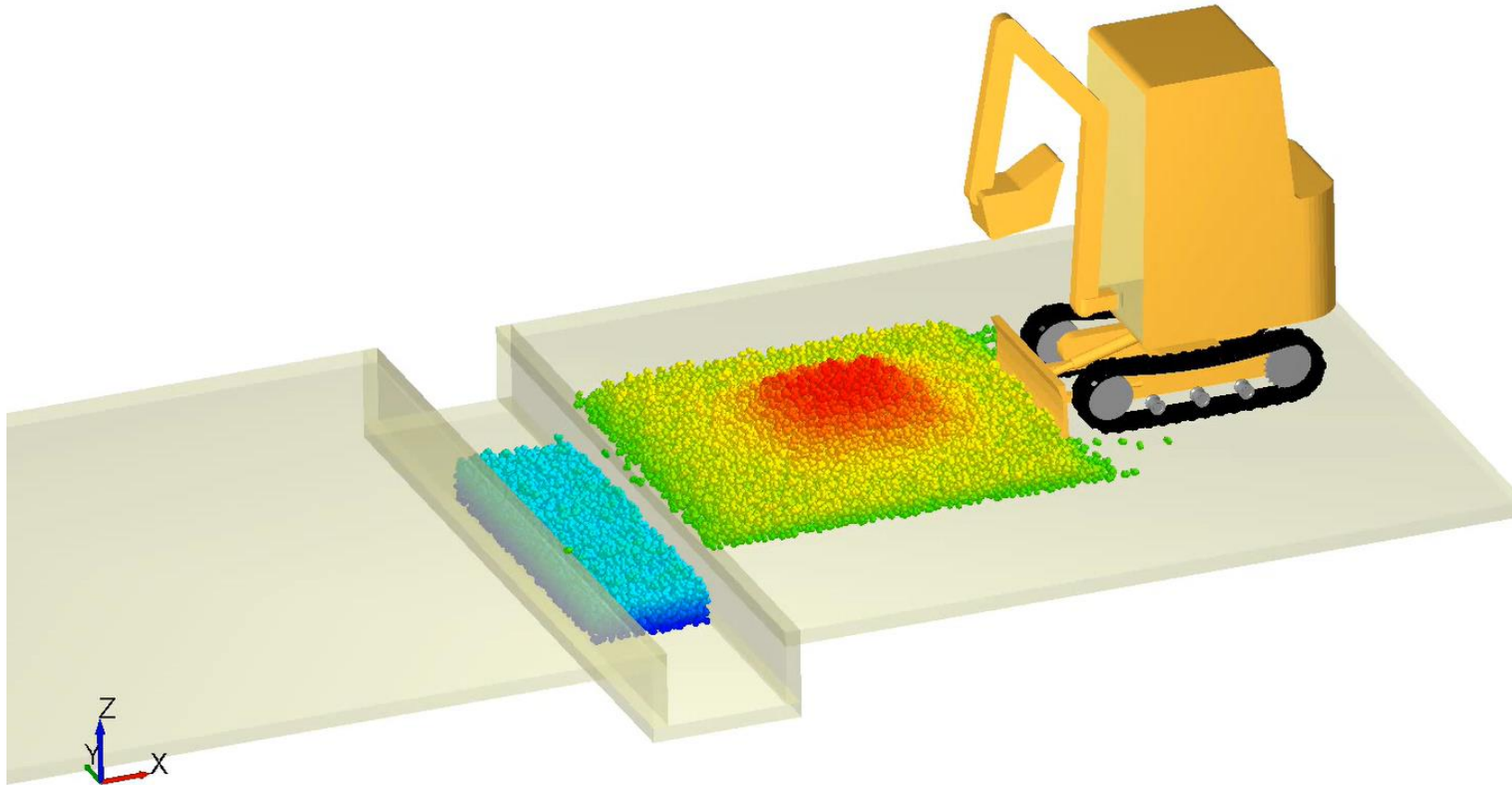


E, Max Principal



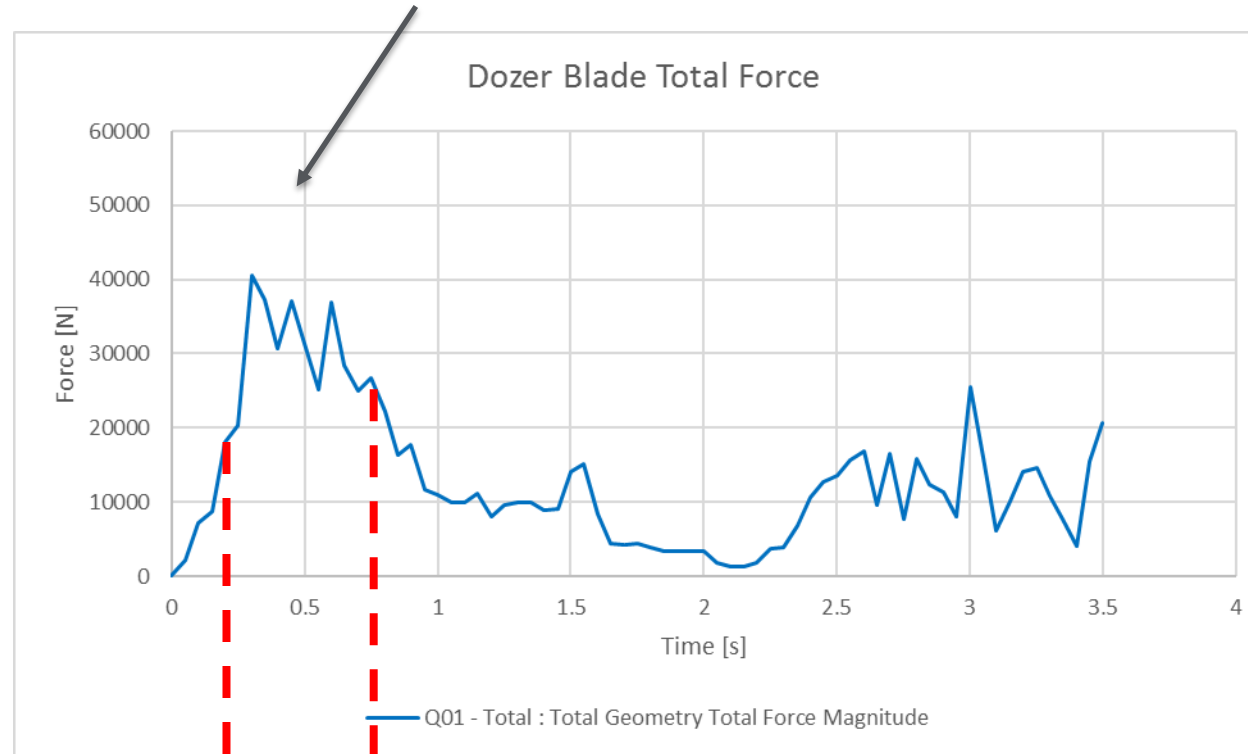
# Mini-Dozer: Dry Soil

Time: 0.0501738 s



# Mini-Dozer: Dry Soil

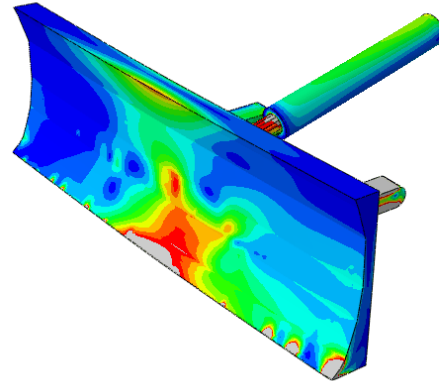
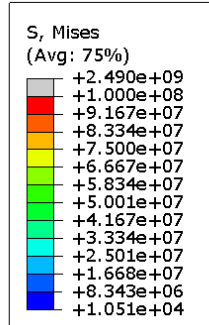
1) Max load on excavator blade at ~ 0.3s (Static Mode)



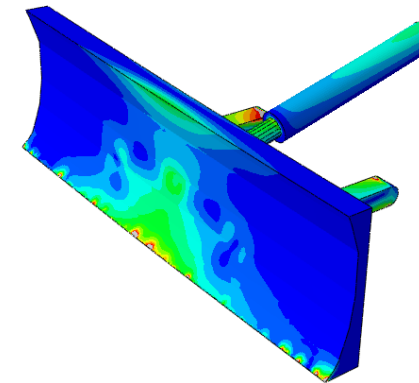
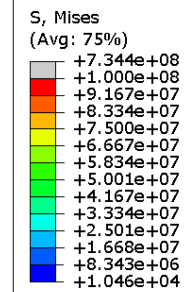
2) Average load on excavator blade between 0.2s to 0.8s (Average Mode)

# Mini-Dozer: Dry Soil

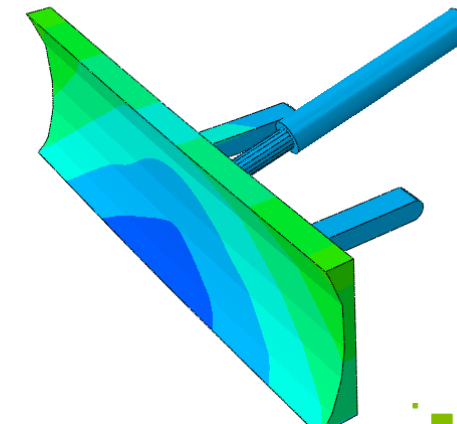
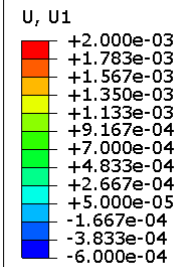
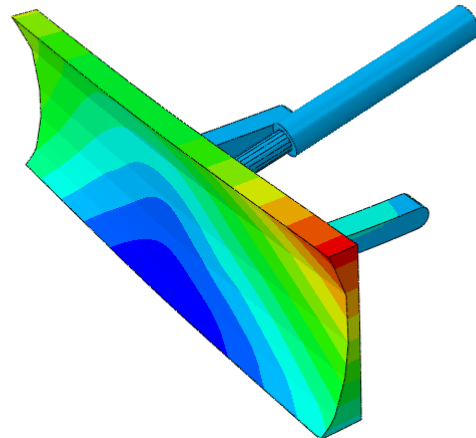
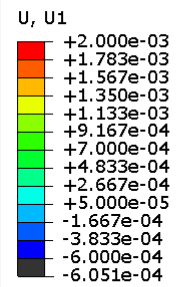
Static at 0.3s



Averaged at 0.2s to 0.8s



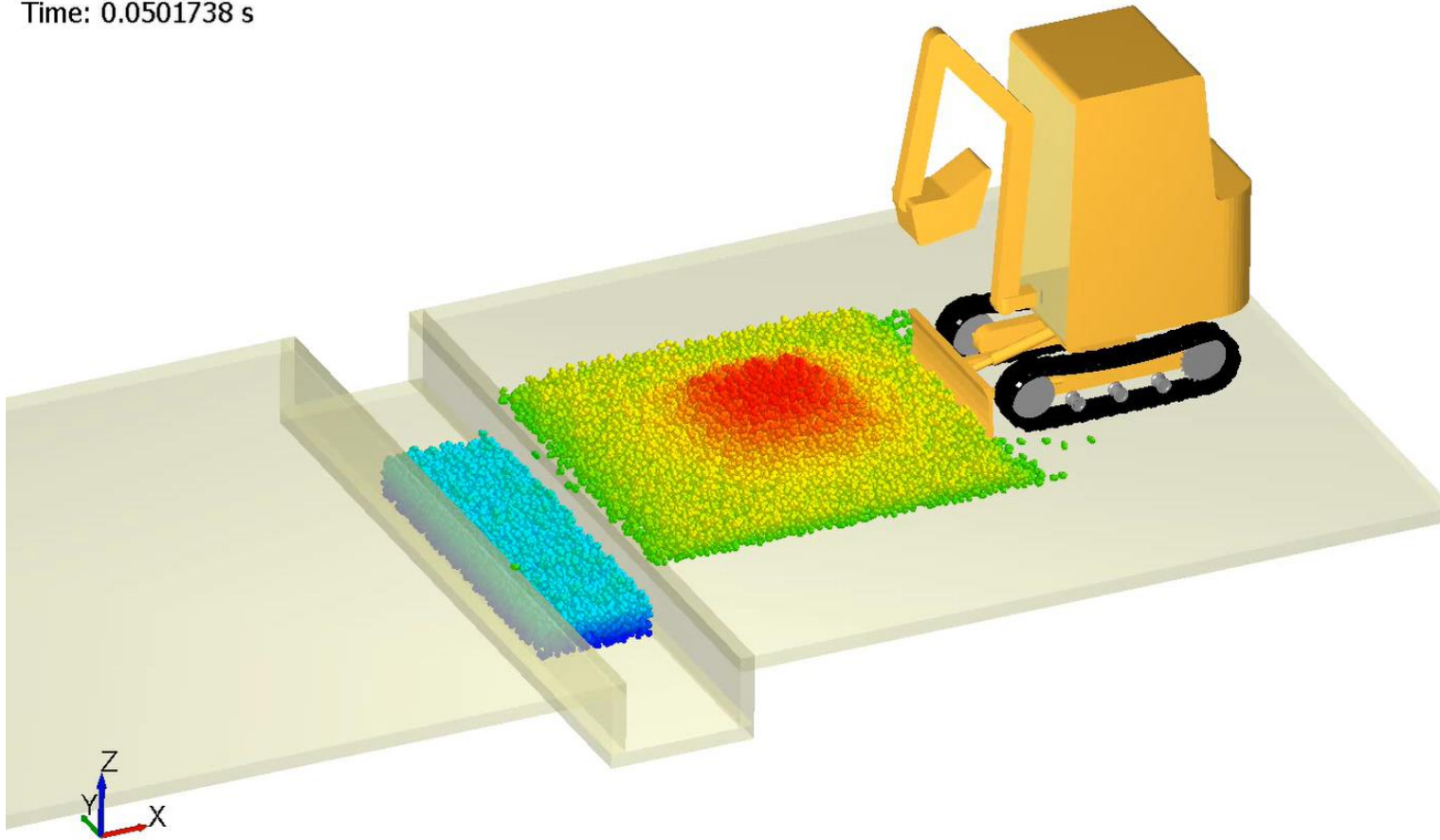
Stress, Mises



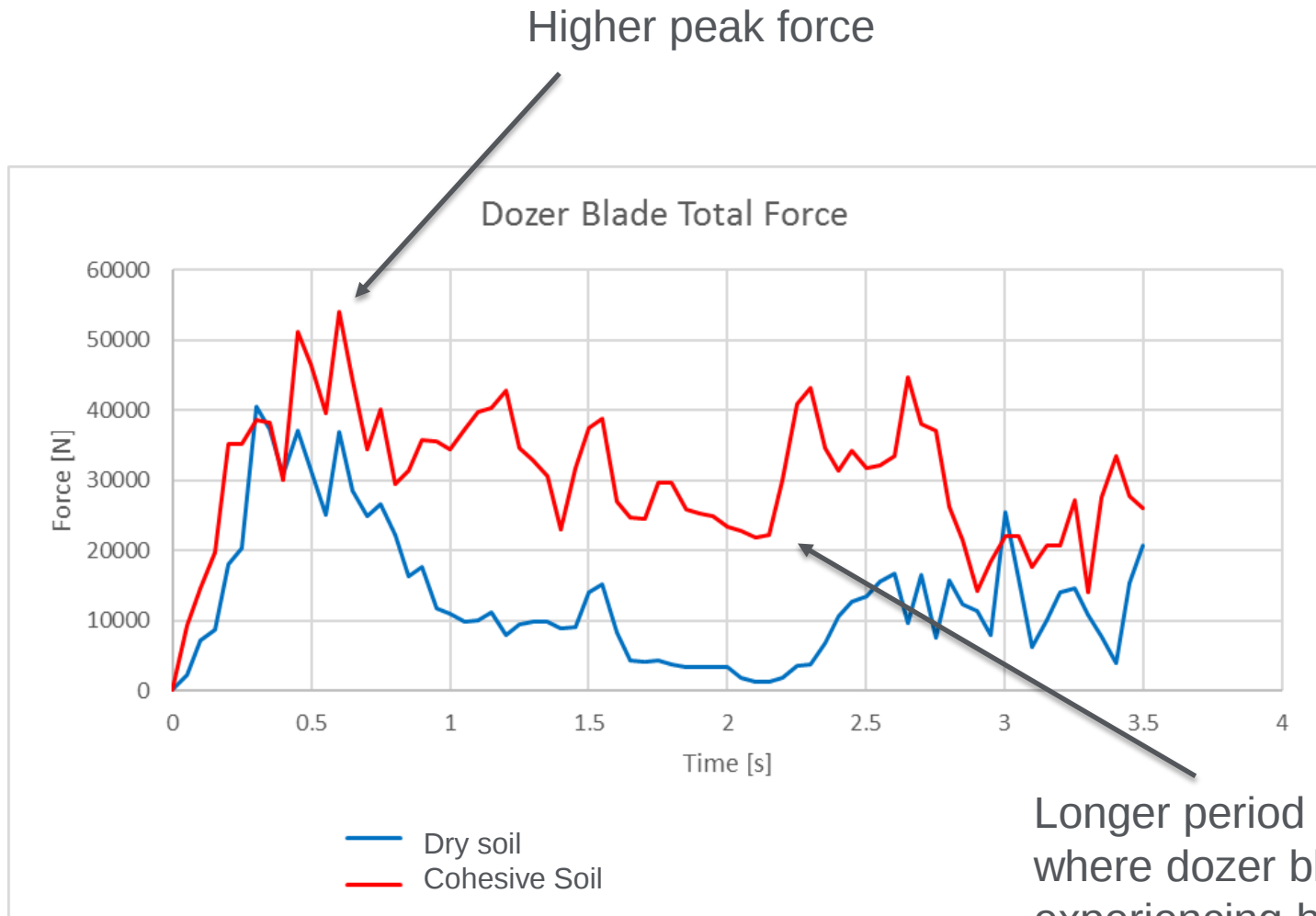
Deformation

# Mini-Dozer: Cohesive Soil

Time: 0.0501738 s

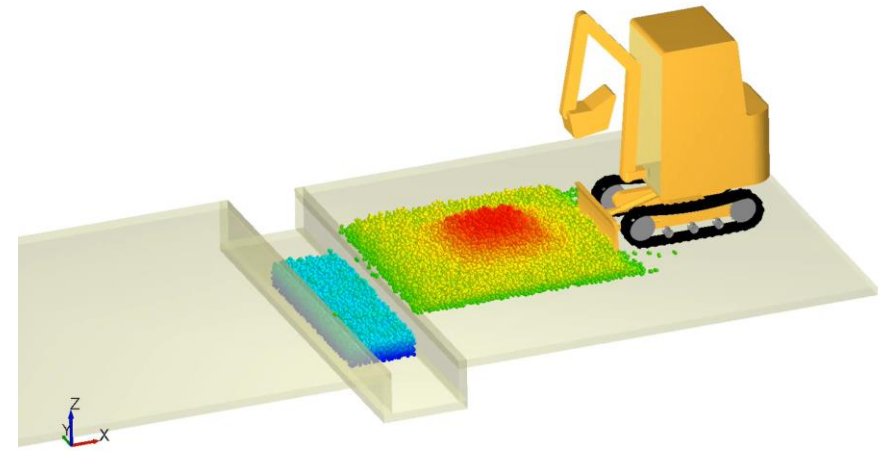


# Mini-Dozer: Cohesive Soil



Longer period of time  
where dozer blade is  
experiencing higher  
loads

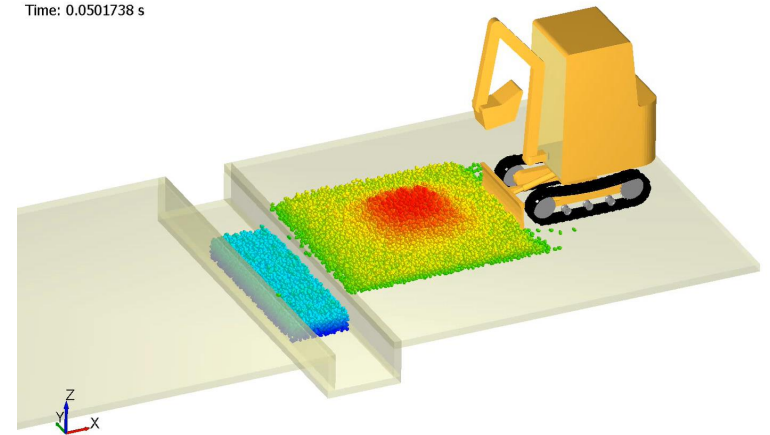
Time: 0.0501738 s



EDEM™

Dry soil

Time: 0.0501738 s



EDEM™

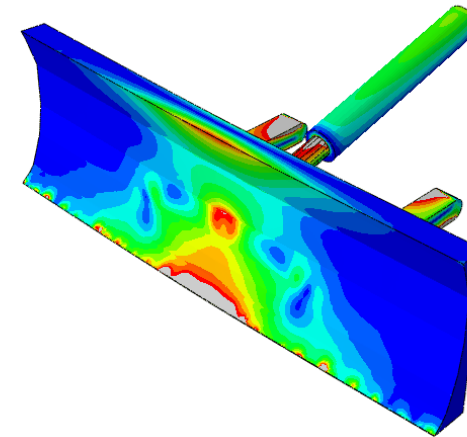
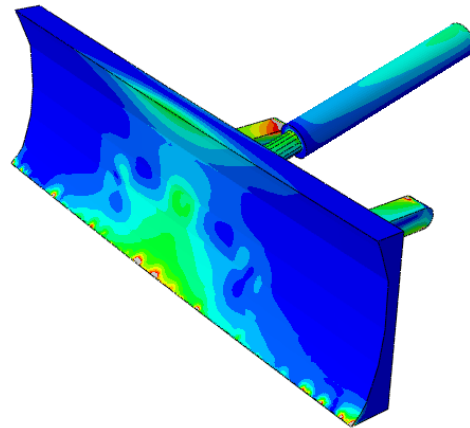
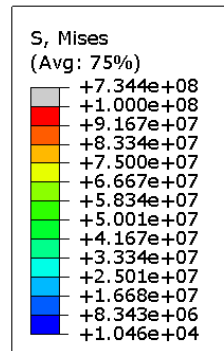
Cohesive soil

EDEM®

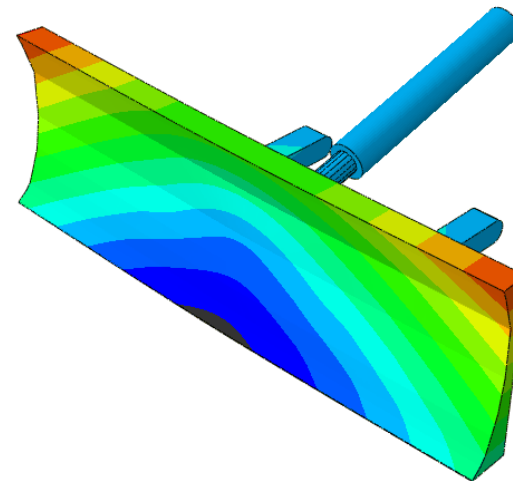
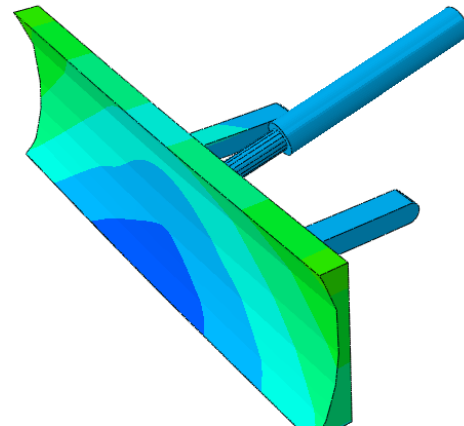
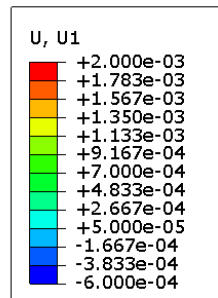
# Mini-Dozer: Dry vs Cohesive Soil

Dry Soil

Cohesive Soil



Stress, Mises

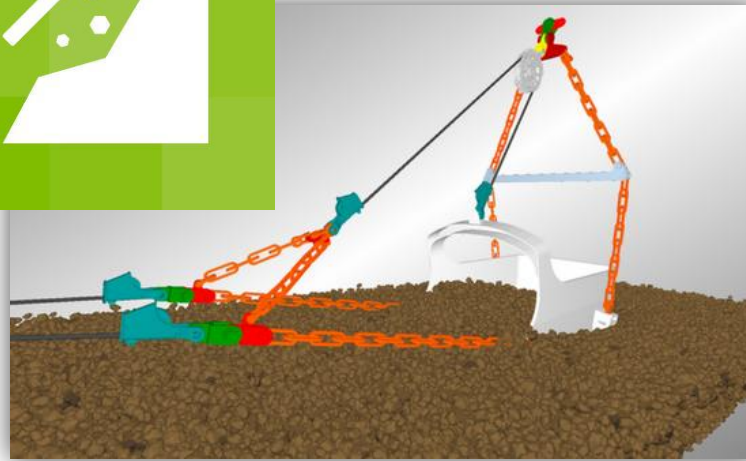


Deformation

# Applications

## Construction & Agricultural

Wheel loaders & excavators, backhoes, tracked vehicles, tillage, grain harvesters and combines, augers



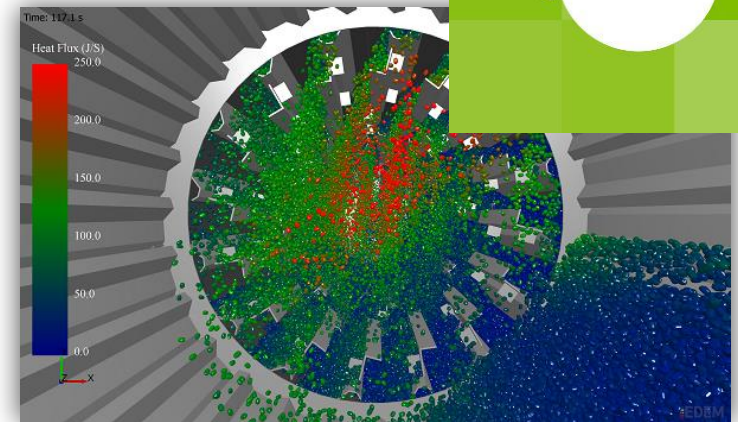
## Mining

Long-wall shearers, drag line excavators, transfer chutes, crushers, mills, screens



## Process & Food

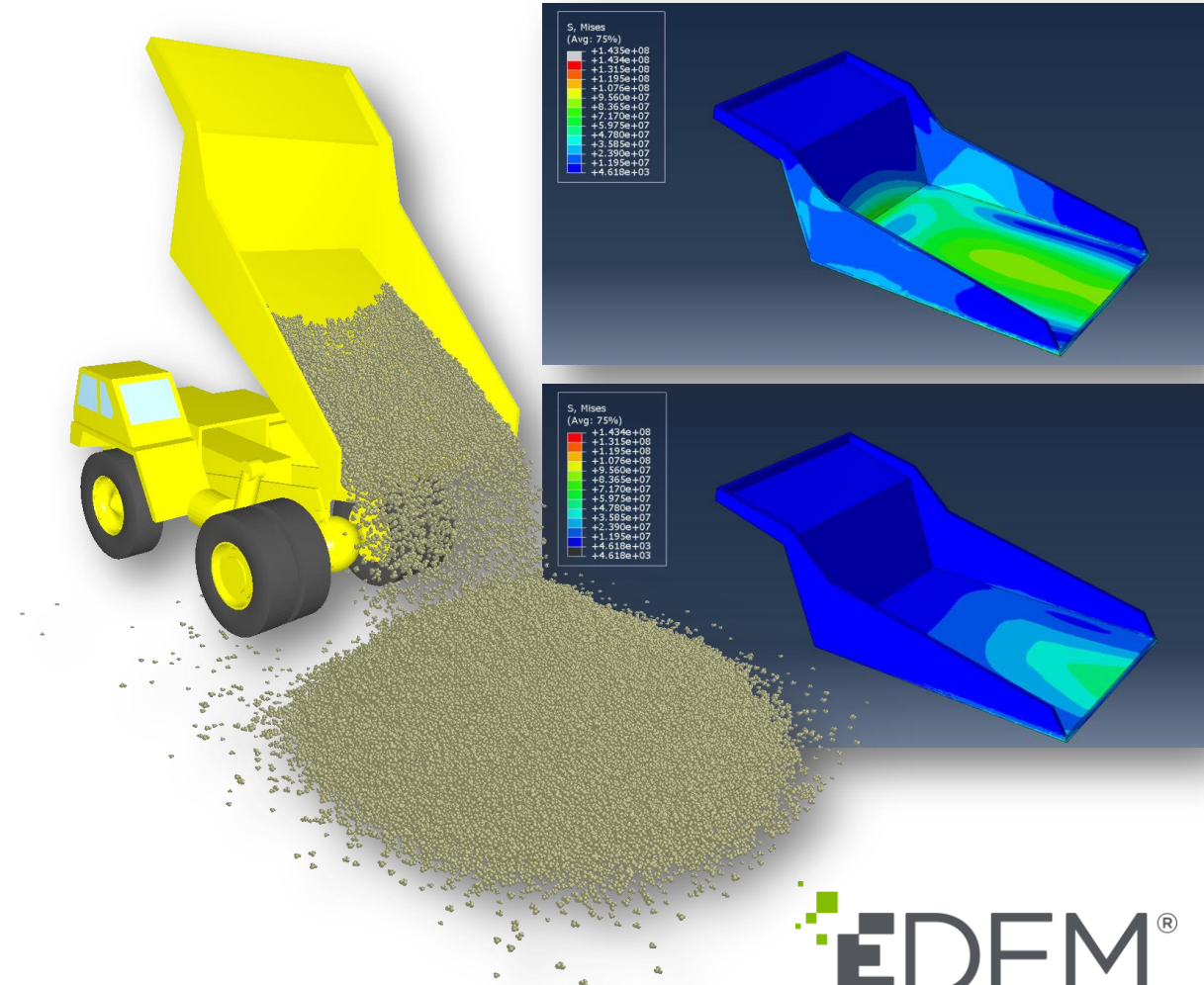
Mixers, tablet coating, powder handling and processing, conveying, filling devices, driers



# Summary

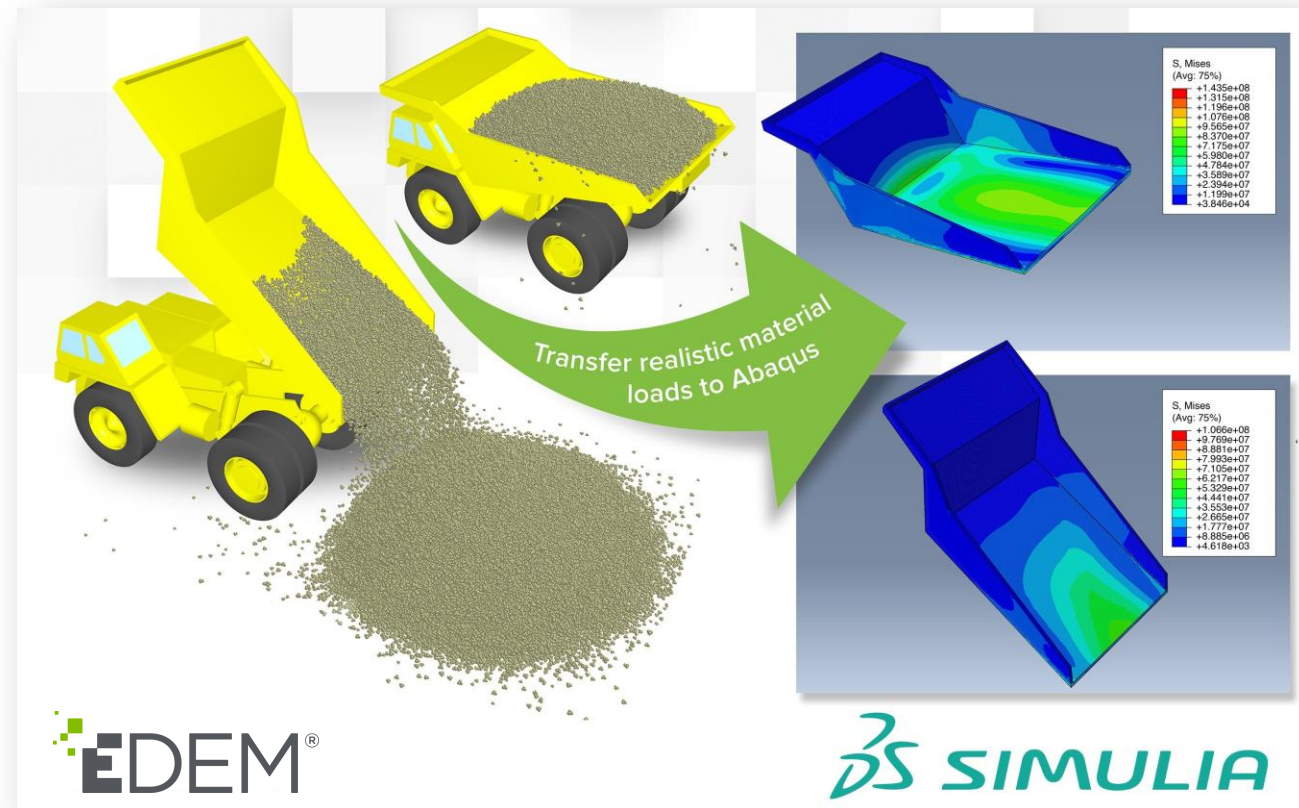
## EDEM Abaqus coupling provides new insights into equipment design

- Replace simplified material assumptions in FE analysis
- Use realistic material behaviors and loads as standard
- Insight into equipment performance early in design cycle
- Improve design accuracy and reduce prototyping



Thank you for listening!

To learn more come  
see us at booth 22!



[www.edemsimulation.com](http://www.edemsimulation.com)

[callum.bruce@edemsimulation.com](mailto:callum.bruce@edemsimulation.com)





Simulate material. Deliver results.