A Strategy for Material Testing and Data Management for the Automotive Industry

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DatapointLabs
+
Matereality
a **Datapoint**Labs Affiliate

EST 1995
ISO 17025 Quality

Inc. 500
America's fastest growing private companies

Material Testing ¤ Data Management ¤ Software

the science of materials... matereality + DatapointLabs

About us

Expertise

- **Pioneers in materials support of product development / R&D for 18 yrs**
- **Broad experience with diverse materials**
- **Testing over 1500+ materials/yr**
- **Support of 34 CAE design codes**
- **1000+ customers, 34 countries**

Technology

- **Extensible material databases**
- **Enabling software apps**

–Plastic
–Rubber
–Film
–Metal
–Foam
–Adhesive
–Composite
–Cement
–Ceramic
–Paper
–Fiber

The Material Data Challenge

Obtaining enterprise-relevant data

- **Not commonly in public domain**
- **Free data may be too generic**
- **Unmanageable risk for PLM**

Today's best practice

- **Test your own materials**
- **Understand your data**
- **Use with confidence**
- **Don't lose it**

Adding materials to the PLM core

Relevant (purpose-specific) data
Trusted and Validated
Disseminated
Controlled
Expandable

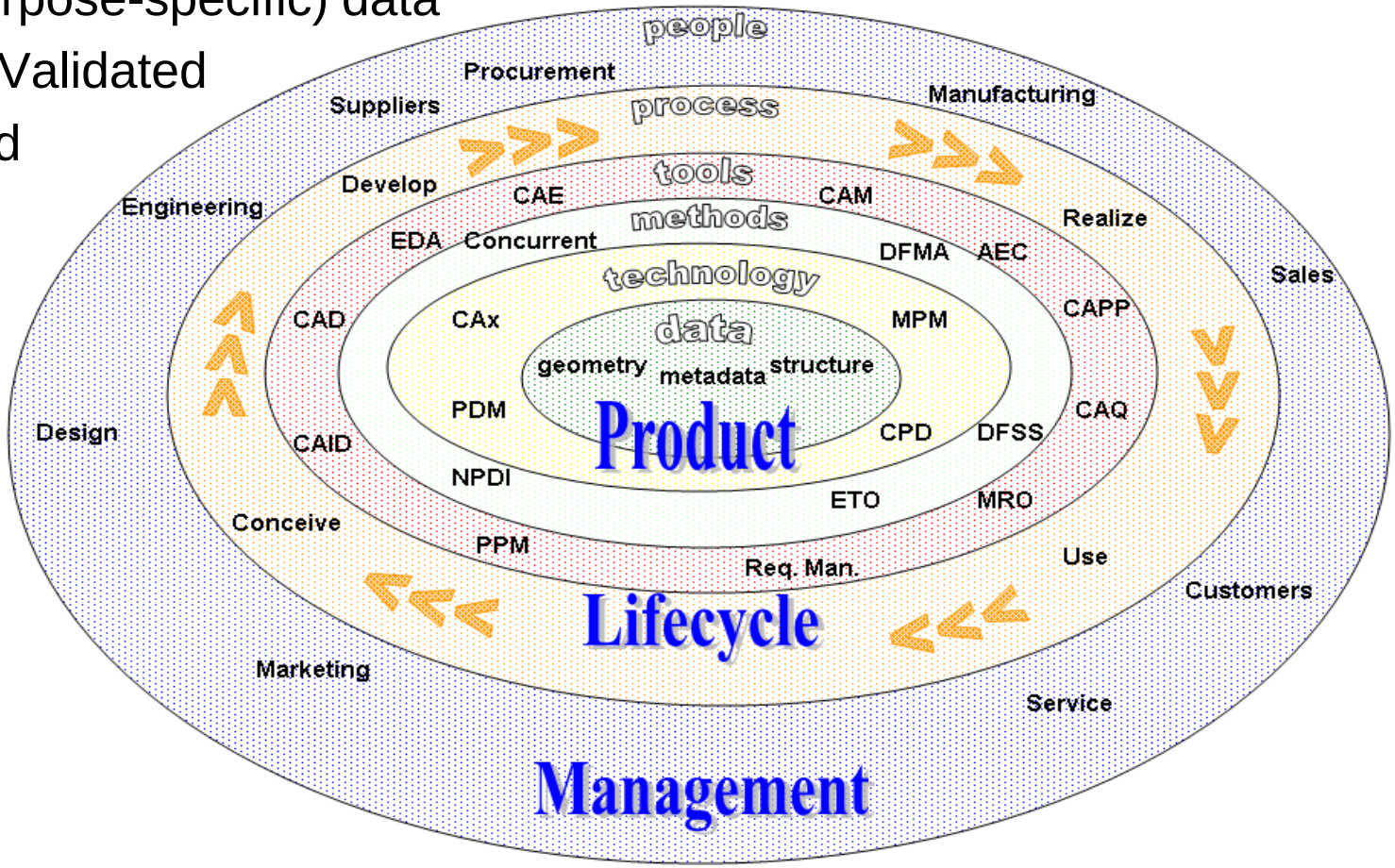


Image copied from wikimedia.org/wikipedia/en/1/1c/Plm1.png

Relevant Material Data

The actual material used for the product

Must represent the actual end application

- **Processing**
  - *Formed, tempered…*
- **Environment**
  - *Fuel, coolant, salt spray saturated*
- **Situation**
  - *Rate dependent*
  - *Temperature*
- **…**

Mechanical stress-strain testing
in a liquid, non-ambient environment

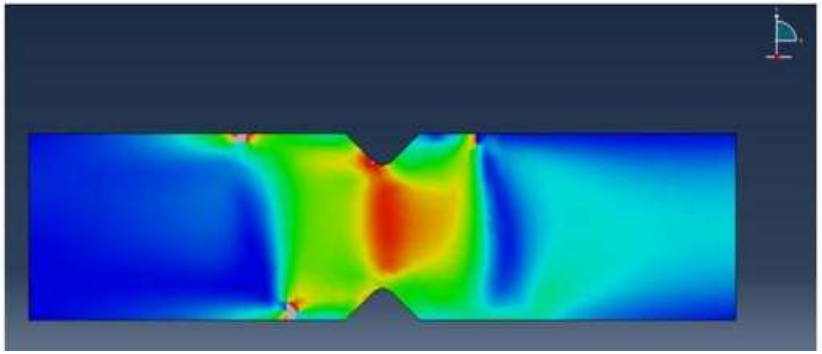
Trust and Validity

Data must be from a trusted source

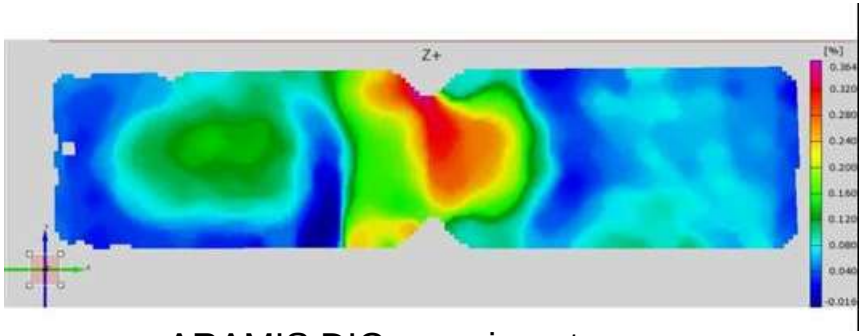
- **Internal lab**
- **Qualified ISO lab**
- **A great technical authority**

Data must be valid

- **It must produce a correct simulation result**
- **Preferably compared to a real test**



Abaqus simulation



ARAMIS DIC experiment

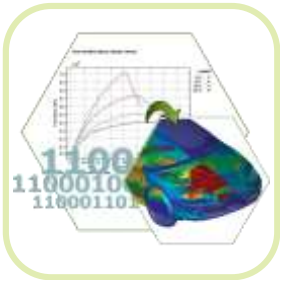
Dissemination–
User Specific Dashboards

Material data is used differently

- **Purchasing**
- **CAD**
- **Expert CAE**
- **Test Lab**
- **IT/Administration**

App suite for each expert is different

Dissemination Example-
Apps for the expert CAE user



CAE Modelers

- **Take raw data and convert to material parameters**
- **Write material cards to different CAE**
- **Manage software version changes**

Model Libraries

- **Manage material cards**
- **Export project cards**
- **Card version control**

Control and Management

Traceability between material card and material data

Assignment of roles for different experts

- **materials engineer**
- **CAE expert**
- **Designer**
- **…**

Exposing the right data for each expert

Sequestration of material data and material cards

Version control

Activity logging

Expandability

New materials are being explored

New processes are being explored

Each new material-process combination = a different material model

Need user ability to add:

- **new materials, processing, compositions**
- **new properties**
- **new CAE Models**

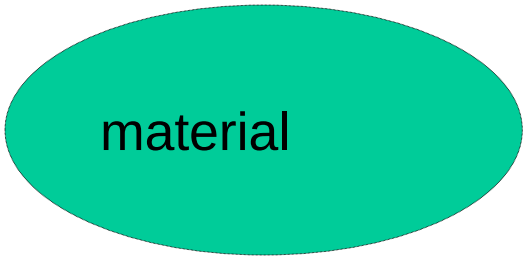
proven expandability is a requirement for future-proofing

Vision- projecting the material into its environment

Capture the true nature of the material

- **Correctly**
- **Completely**

Compositions
- Layups
- Welds
- Coatings



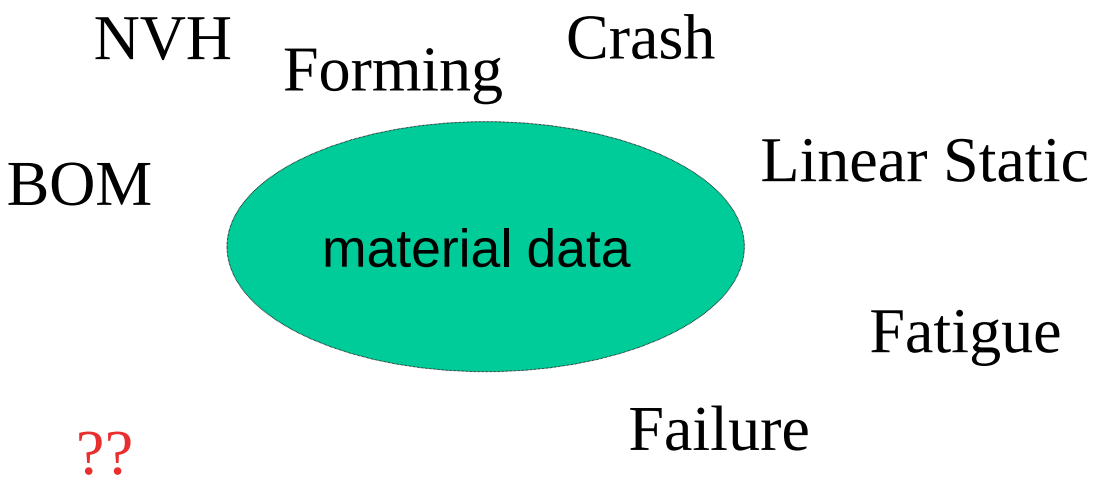
Processing & Sequence
- Cast
- Forged
- Heat treated
- Injection molded

Environments
- Fuel soaked
- Heat aged

Vision- projecting the material into design/CAE

Consistency & fidelity across various simulations

- **It is the same material after all**



Implications for the Crash CAE Expert

Material modeling space can be complex

- **Physical complexity**
- **Mathematical complexity**
- **Data conversion complexity (material parameter generation)**

A different expertise than CAE

- **Usually an expert reference source…institute, reference lab…**

Suggested philosophy

- **First, do it right**
- **Then use and reuse**

Good material modeling practices

Material is appropriate

- **Is this the actual material being simulated?**
- **Composition, processing, processing sequence…**

Material data

- **From traceable source (ISO 17025)**
- **Clean, with minimal noise**

Data is relevant to the simulation

- **Follows material laws**

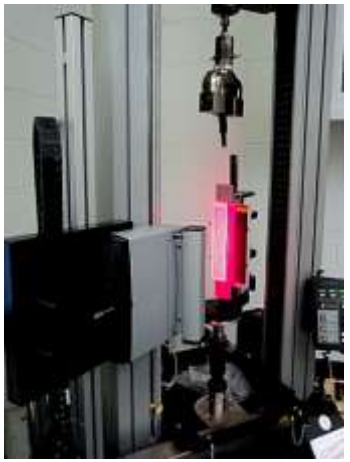
Testing

Use of conventional methods

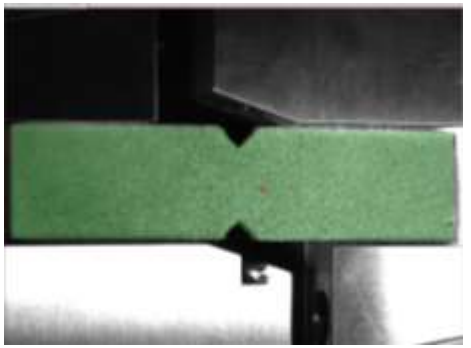
Layering in DIC for advanced measurements

Meeting design timelines

Contact extensometry
- conventional
- quick
- traceable



Video extensometry
- advanced
- quick
- traceable



Aramis DIC
- complex
- slow

Material Parameter Conversion

Raw data must be transformed to material parameters

- **Simple - just collect and deploy**
- **Medium – discretize curve and calculate**
- **Complex - fit equation, obtain parameters**

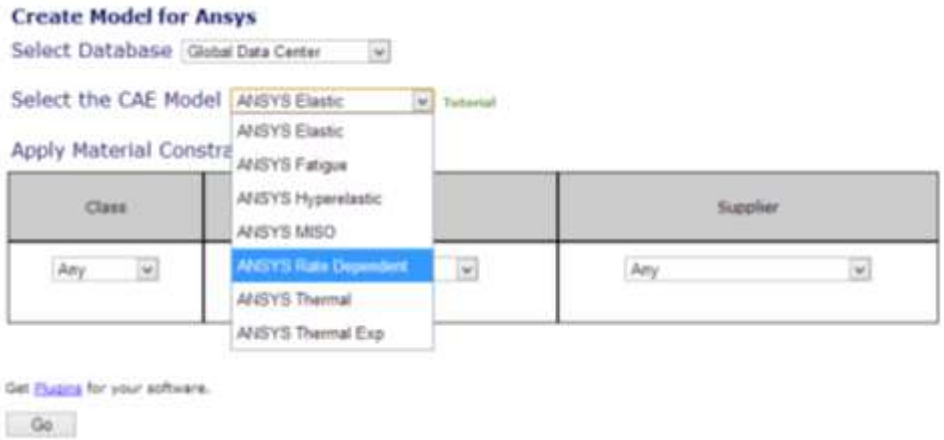
How a CAE Modeler works: locating relevant data

Each material model has different data requirements

The CAE Modeler first finds the required data

Example:

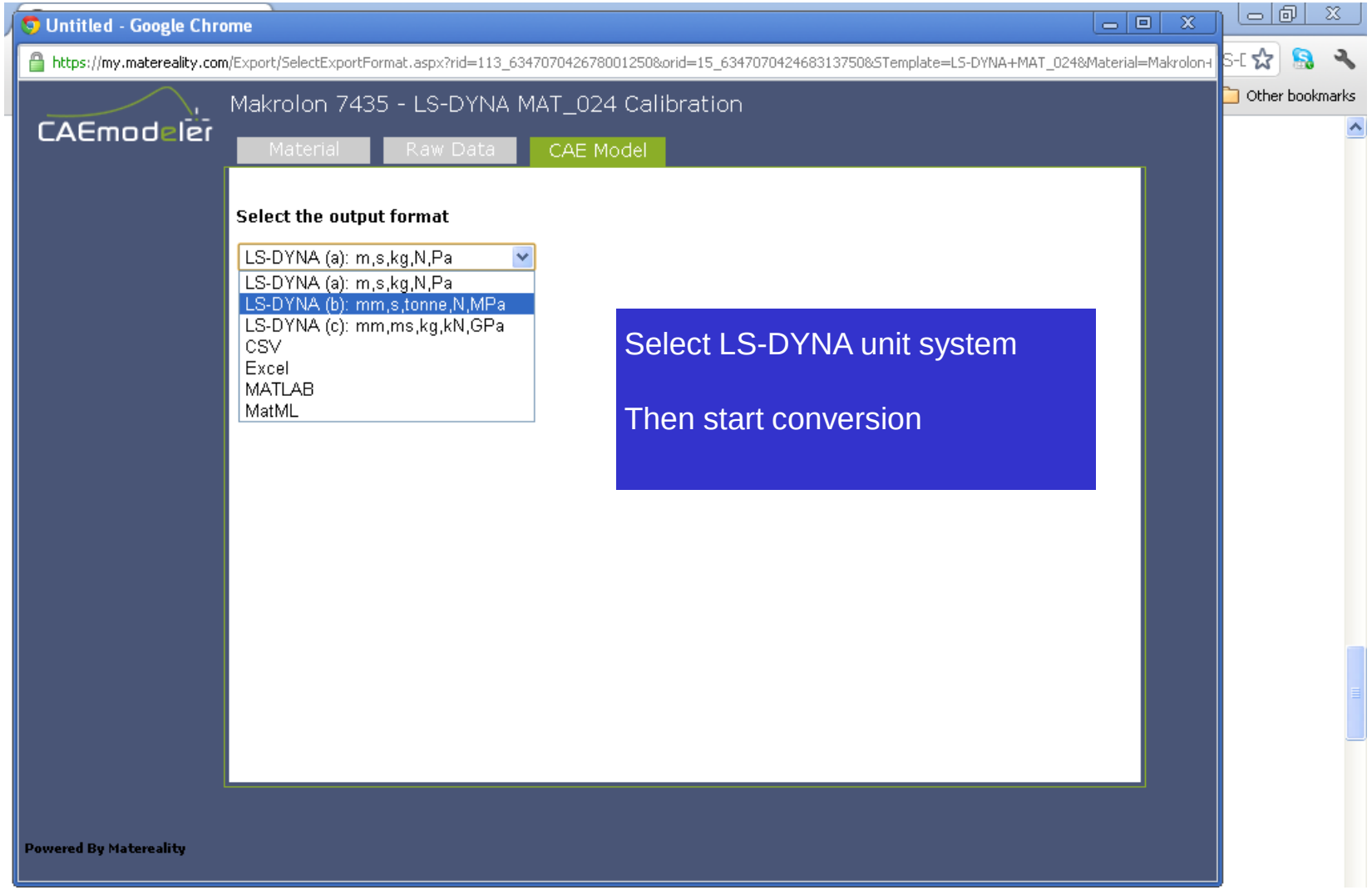
- **Rate Dependent Model = Tensile stress-strain at many strain rates**
- **Hyperelastic Model = Uniaxial, shear and biaxial stress-strain data**
- **Visco-elastic Model = Stress relaxation curve**



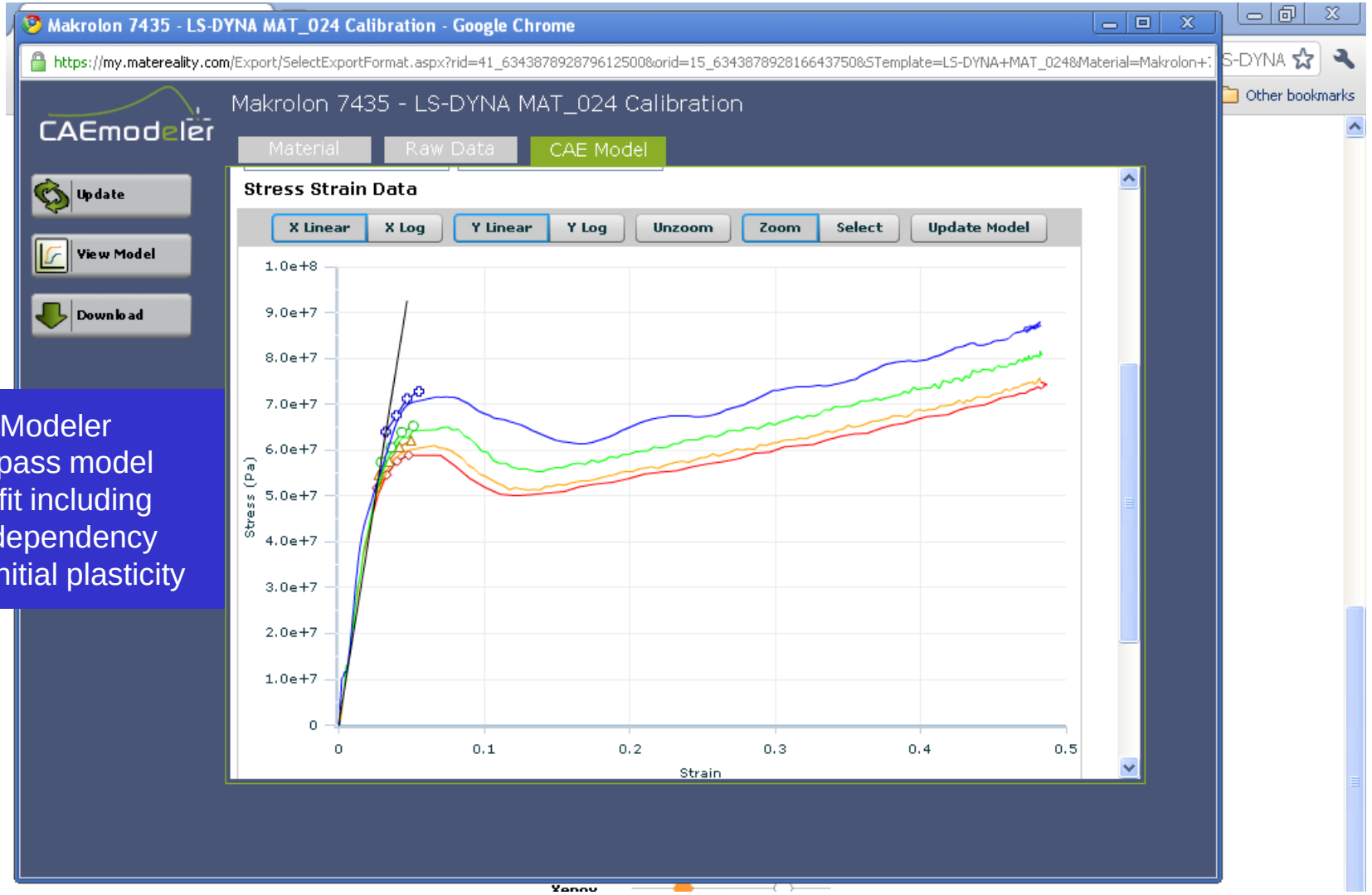
How a CAE Modeler works: candidate materials

Only materials containing required data for that model are presented

How a CAE Modeler works: transform rate-dependent data to LS-DYNA MAT24

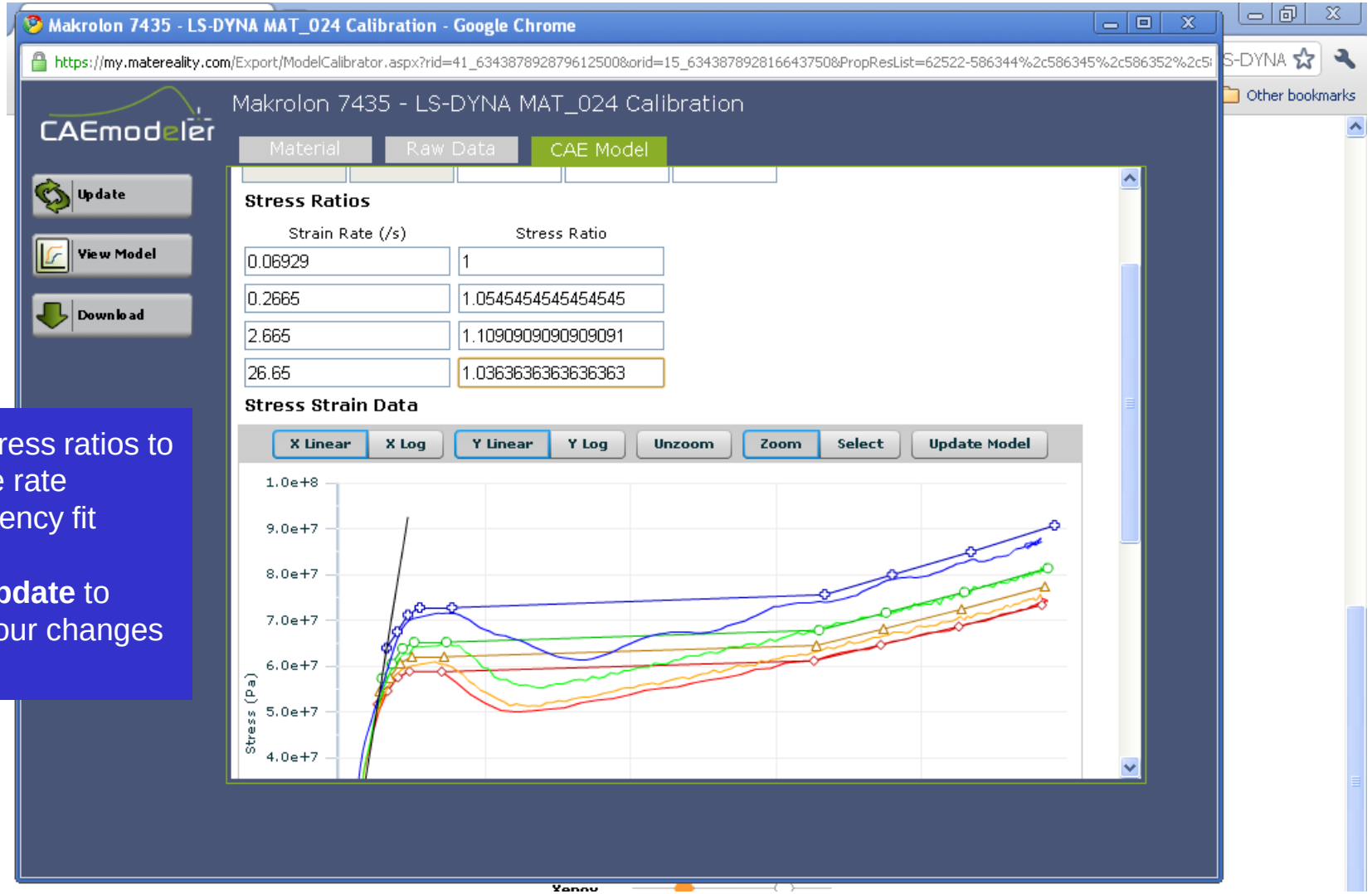


How a CAE Modeler works: fitting elasto-visco-plasticity



CAE Modeler
First pass model auto-fit including rate dependency and initial plasticity

How a CAE Modeler works: manual tuning by CAE expert



Tune stress ratios to improve rate dependency fit

Click **Update** to apply your changes

How a CAE Modeler works:
Fitting complex hyperelastic equations

Data fitting of complex equations

Storage of equation coefficients

Deploy to CAE

How a CAE Modeler works: Reverse CAE Modeling

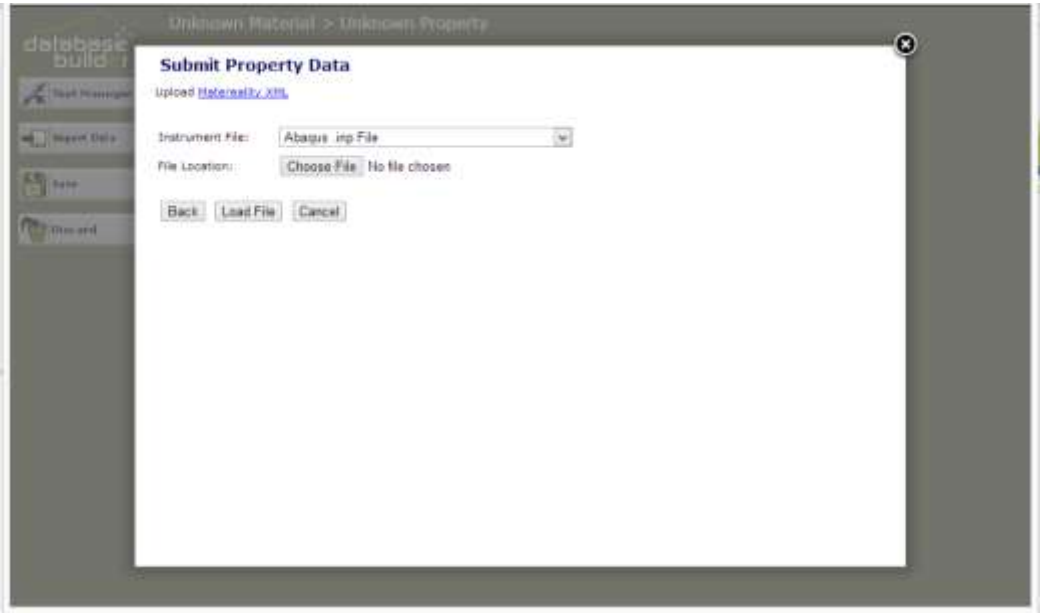
Import CAE material card

Convert to “raw data”

Store “raw data”

Run CAE Modeler

Write a different CAE material card



How a CAE Modeler works: Writing outputs

CAE Modeler manages

- **Writing time-consuming exotic formats**
- **Format changes with software version**
- **Eliminates data entry error**

CAE Expert needs to define

- **Terms not known**
- **Some terms assumed**
- **Impact on simulation = unknown**

```
** Output generated by Matereality
** Abaqus Plastic Model
*MATERIAL, name=Delrin8753K13
*ELASTIC
3607.59123689013, 0.2413, -10
3183.7938807461, 0.323571664399527, 23
2174.59568965032, 0.39415, 60
****
*PLASTIC
46.381708640637, 0,-1.000E+01
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71.8736400512504, 0.010170061742945555,-1.000E+01
76.7156702762688, 0.016802750802138691,-1.000E+01
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83.7520014704219, 0.042400203020399568,-1.000E+01
88.44580120706, 0.07511425176203515,-1.000E+01
101.286187380666, 0.18221125102592156,-1.000E+01
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41.2027474277636, 0,2.300E+01
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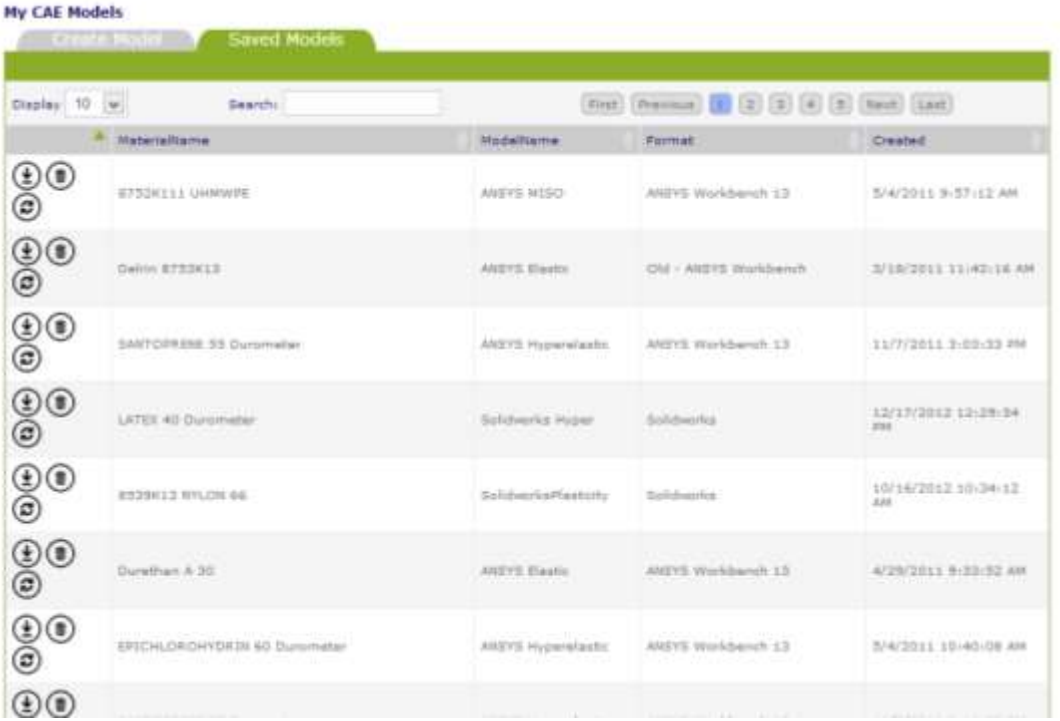
The CAE Model Library:
Save and deploy your work

Store expert-created material cards

Manage version control

Manage CAE software version changes

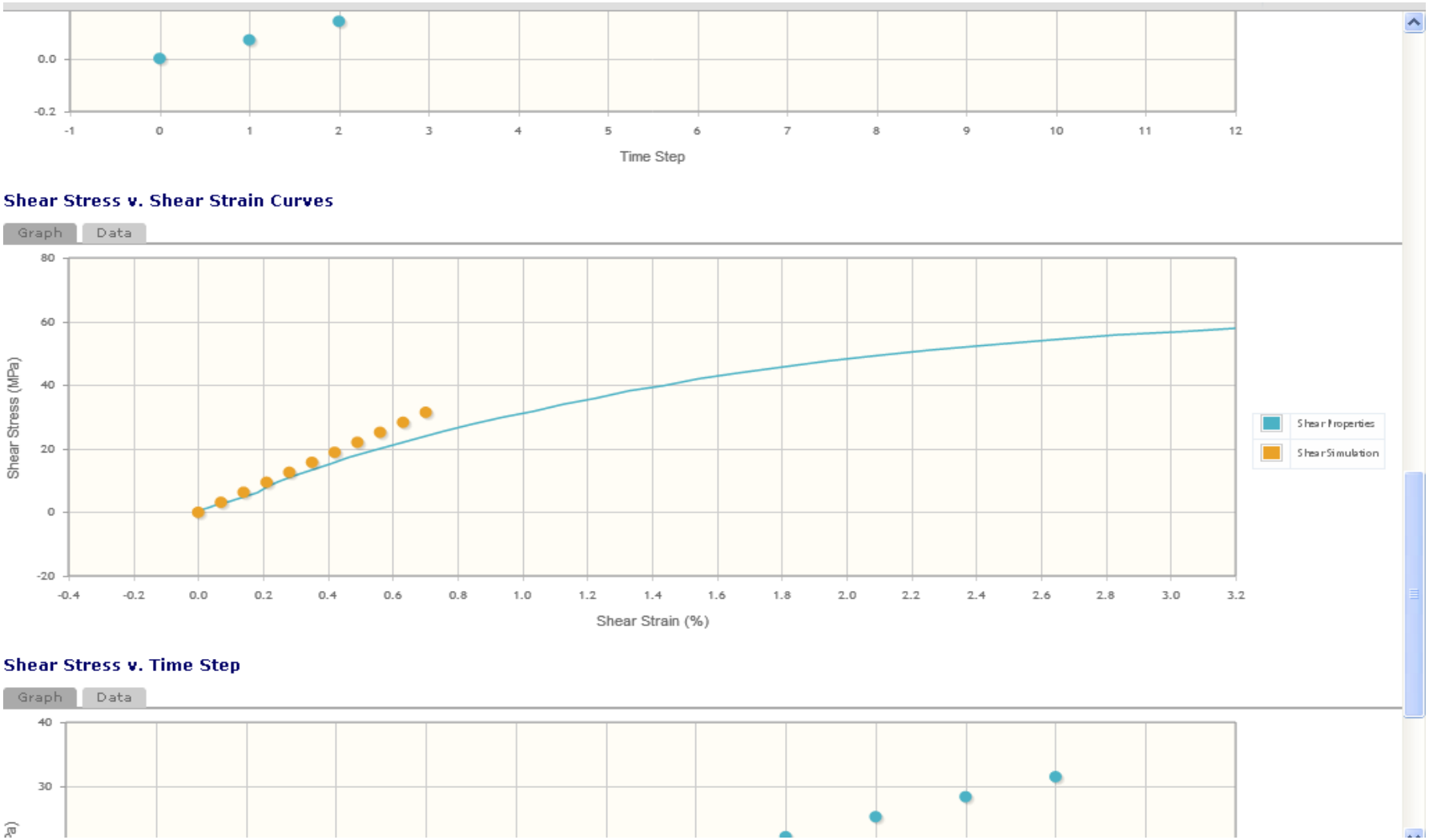


CAE Validation:
Comparing experiment to simulation

Cohabited datasets

- **experiment and simulation data share same platform**

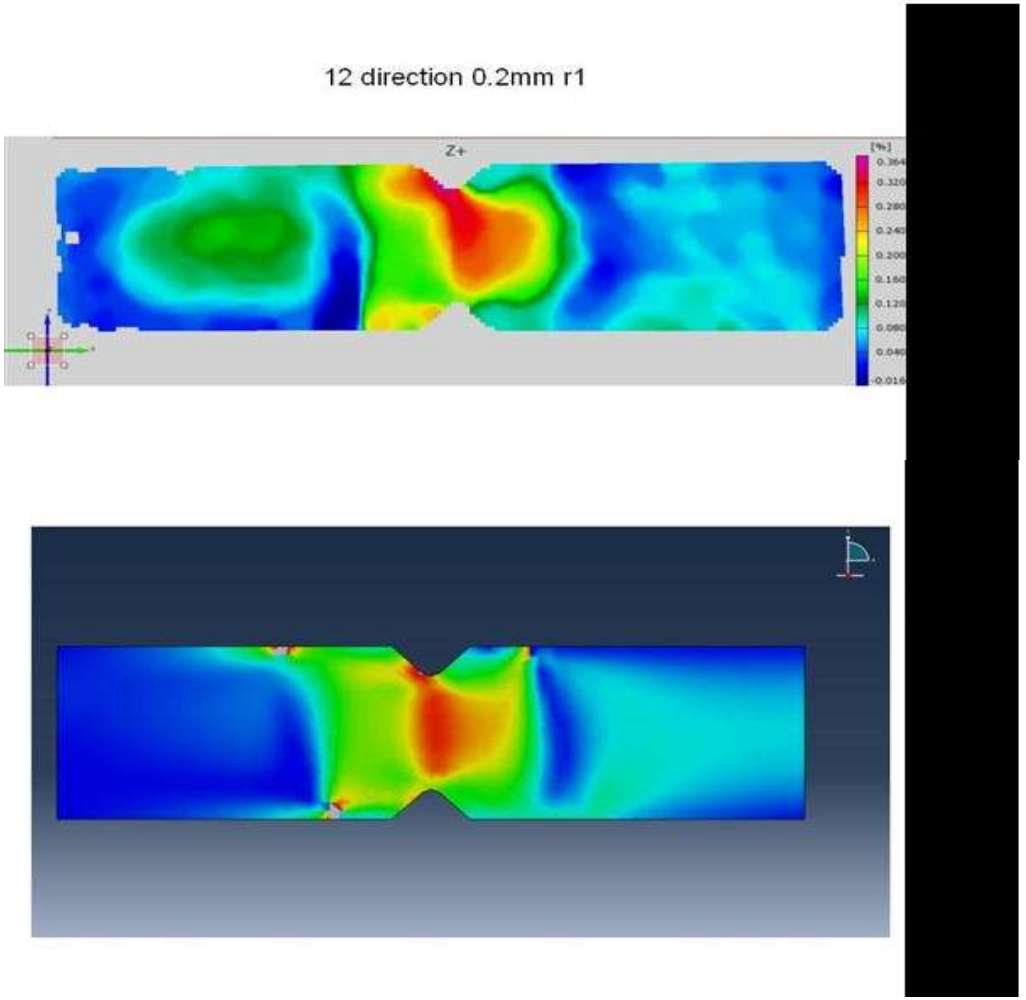
Validation
Auto-comparing experiment and simulation



Validation:
Comparing strain field images

Effect of Experiment

Shear Field Image



What is your materials strategy?

Material data

- **Precisely measured**
- **Perfectly managed**

Thank you!