



**DatapointLabs**

technical center for materials

+

**matereality**  
a DatapointLabs affiliate

materialsphere

**Materials**

**Testing x Software x Data Infrastructure**

EST 1995

ISO  
17025  
Quality



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**matereality**



# Providing an Experimental Basis in Support of FEA

Hubert Lobo



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# Heritage

- 1986 - Cornell Injection Molding Program (CIMP)
  - Research: Properties of molten plastics for CAE
- 1995 - Datapoint Testing Services
  - Commercialization: Properties of plastics for molding CAE
- 1998 - TestPaks Alliance Program
  - Partnerships with FEA companies – properties & modeling for FEA
- 2000 - Company rebranded as DatapointLabs
  - Supporting 8 simulation codes for plastics
- 2002 - Matereality started
  - R&D to create multivariate material database for plastics
- 2014 - Today
  - Testing any materials any properties, supporting 34 CAE codes
  - Super-database+software to analyze and transform material data



# Trends

- CAE and the single physical prototype
- New, lighter materials replacing metals
  - Non-linear, multivariate behavior
  - Effect of processing and environment not considered
- Test data are part of Enterprise PLM core
  - Engineering knowledge is captured by the system
  - Globally accessible

# Single Physical Prototype Concept

- Adopt CAE
- Use accurate material representations
- Verify & Validate
  - Baseline correlation
- Perform upfront iterative virtual design
  - Simulate process
  - Simulate use
- Build and test single prototype

# Today's Materials Landscape

- Metals
- Plastics
- Rubber
- Foam
- Composite
- Paper

- Aerospace
- Automotive
- Appliance
- Biomedical
- Consumer products
- Electronics
- Industrial Goods
- Materials
- Petroleum
- Packaging



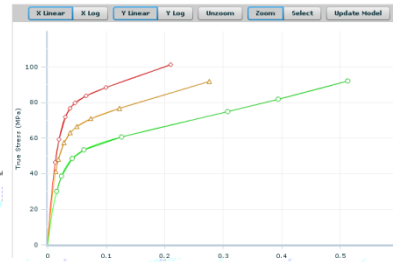
# Plastics FEA



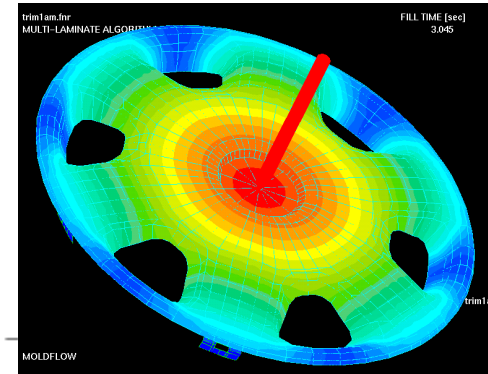
**plastics**



**testing**



**CAE conversion**



**Your CAE**

- Plastics testing and CAE material parameter conversion
  - Elastic, MISO, viscoelastic, creep, fatigue
  - High strain rate data for crash
  - Thermoforming/blowmolding properties
  - Injection-molding CAE data
  - DIGIMAT MX - directional properties for mold analysis to FEA



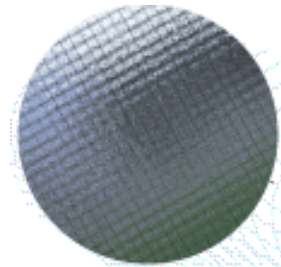
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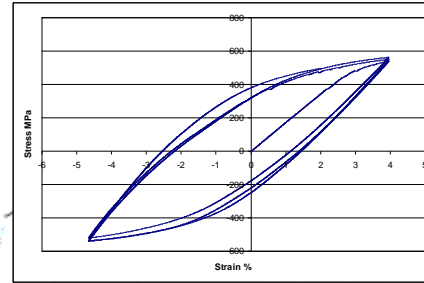
# Metals FEA



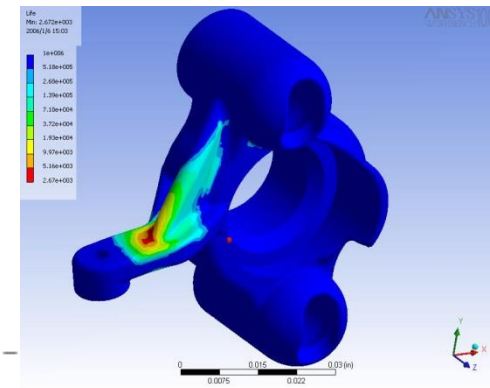
**metals**



**testing**



**CAE conversion**



**Your CAE**

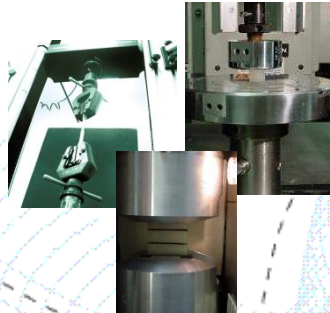
- Metal testing and CAE material parameter conversion
  - Elastic, elasto-plasticity, Chaboche (cyclic)
  - Lankford parameters
  - High strain rate data for crash



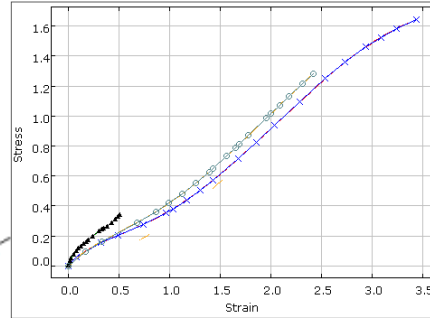
# Rubber FEA



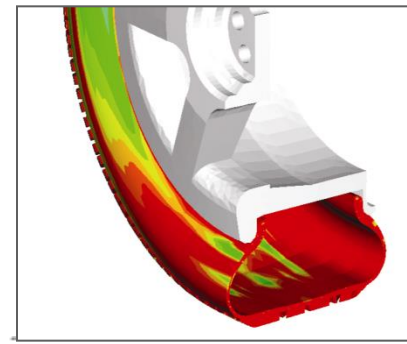
**rubber**



**test**



**conversion**



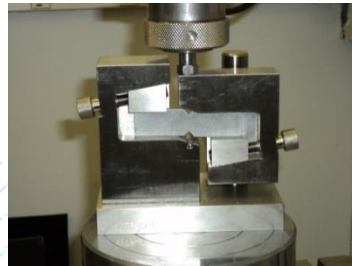
**Your CAE**

- Rubber testing and CAE material parameter conversion
  - Hyperelastic, viscoelastic, Ogden foam
  - High strain rate data for impact
  - -40C to 150C

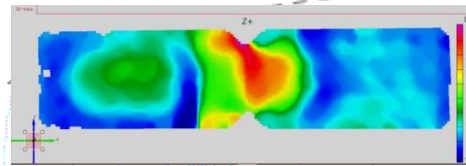
# Composites FEA



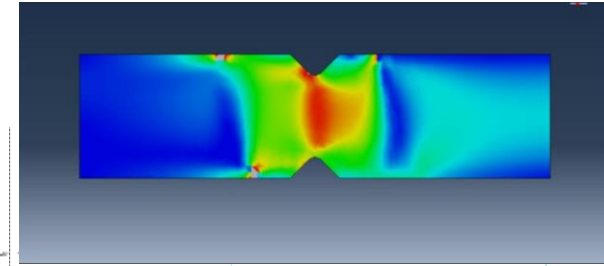
**composite**



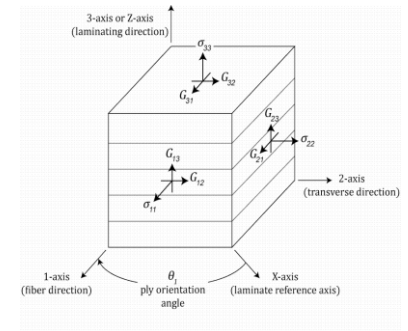
**testing**



**DIC conversion**



**Your CAE**



- Composite testing and CAE material parameter conversion
  - Directional shear moduli and failure
  - Directional elastic moduli



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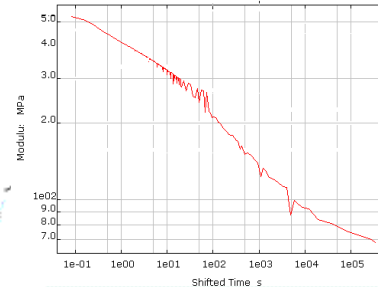
# Foams FEA



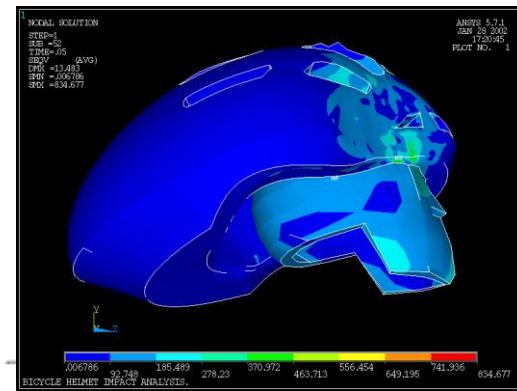
**foams**



**testing**



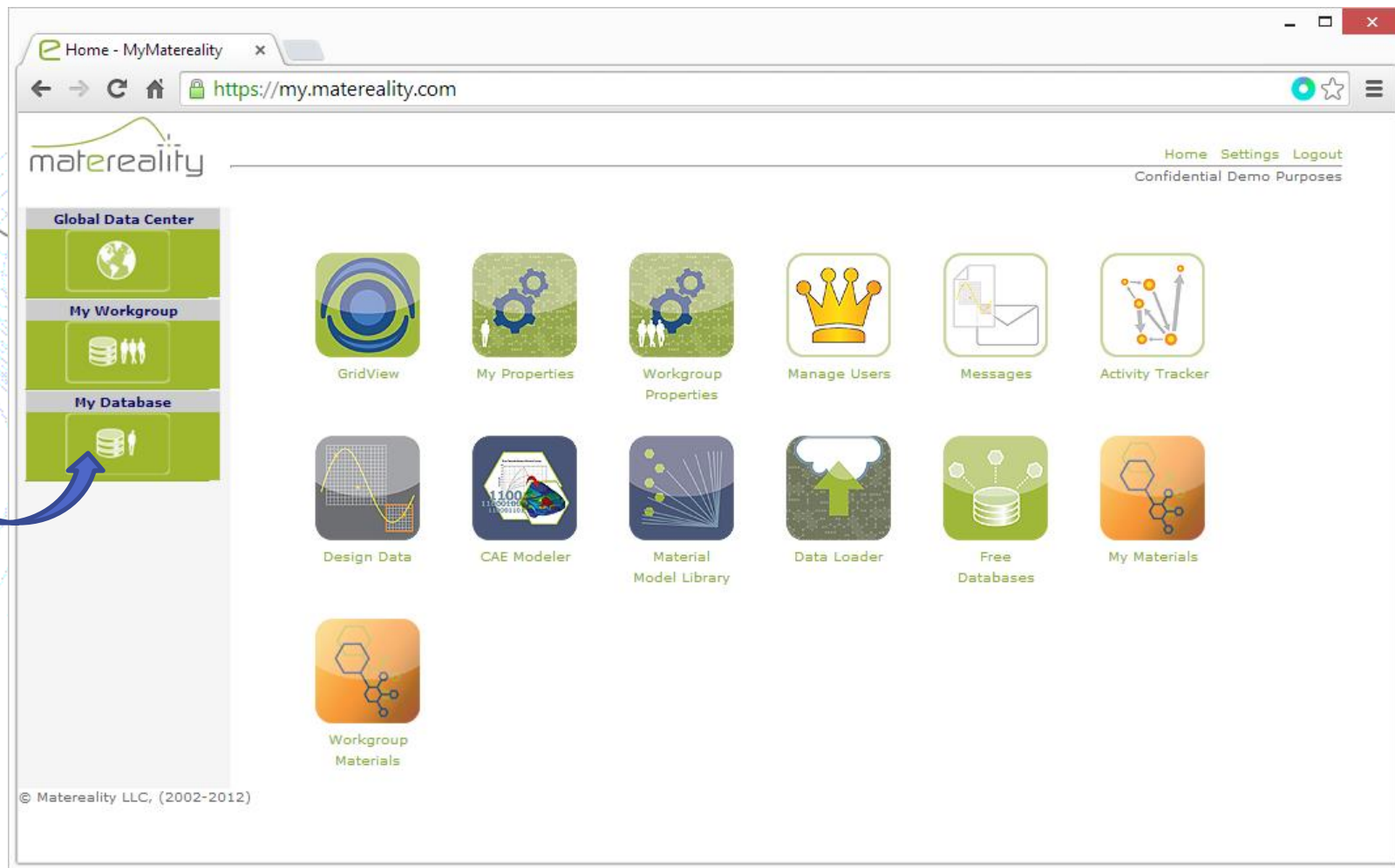
**conversion**



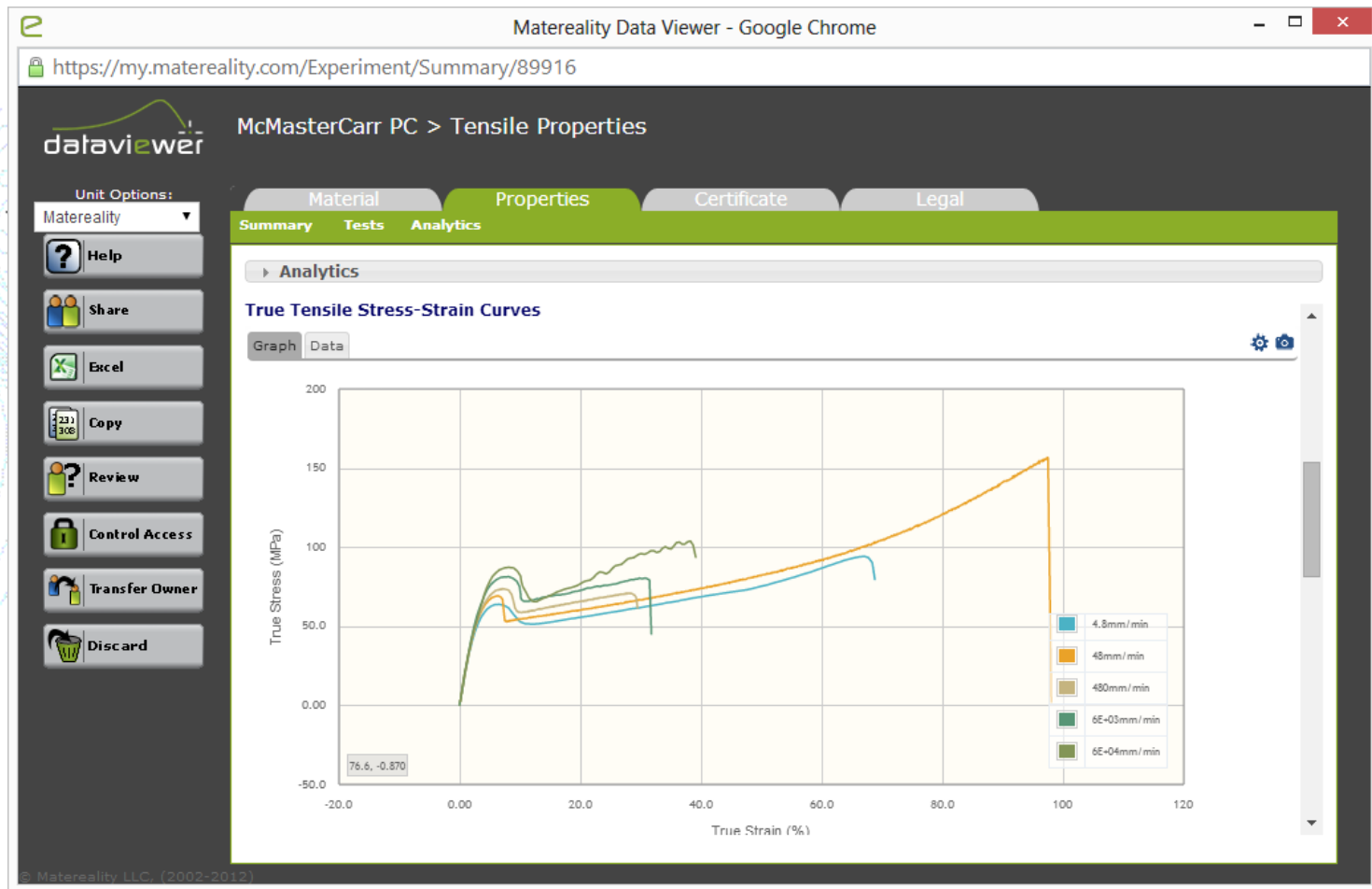
**Your CAE**

- Foam testing and CAE material parameter conversion
  - Ogden foam, anisotropic foam, viscoelasticity
  - High strain rate compression for crash

# We Upload Your Data

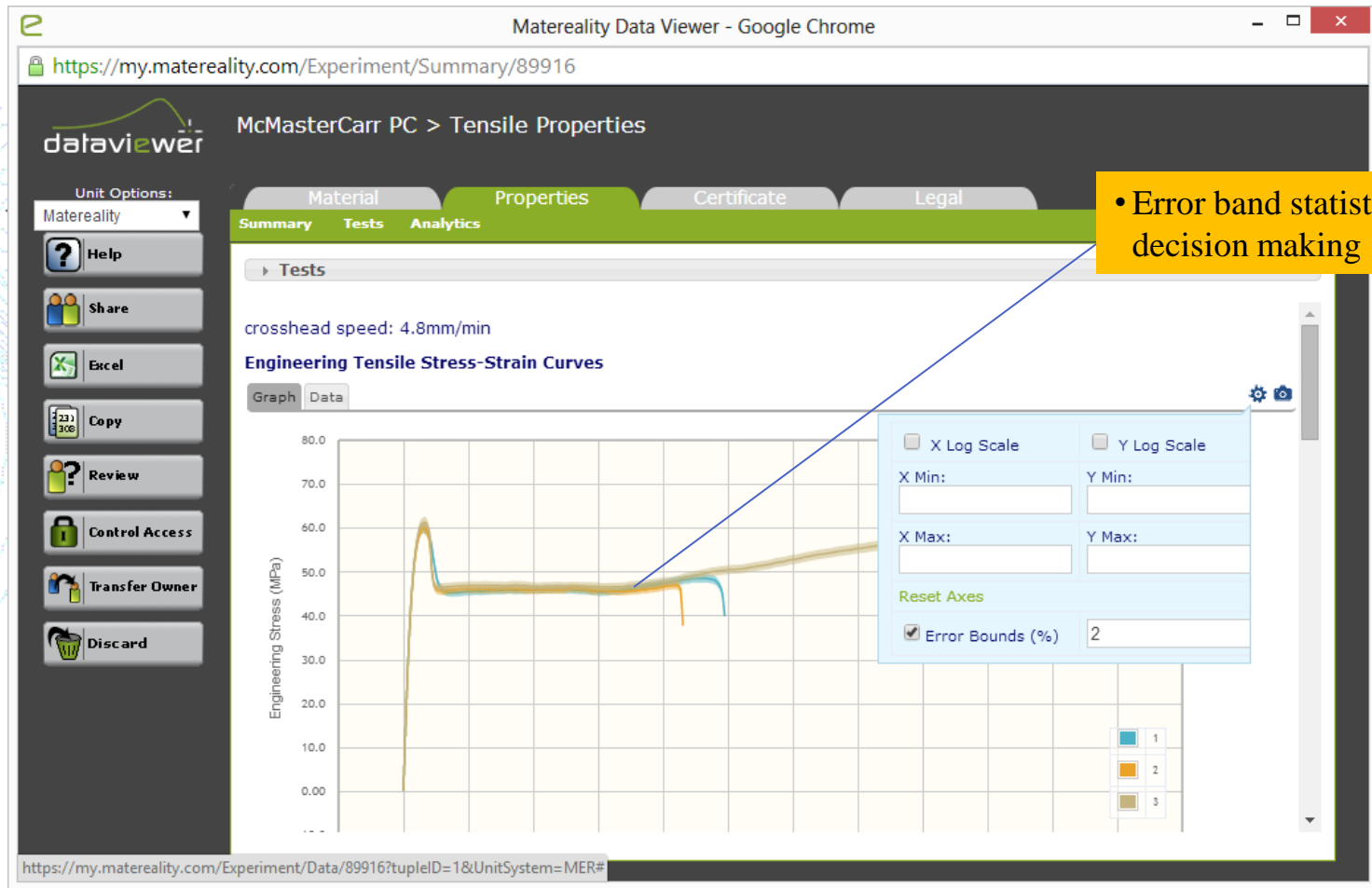


# Automated Analytics



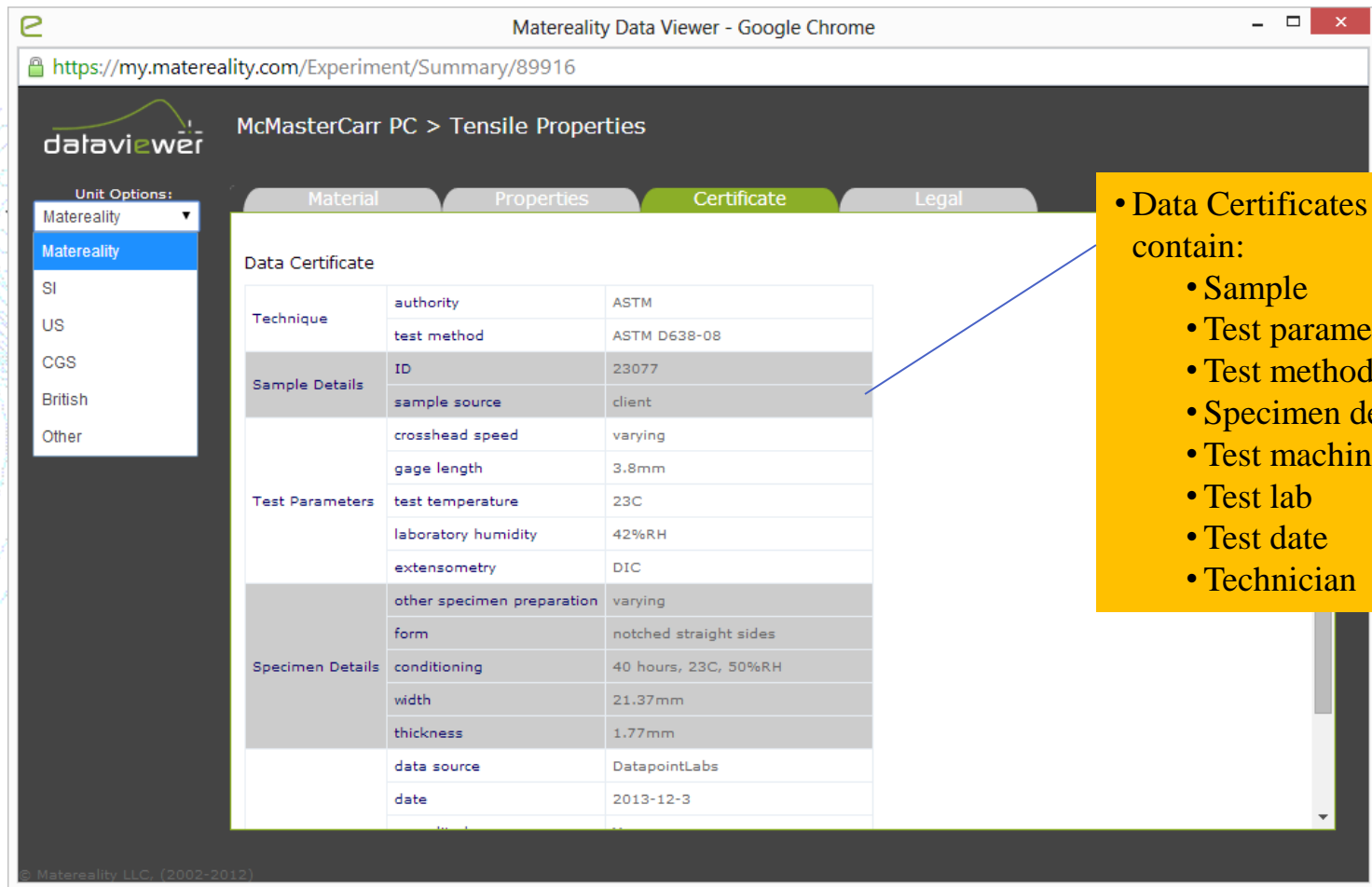


# Variability Analysis



• Error band statistics aid decision making

# ISO 17025 Compliant Traceability



The screenshot displays the Matereality Data Viewer interface in Google Chrome. The browser address bar shows the URL <https://my.matereality.com/Experiment/Summary/89916>. The page title is "McMasterCarr PC > Tensile Properties". The interface includes a sidebar with "Unit Options" (Matereality, SI, US, CGS, British, Other) and a main content area with tabs for "Material", "Properties", "Certificate", and "Legal". The "Certificate" tab is active, showing a "Data Certificate" table. A blue arrow points from a yellow callout box to the "sample source" field in the "Sample Details" section of the table.

Data Certificate		
Technique	authority	ASTM
	test method	ASTM D638-08
Sample Details	ID	23077
	sample source	client
Test Parameters	crosshead speed	varying
	gage length	3.8mm
	test temperature	23C
	laboratory humidity	42%RH
	extensometry	DIC
Specimen Details	other specimen preparation	varying
	form	notched straight sides
	conditioning	40 hours, 23C, 50%RH
	width	21.37mm
	thickness	1.77mm
	data source	DatapointLabs
	date	2013-12-3

- Data Certificates contain:
  - Sample
  - Test parameters
  - Test method
  - Specimen details
  - Test machine
  - Test lab
  - Test date
  - Technician

# Using Compare Analytics

The screenshot shows the 'My Database' interface of the Matereality application. The browser address bar displays <https://my.matereality.com/MyDatabase>. The application header includes the Matereality logo, navigation links (Home, Settings, Logout), and a note: 'Confidential Demo Purposes'.

On the left sidebar, there is a 'Search' field and a 'Tools' section containing a 'Compare' button (with a magnifying glass icon) and a 'Share' button (with a person icon).

The main content area is titled 'My Database' and features a tabbed interface with 'Published' (selected), 'Unpublished', 'In Review', 'Downgraded', and 'Selection'. Below the tabs, there is a 'Display' dropdown set to '10' and pagination controls showing '21 to 24 of 24 (61 total)'. The table below lists material test data:

	Test Date	Project ID	Sample ID	Sample Name	Material	Property	Access	Visibility
<input checked="" type="checkbox"/>	2013-12-3	27653	23077		McMasterCarr PC	Tensile Properties	Workgroup	Visible
<input type="checkbox"/>	2014-1-21	27653	23077		McMasterCarr PC	Shear Properties	Workgroup	Visible
<input checked="" type="checkbox"/>	2014-2-26	28302	23421		Mcmaster carr HDPE R-28302	Tensile Properties	Workgroup	Visible
<input type="checkbox"/>	2013-1-20	27653	23077		McMasterCarr PC	Compressive Properties	Workgroup	Visible

© Matereality LLC, (2002-2012)

- Select materials to compare
- Then click **Compare**



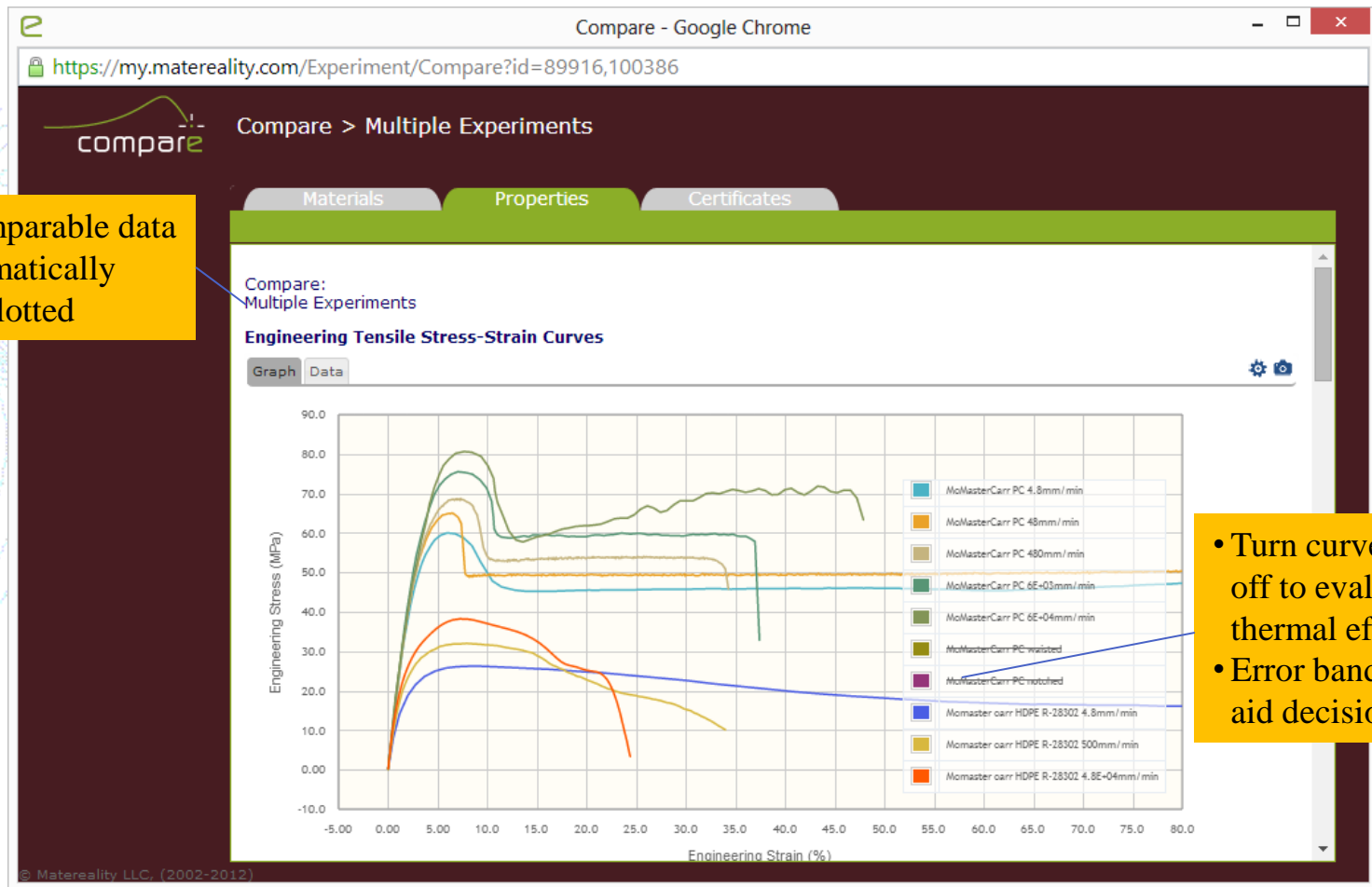
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# Rate Dependency of PC & HDPE

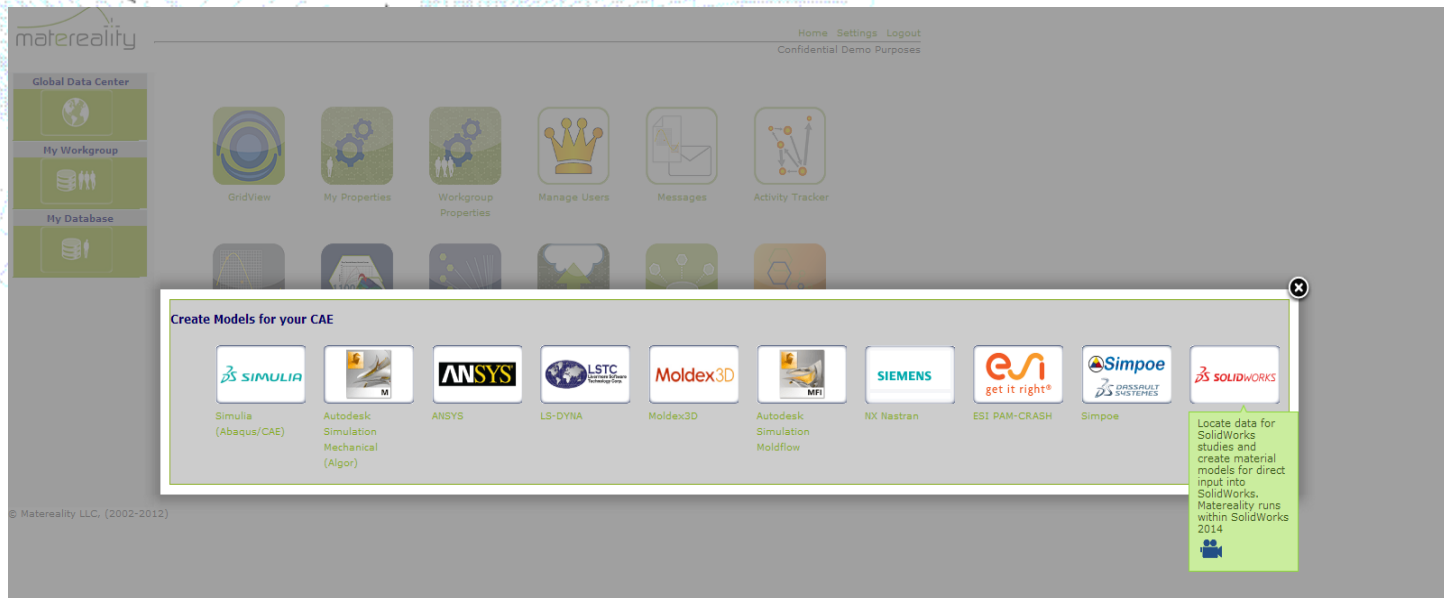
- All comparable data is automatically cross-plotted



- Turn curves on and off to evaluate thermal effects
- Error band statistics aid decision making

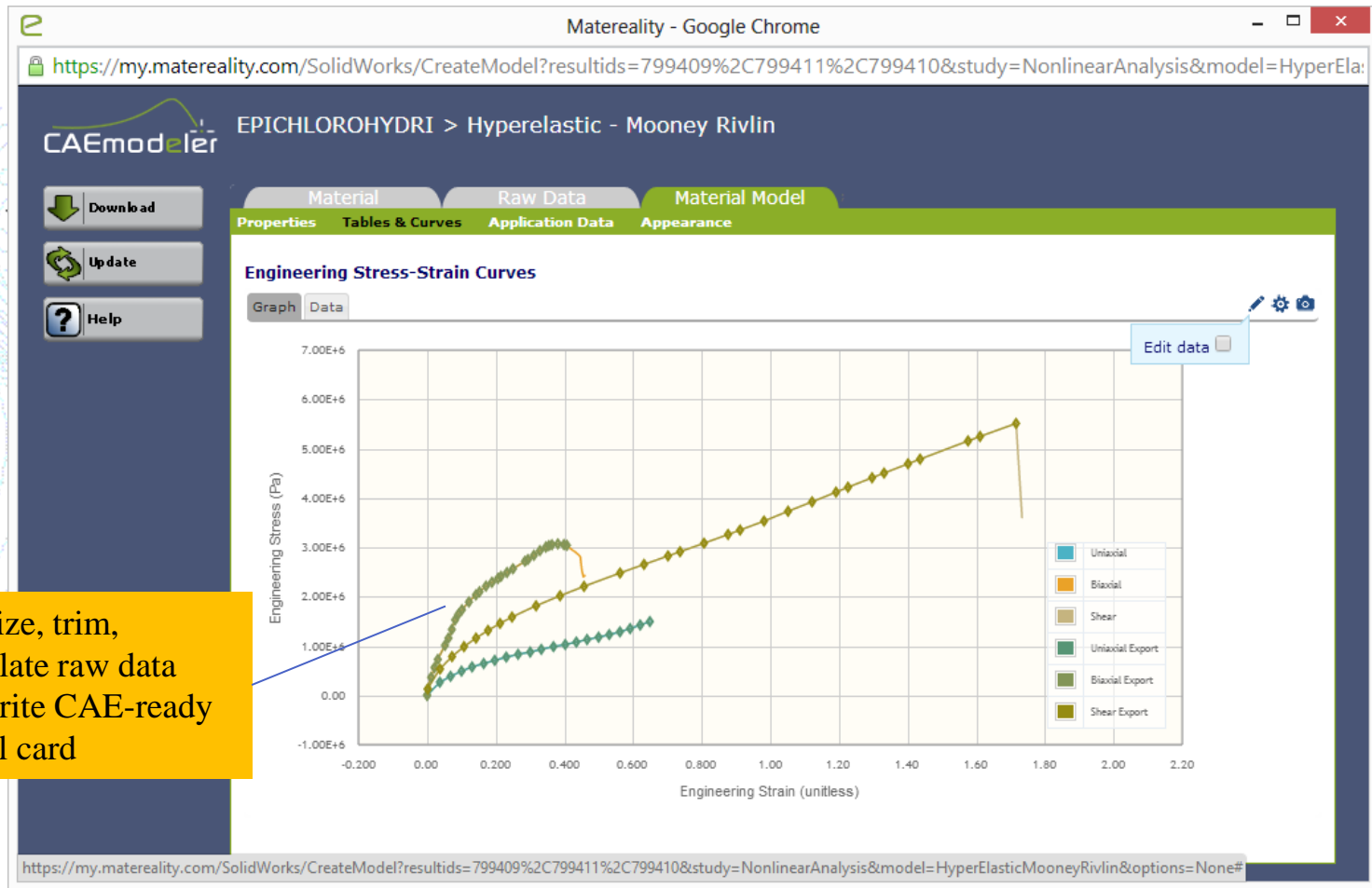
# Sending Data to Simulation

- CAE Modeler slices multivariate data into CAE-consumable slices
  - Rate dependency for LS-DYNA, PAMCRASH, ANSYS, ABAQUS...
  - Temperature dependency for ABAQUS, ANSYS, NASTRAN...
  - Flow/thermal/PVT/shrinkage data for Moldflow, Moldex3D, Simpoe...
- Converts material data to model parameters
- Writes files to **Material Model Library**





# Convert Raw Data to Hyperelastic



- Discretize, trim, extrapolate raw data
- Then write CAE-ready material card



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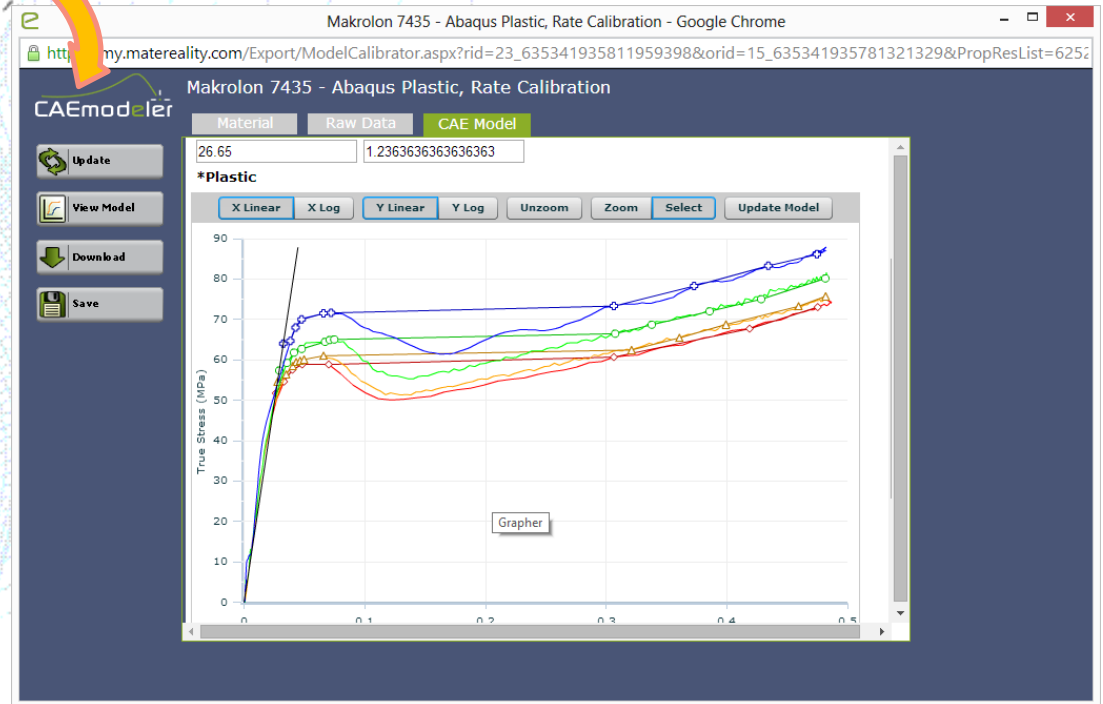
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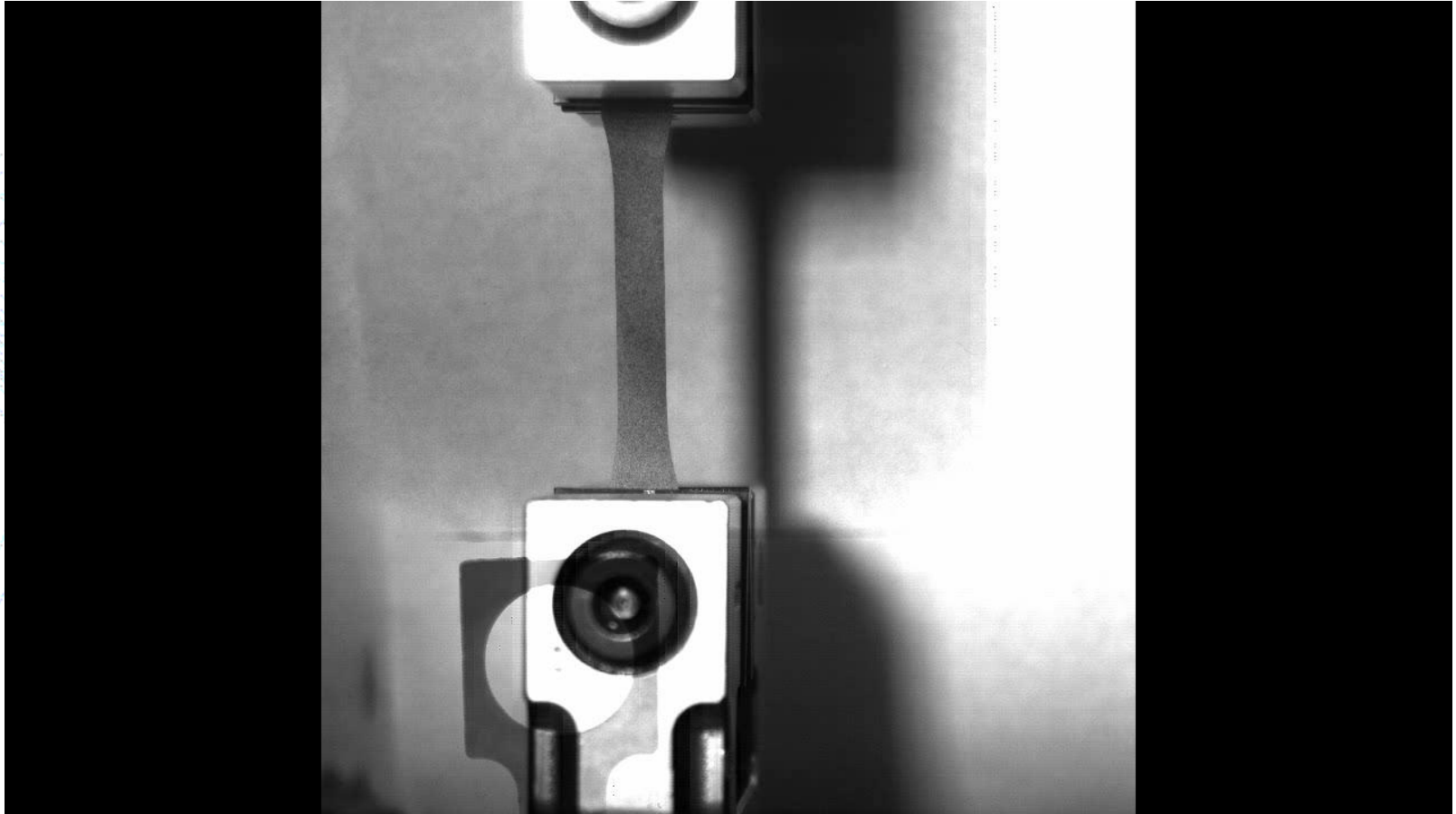
# Verification & Validation

- Unit Element Test (easy)
  - Can be performed by analyst
  - Simple check on whether the model is sensible
- Closed Loop Validation (moderately difficult)
  - Check if FEA returns the original material data
- Open Loop Validation (difficult)
  - Comparison to alternate or multi-mode experiment

# Closed Loop Validation



# High-speed Video

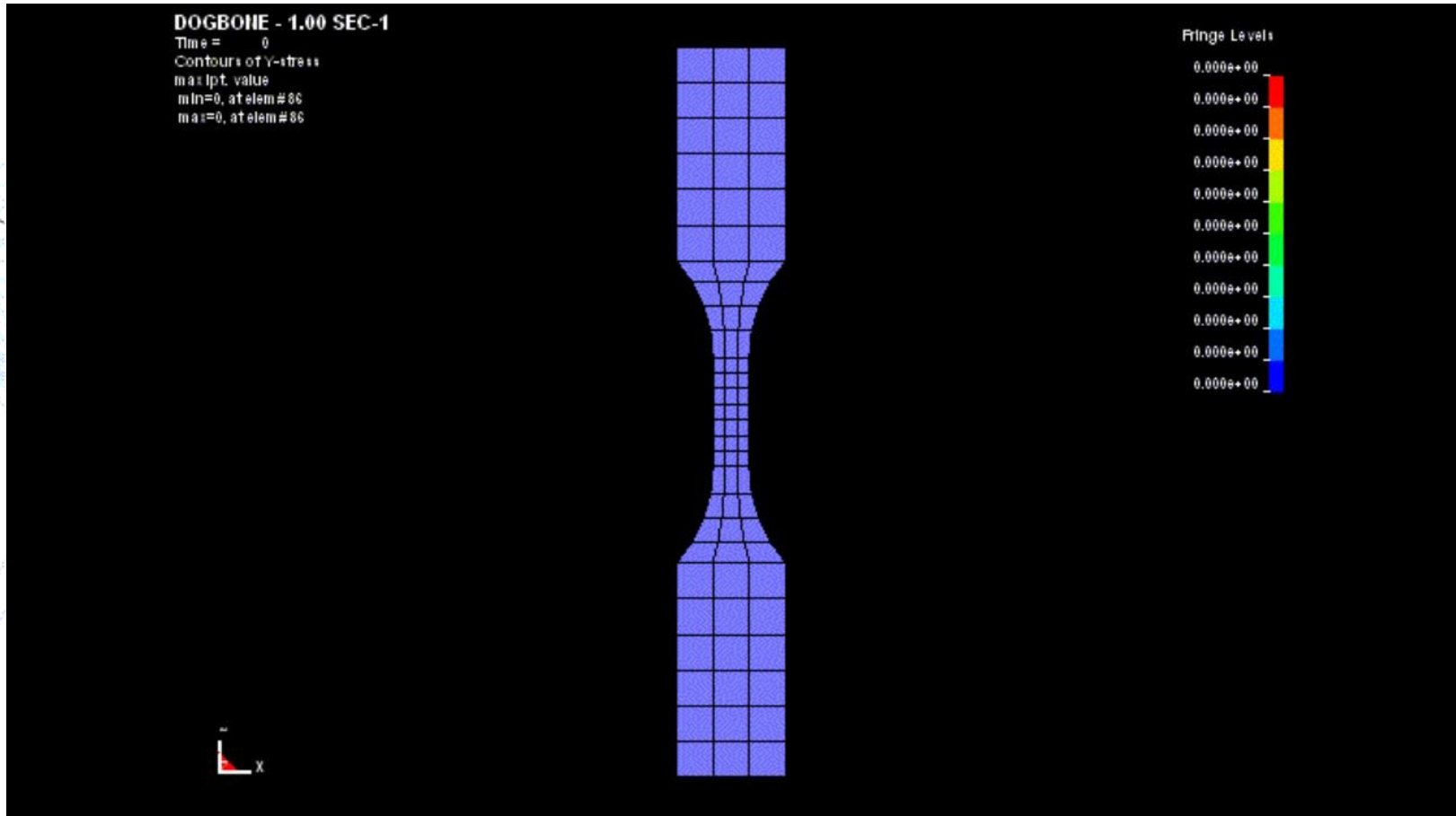


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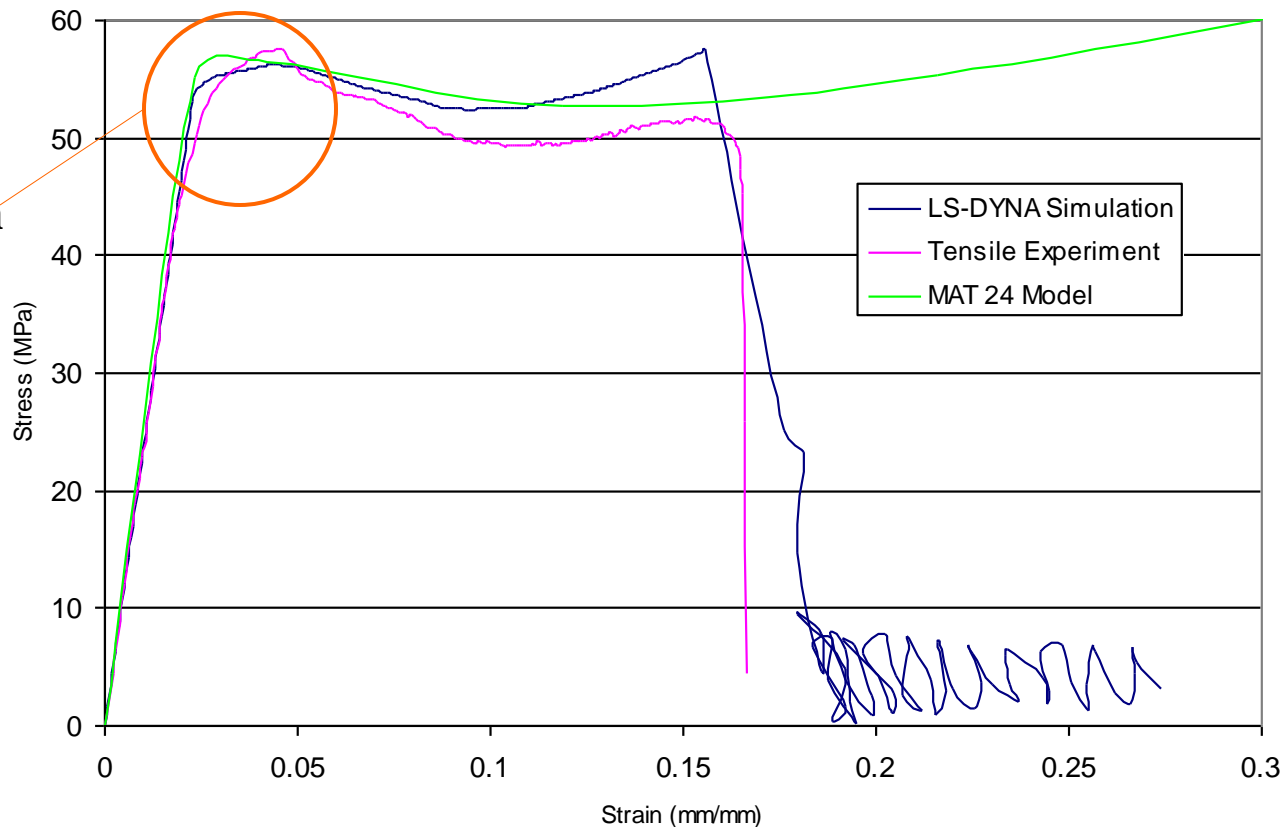
# Simulation





# Comparison to Experiment

**limitation**



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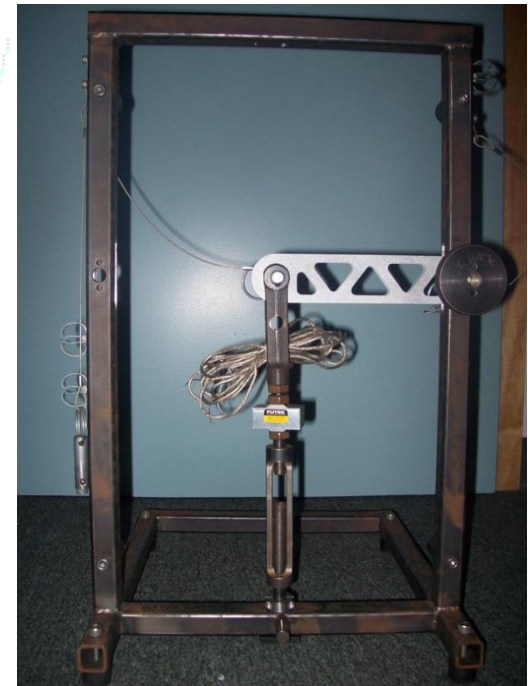
# What is CAE TestBench™

- Open Loop Validation
  - Carefully designed Benchmark models
  - Not real-life component
  - Simple multi-mode case
  - Well defined boundary conditions
  - Load cases reproducible in virtual and real life

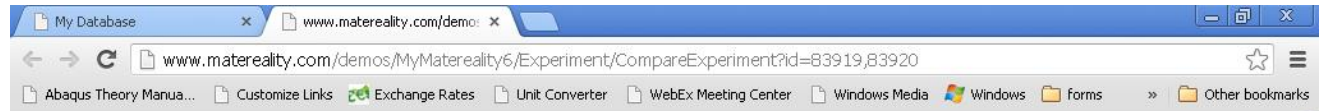
# Static FEA TestBench Model

- Cornell Bike Crank Study

- Static loading
- Complex geometry
- Analytical solution exists
- Well defined load case



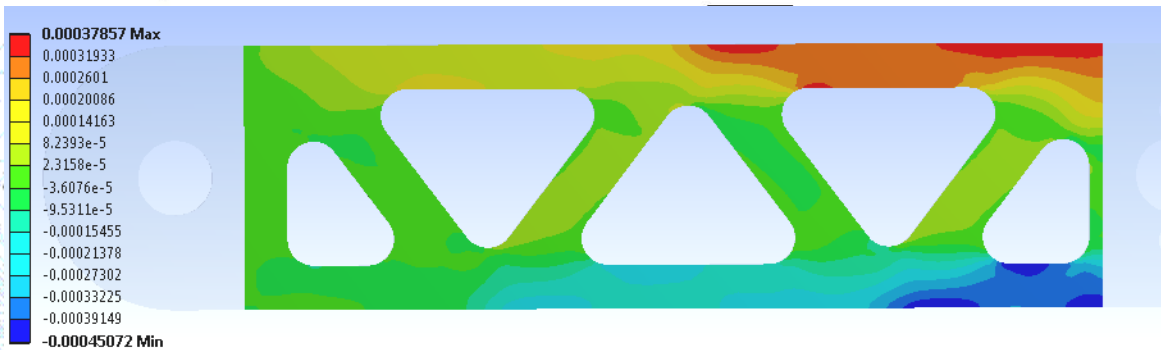
# Comparing Simulation and Test



Effect of Experiment

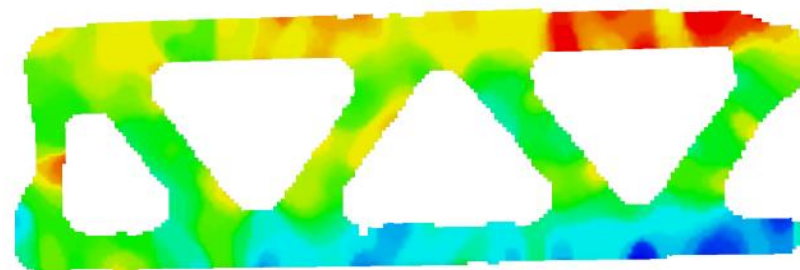
• Simulation

Shear Field Image



Cornell_Bike_Crank_config4_Instron_r1.dap	
Visualization	Epsilon X
Stage from to	0 -> 236

Z+



[%]

0.0378  
0.0300  
0.0200  
0.0100  
0.0000  
-0.0100  
-0.0200  
-0.0300  
-0.0450

• DIC Experiment



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# Confidence!



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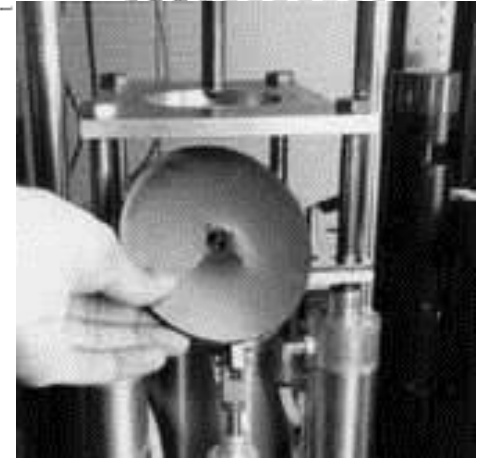


matereality

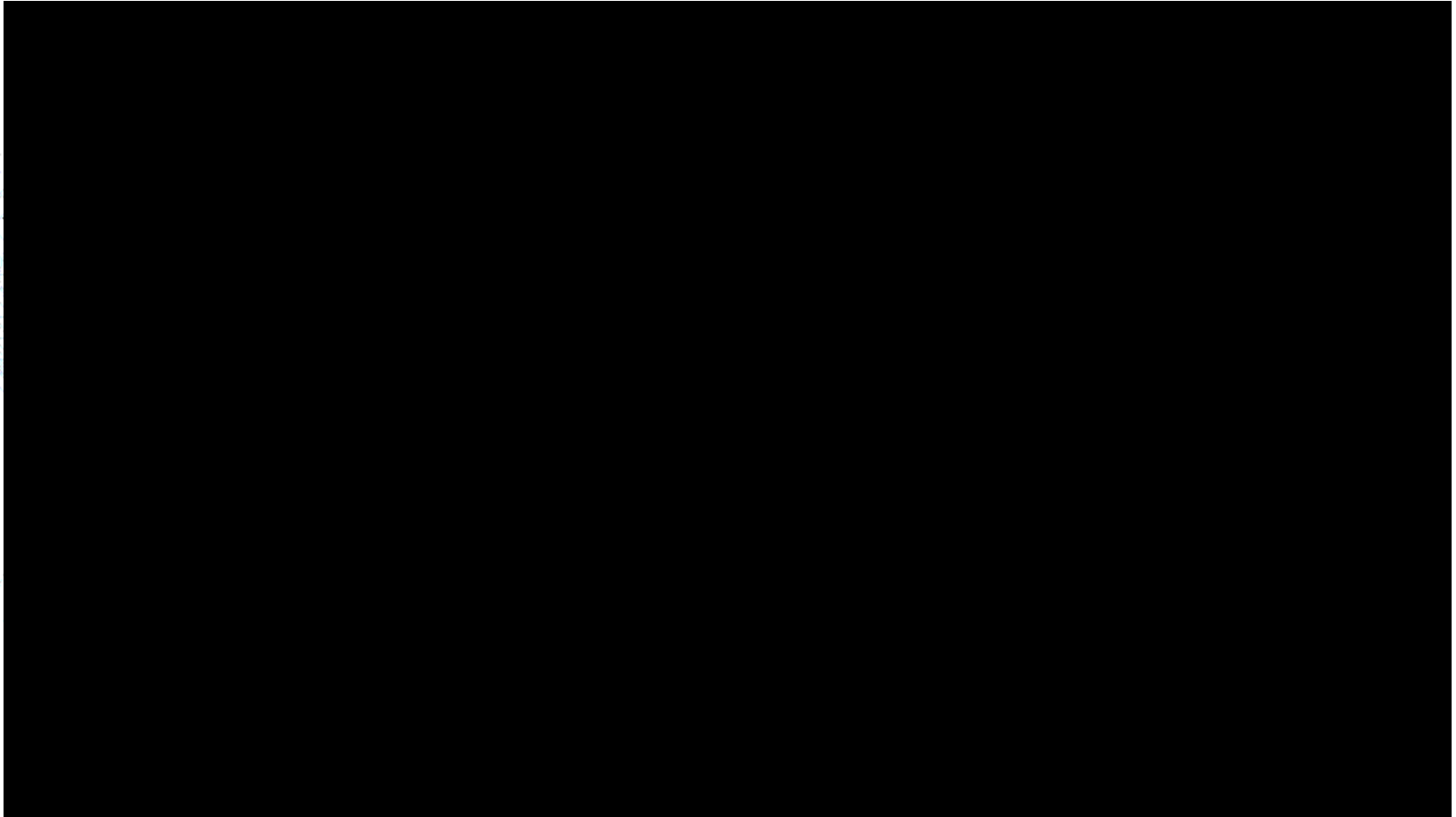


# Dynamic FEA TestBench Model

- Falling Dart Impact
- Dynamic test
- Multi-axial loading
- Well defined boundary conditions



# Simulation of Falling Dart Test

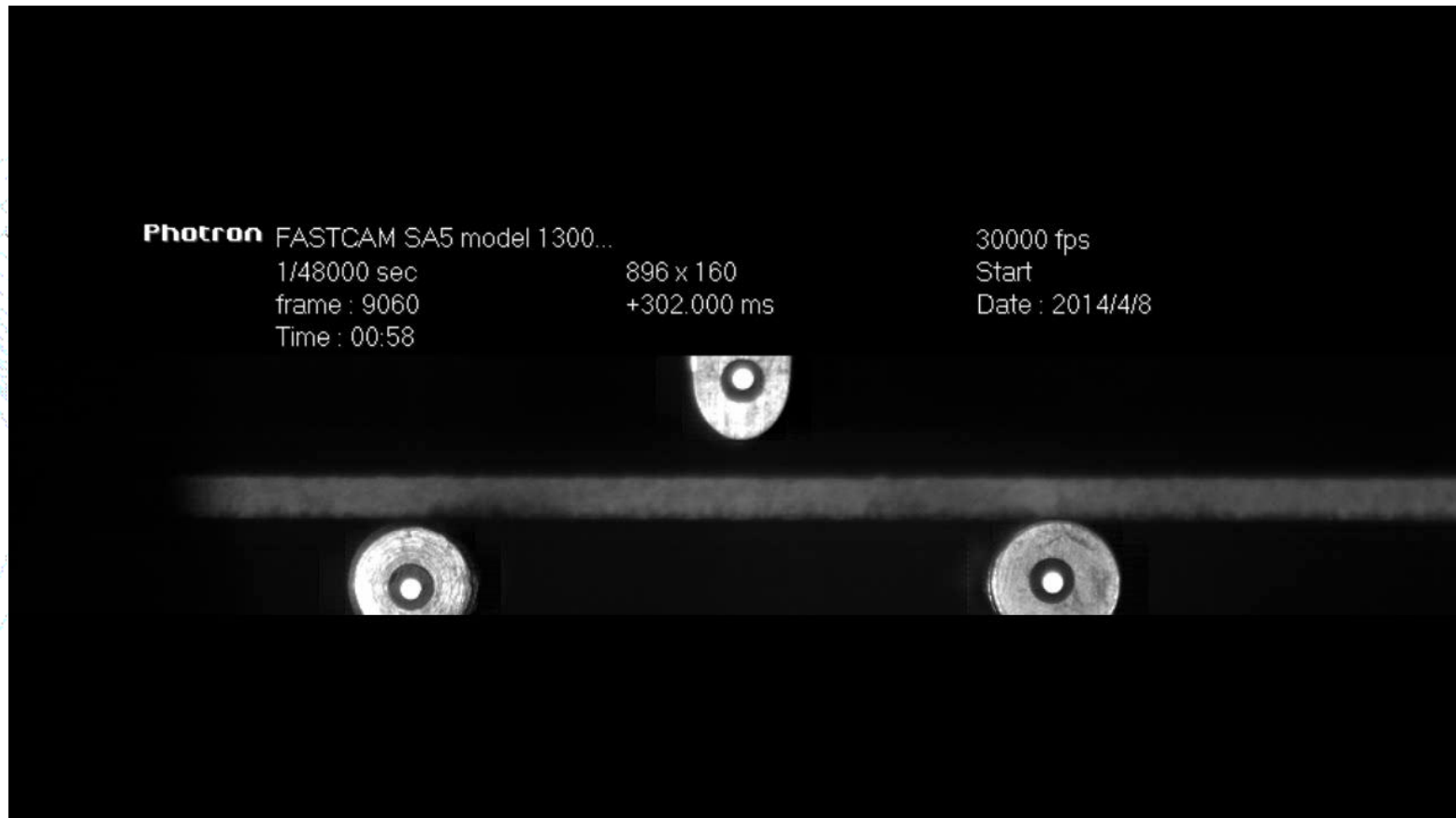


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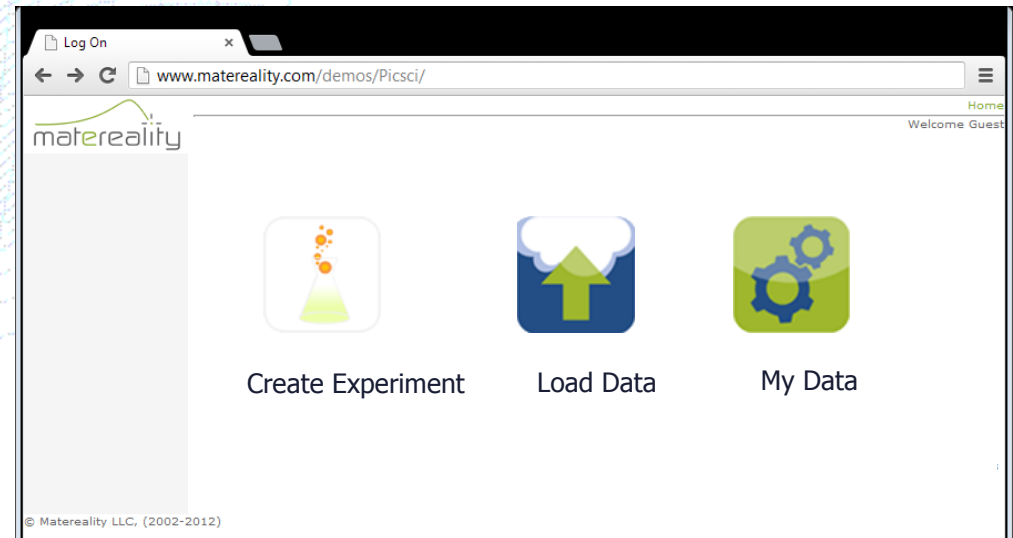
# High-speed Composite 3 Point Bend



# Software for TestBench

## – Project PICSCI (a Matereality product)

- Create experiment
- Load test data
- Load simulation data
- Compare
  - apples to apples



\*NAFEMS World Conference, Salzburg, Austria (2013)

# Goal of CAE TestBench

- Create a library of benchmark models
- Validate for different aspects of CAE
  - Non-linear
  - Dynamic
  - Creep
  - Viscoelastic
  - Hyperelastic
  - Hyperelastic rate dependent
- Validate for different CAE codes