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GRANTA
MATERIAL INTELLIGENCE

Exporting Data from Granta MI

Discussion with NEA&AWE, 2015-May-5

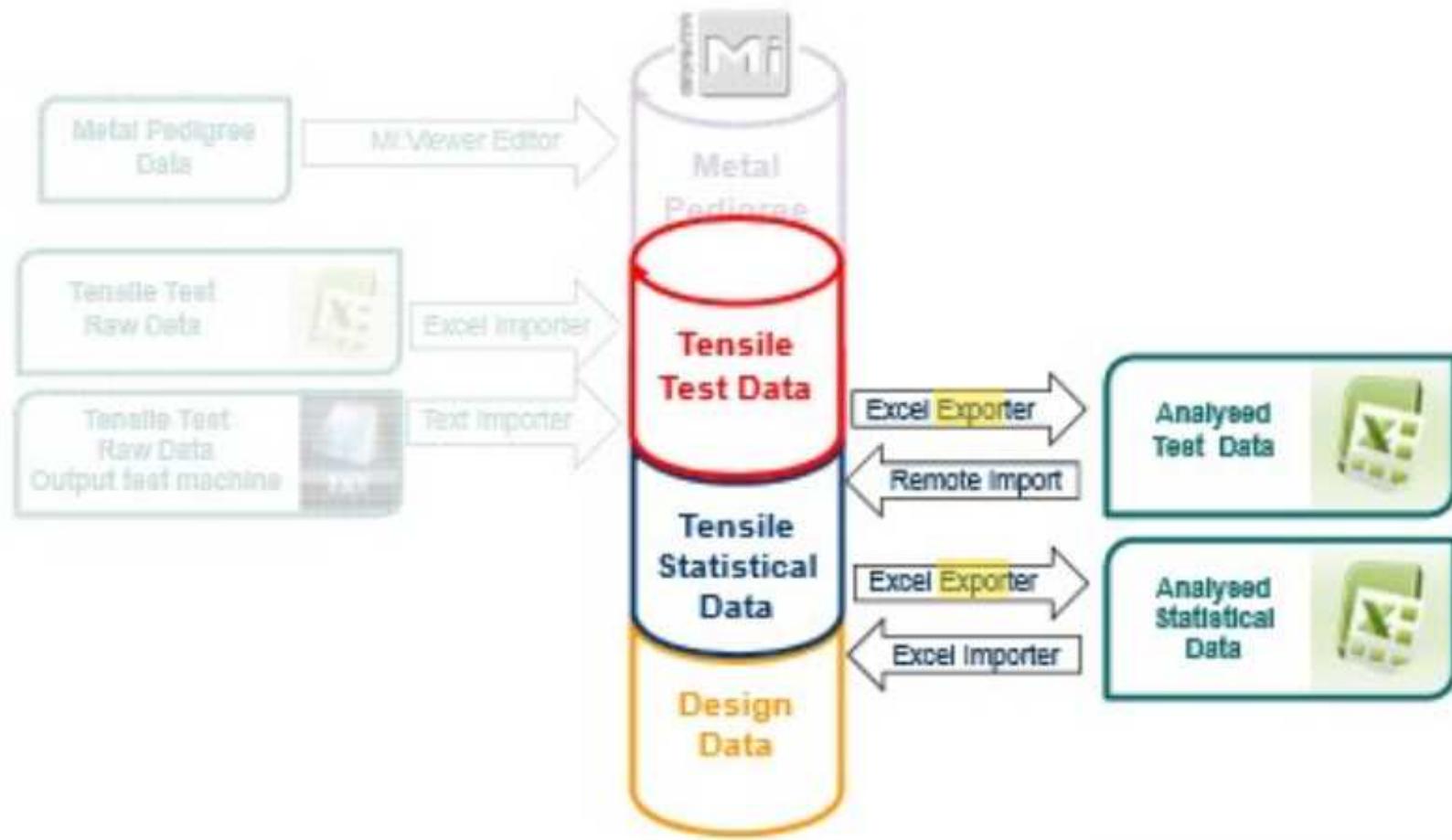
Richard Karnesky, rakarne@sandia.gov



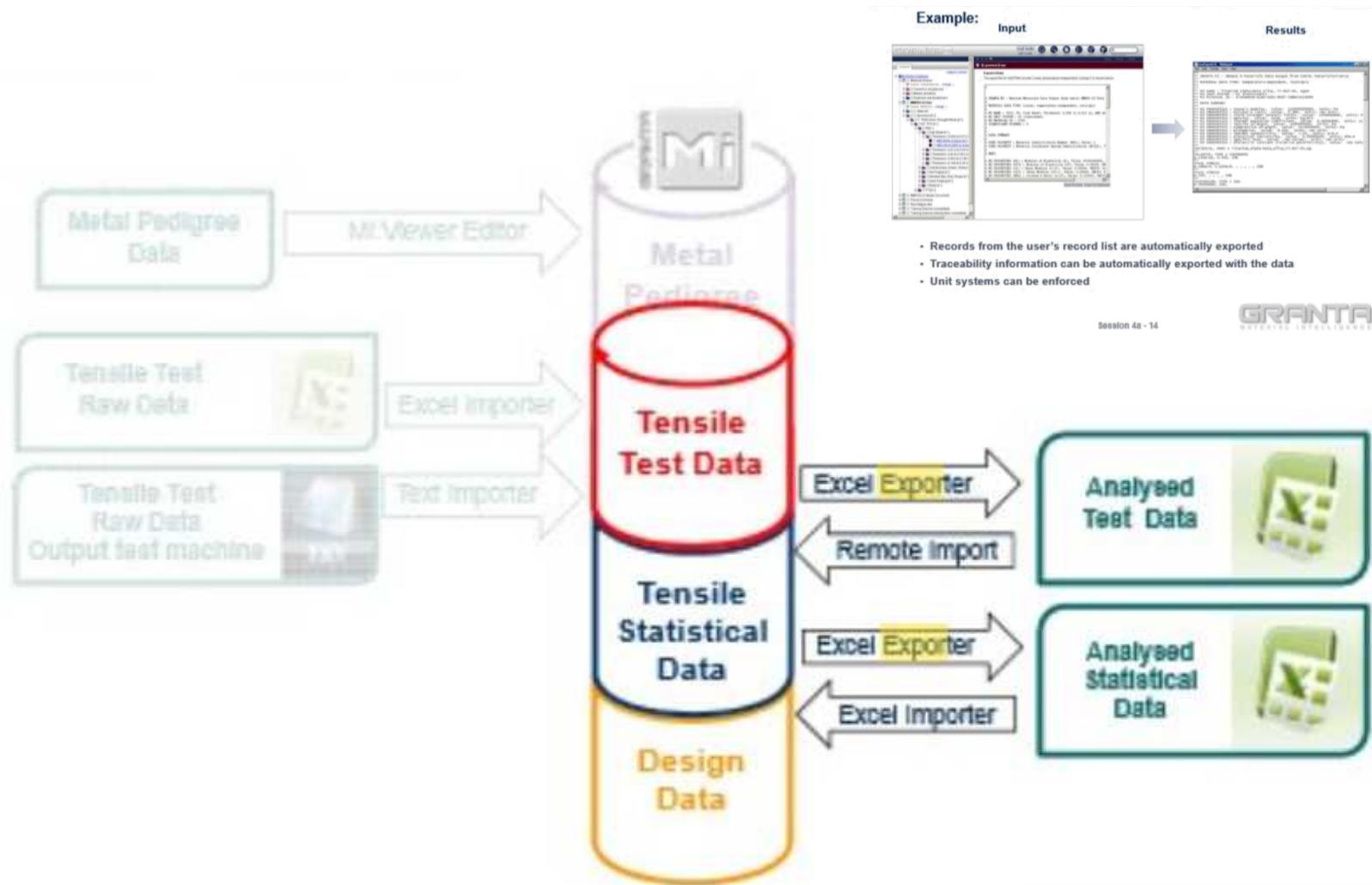
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First: A disclaimer

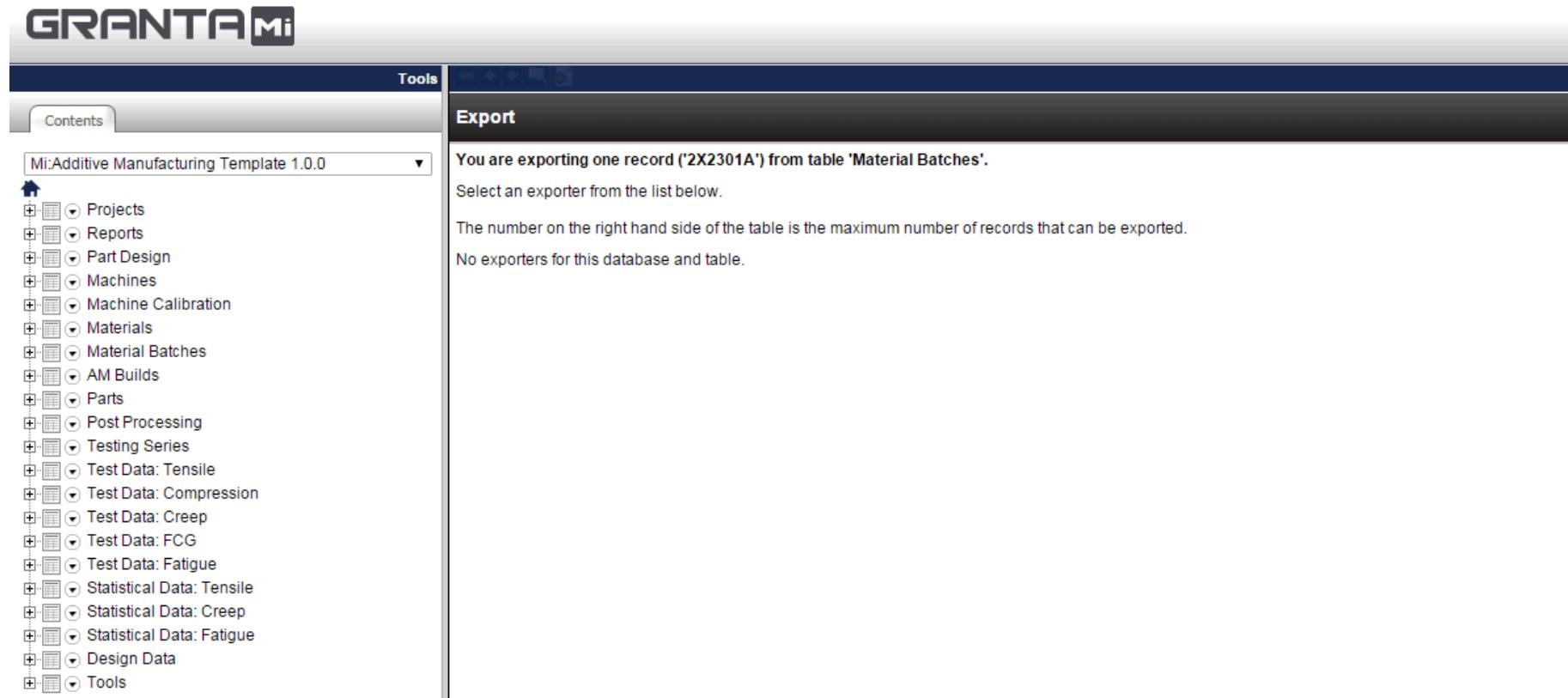
First: A disclaimer...Desired workflow



First: A disclaimer...Desired workflow



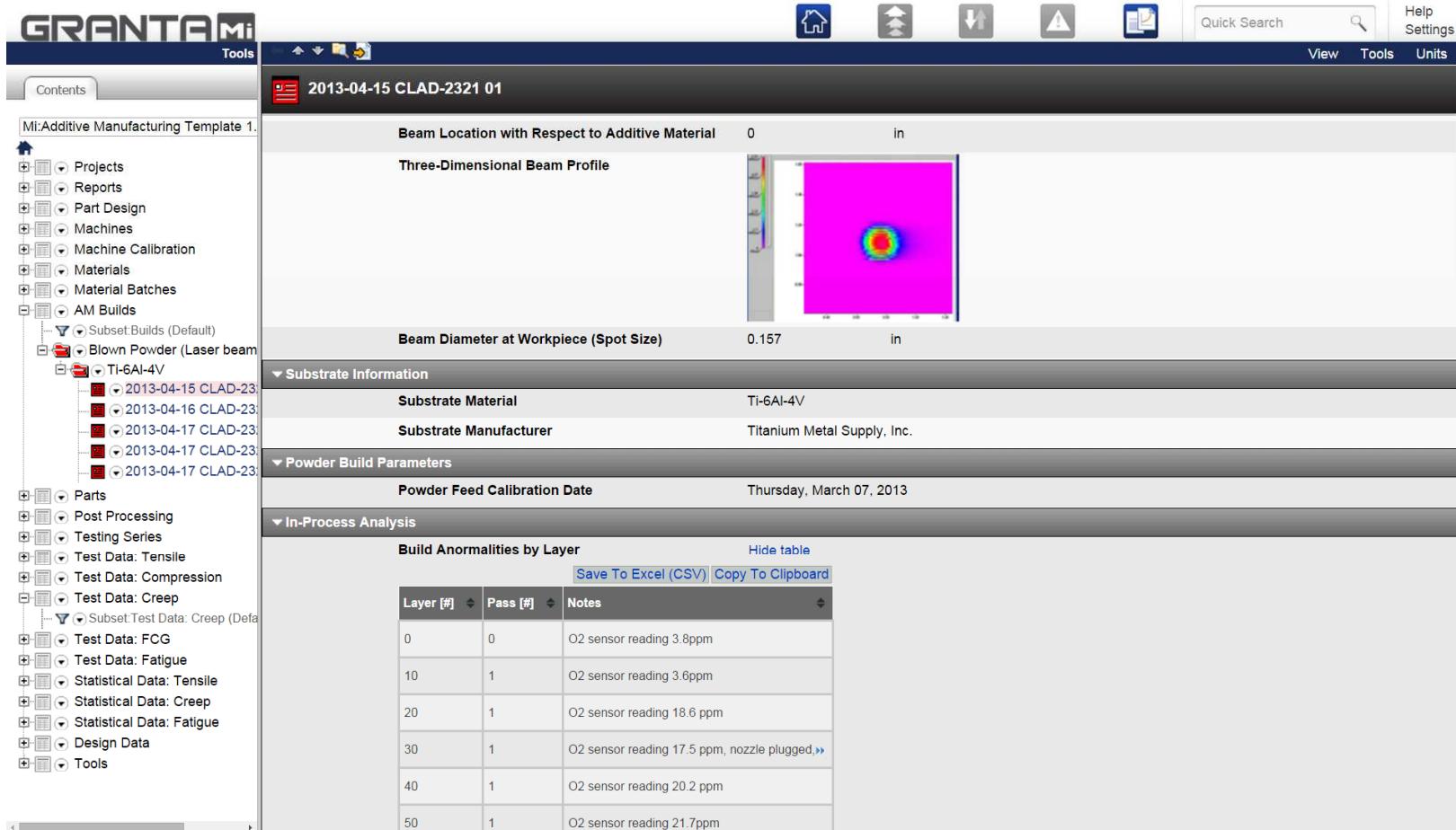
First: A disclaimer...Current workflow



The screenshot shows the GRANTA MI software interface. The left sidebar contains a tree view of database tables: Projects, Reports, Part Design, Machines, Machine Calibration, Materials, Material Batches, AM Builds, Parts, Post Processing, Testing Series, Test Data: Tensile, Test Data: Compression, Test Data: Creep, Test Data: FCG, Test Data: Fatigue, Statistical Data: Tensile, Statistical Data: Creep, Statistical Data: Fatigue, Design Data, and Tools. The 'Material Batches' node is expanded. The main content area is titled 'Export' and displays the message: 'You are exporting one record ('2X2301A') from table 'Material Batches''. It also says 'Select an exporter from the list below.' and 'The number on the right hand side of the table is the maximum number of records that can be exported.' A note at the bottom states 'No exporters for this database and table.'

Version 1.0.0 of the MI AM template has very few exporters “built-in”.
Granta and the AM working group will no doubt add more in the future.

That's not to say we can't already store useful data!



The screenshot shows the GRANTA Mi software interface. The left sidebar contains a navigation tree with categories like Mi: Additive Manufacturing Template 1, Projects, Reports, Part Design, Machines, Machine Calibration, Materials, Material Batches, AM Builds, Parts, Post Processing, Testing Series, Test Data: Tensile, Test Data: Compression, Test Data: Creep, Test Data: FCG, Test Data: Fatigue, Statistical Data: Tensile, Statistical Data: Creep, Statistical Data: Fatigue, Design Data, and Tools. The main workspace displays a 3D beam profile titled 'Three-Dimensional Beam Profile' with a beam diameter of 0.157 in. Below this, there is 'Substrate Information' (Substrate Material: Ti-6Al-4V, Substrate Manufacturer: Titanium Metal Supply, Inc.) and 'Powder Build Parameters' (Powder Feed Calibration Date: Thursday, March 07, 2013). The 'In-Process Analysis' section shows a table titled 'Build Anomalies by Layer' with the following data:

Layer [#]	Pass [#]	Notes
0	0	O2 sensor reading 3.8ppm
10	1	O2 sensor reading 3.6ppm
20	1	O2 sensor reading 18.6 ppm
30	1	O2 sensor reading 17.5 ppm, nozzle plugged.»
40	1	O2 sensor reading 20.2 ppm
50	1	O2 sensor reading 21.7ppm

And there are some extremely basic exporters already

GRANTAMi

Tools

Contents

Mi-Additive Manufacturing Template 1.0.0

- Projects
- Reports
- Part Design
- Machines
- Machine Calibration
- Materials
- Material Batches
- AM Builds
- Parts
- Post Processing
- Testing Series
- Test Data: Tensile
- Test Data: Compression
- Test Data: Creep
- Test Data: FCG
- Test Data: Fatigue
- Statistical Data: Tensile
- Statistical Data: Creep
- Statistical Data: Fatigue
- Design Data
- Tools
 - Subset: Tools (Default)
 - Export
 - Creep
 - Single Record
 - Creep (Imperial)
 - Creep (Metric)
 - Relaxation
 - Single Record
 - Relaxation (Imperial)
 - Relaxation (Metric)
 - Import

L13L12

Part Information

Part ID: L13L12
Part of Build: 2013-04-15 CLAD-2321 01
Build ID: 2013-04-15 CLAD-2321 01

Samples from this Part

Cut-off Diagram

Number of Samples Cut from Part: 9

Description of Tensile Samples cut from this Part

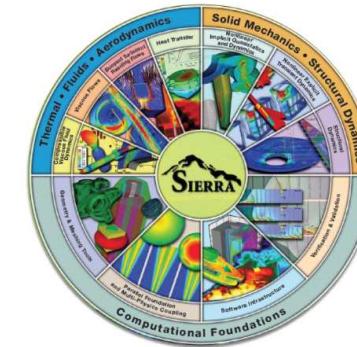
Save To Excel (CSV) | Copy To Clipboard

Specimen ID	Specimen location	Specimen orientation
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But: SNL already makes use of GRANTA MI data in design and analysis

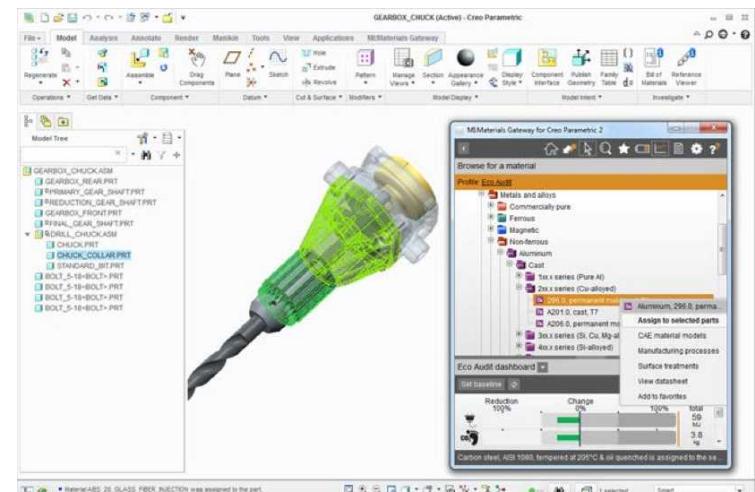
■ Sierra Mechanics Exporter (*J. Dike*)

- Supply Temperature Dependent Response
- Multiple Alloys
- For use in statics code



■ Drafting via MI:Materials Gateway Tool (*A. Machado*)

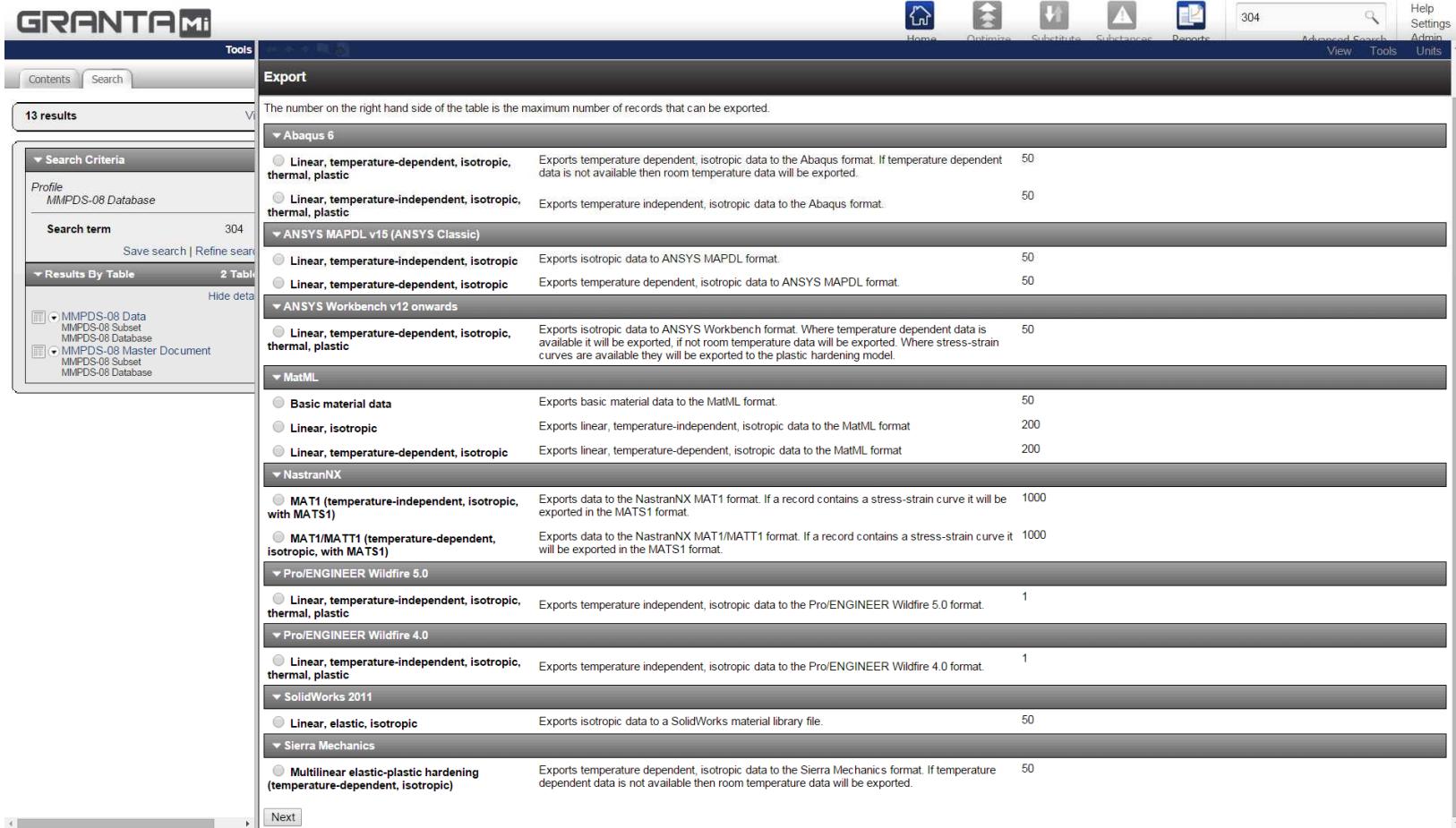
- Direct access to public and SNL-specific materials information
- Direct insertion into CAD models



Envisioned modes of data sharing

- Contribute to external database that uses Granta (e.g. ASM)
- Provide a raw database dump to other Granta users
- Allow web-based access to MI
 - We already do this for users of the SRN (can include non-Sandians)
 - We plan to do this for the SON for a “proof-of-principle” project
- Internally, we will allow integration with CREO
- We will use the export functionality built by the AM working group and in-house

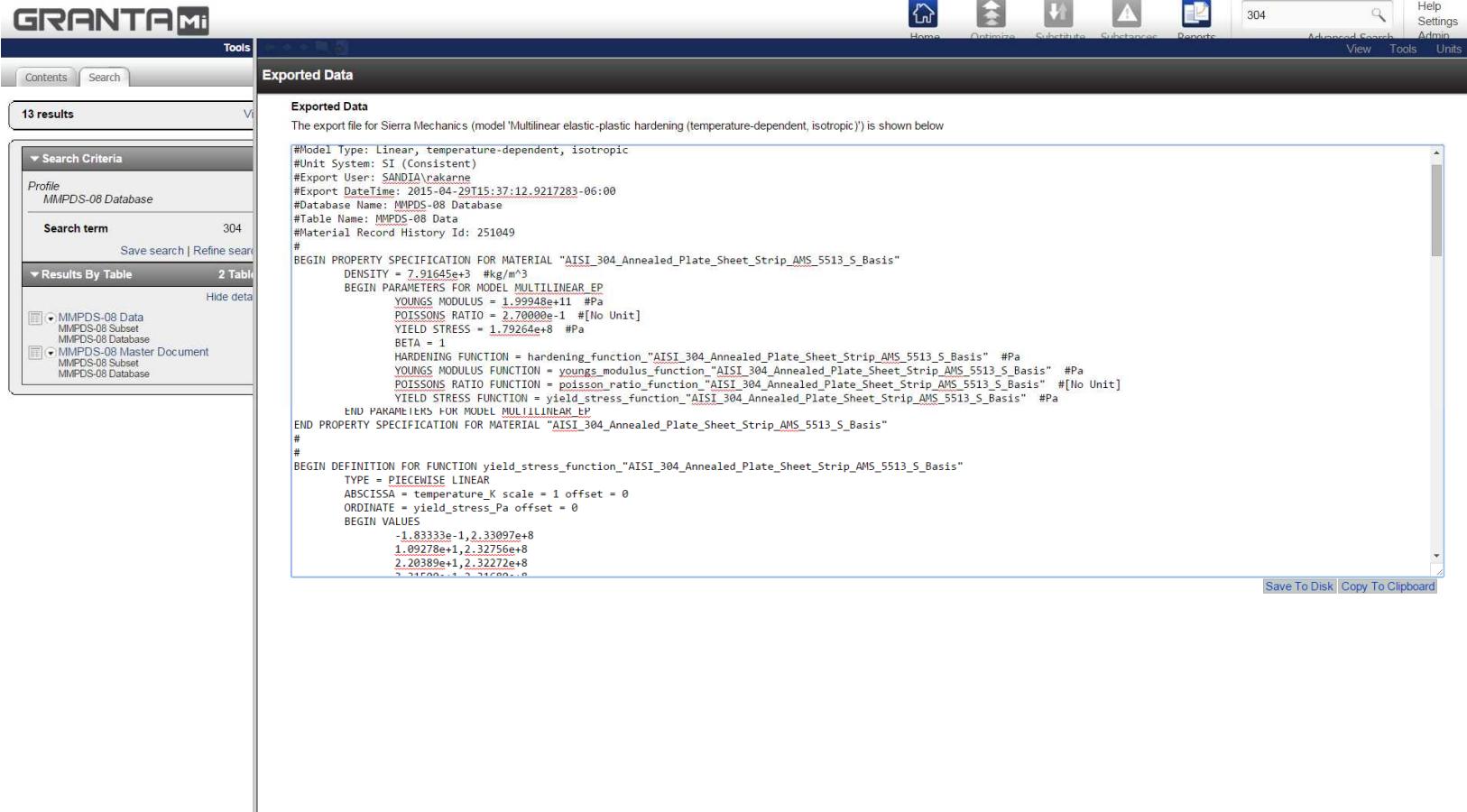
The MMPDS database gives an example of the rich export possibilities



The screenshot shows the GRANTA Mi MMPDS database interface. The left sidebar displays search criteria for 'Profile MMPDS-08 Database' and 'Search term 304'. The main content area is titled 'Export' and lists various software formats with their specific export options and maximum record counts. The listed formats include Abaqus 6, ANSYS MAPDL v15 (ANSYS Classic), ANSYS Workbench v12 onwards, MatML, NastranNX, Pro/ENGINEER Wildfire 5.0, Pro/ENGINEER Wildfire 4.0, SolidWorks 2011, and Sierra Mechanics. Each format section contains one or more export options, such as 'Linear, temperature-dependent, isotropic, thermal, plastic' for Abaqus 6, which has a maximum of 50 records.

Format	Export Option	Max Records
Abaqus 6	Linear, temperature-dependent, isotropic, thermal, plastic	50
	Linear, temperature-independent, isotropic, thermal, plastic	50
ANSYS MAPDL v15 (ANSYS Classic)	Linear, temperature-independent, isotropic	50
	Linear, temperature-dependent, isotropic	50
ANSYS Workbench v12 onwards	Linear, temperature-dependent, isotropic, thermal, plastic	50
	Basic material data	50
MatML	Linear, isotropic	200
	Linear, temperature-dependent, isotropic	200
NastranNX	MAT1 (temperature-independent, isotropic, with MATS1)	1000
	MAT1/MATT1 (temperature-dependent, isotropic, with MATS1)	1000
Pro/ENGINEER Wildfire 5.0	Linear, temperature-independent, isotropic, thermal, plastic	1
	Linear, temperature-independent, isotropic	1
Pro/ENGINEER Wildfire 4.0	Linear, temperature-independent, isotropic, thermal, plastic	1
	Linear, temperature-independent, isotropic	1
SolidWorks 2011	Linear, elastic, isotropic	50
	Multilinear elastic-plastic hardening (temperature-dependent, isotropic)	50
Sierra Mechanics	Multilinear elastic-plastic hardening (temperature-dependent, isotropic)	50

The Sierra Mechanics exporter was built for us by Granta



The screenshot shows the GRANTA Mi software interface. On the left, the 'Search Criteria' and 'Results By Table' sections are visible, showing a search for 'Sierra Mechanics' with 13 results. The main area is titled 'Exported Data' and displays the export file for the 'Sierra Mechanics' model. The file content is a text-based specification for a material model, including properties like density, modulus, and yield stress, and a piecewise linear yield stress function. The interface includes a navigation bar with 'Home', 'Optimise', 'Substances', 'Reports', '304', 'Advanced Search', 'View', 'Tools', and 'Units' buttons. A 'Help' menu is also present.

```
#Model Type: Linear, temperature-dependent, isotropic
#Unit System: SI (Consistent)
#Export User: SANDIA\rakarne
#Export Date/Time: 2015-04-29T15:37:12.9217283-06:00
#Database Name: MMPSD-08 Database
#Table Name: MMPSD-08 Data
#Material Record History Id: 251049
#
BEGIN PROPERTY SPECIFICATION FOR MATERIAL "AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
DENSITY = 7.91645e+3 #[kg/m^3]
BEGIN PARAMETERS FOR MODEL MULTILINEAR_EP
YOUNGS MODULUS = 1.99948e+11 #Pa
POISSONS RATIO = 2.70000e-1 #[No Unit]
YIELD STRESS = 1.79264e+8 #Pa
BETA = 1
HARDENING FUNCTION = hardening_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
YOUNGS MODULUS FUNCTION = youngs_modulus_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
POISSONS RATIO FUNCTION = poisson_ratio_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #[No Unit]
YIELD STRESS FUNCTION = yield_stress_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
END PARAMETERS FOR MODEL MULTILINEAR_EP
END PROPERTY SPECIFICATION FOR MATERIAL "AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
#
#
BEGIN DEFINITION FOR FUNCTION yield_stress_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
TYPE = PIECEWISE LINEAR
ABSCISSA = temperature_K scale = 1 offset = 0
ORDINATE = yield_stress_Pa offset = 0
BEGIN VALUES
-1.83333e-1,2.33097e+8
1.09278e+1,2.32756e+8
2.20389e+1,2.32272e+8
3.21500e+1,2.31500e+8

```

Exporters are coded in XSLT and can be shared

```
1 |<?xml version="1.0" encoding="utf-8"?>
2 |<!--$Rev: 50662 $--&gt;
3 |&lt;xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:fe="http://www.grantadesign.com/Granta-MI/exports" xmlns:xtn="http://www.grantadesign.com/xmlns/xtension"&gt;
4 |
5 |&lt;xsl:import href="CommonUtilities.xsl"/&gt;
6 |&lt;xsl:include href="SierraMechanicsFunctions.xsl"/&gt;
7 |
8 |&lt;xsl:output method="text"/&gt;
9 |
10|&lt;!--Some useful constants--&gt;
11|xsl:param name="nDigFigs" select="6"/>
12|xsl:param name="noValue" select="'[No Value]'/"/>
13|xsl:param name="noUnit" select="'[No Unit]'/"/>
14|
15|xsl:template match="tab">
16|<xsl:text>&#x09;</xsl:text>
17|xsl:apply-templates select="tab"/>
18|xsl:copy-of select="self::node()|not(tab) and not(*|tab)]"/>
19|</xsl:template>
20|
21|<!-- Output the boiler-plate that we put at the start of each record section in the Sierra Mechanics file -->
22|xsl:template name="writeRecordHeader">
23|<xsl:param name="modelType"/>
24|#GRANTA Material Name: <xsl:value-of select="xtn:escapeApos(string(@fullname))"/>
25|#Model Type: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:info/fe:UnitSystem))"/>
26|#Unit System: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:info/fe:user))"/>
27|#Export User: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:info/fe:date))"/>
28|#Export Date/Time: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:volumeDetails/@name))"/>
29|#Database Name: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:volumeDetails/@name))"/>
30|#Table Name: <xsl:value-of select="xtn:escapeApos(string(fe:FEAExport/fe:definitions/fe:info/fe:table))"/>
31|#Material Record History Id: <xsl:value-of select="@recordHistoryIdentity"/>
32#
33|</xsl:template>
34|
35|<!-- Writes one of the MI PROPERTIES sections as part of the human readable pedigree attribute: Granta name of the attribute to look up in the initial XML -->
36|xsl:template name="writePropertyValue">
37|<xsl:param name="attribute"/>
38|<xsl:param name="modelAttributeNames"/>
39|<xsl:param name="functionName"/>
40|
41|xsl:variable name="attrDefinition" select="fe:FEAExport/fe:definitions/fe:attributes/fe:attribute[fe:Name = $attribute]"/>
42|xsl:variable name="attr" select="fe:attributes/fe:attribute[@attributeID = $attrDefinition/@id]"/>
43|
44|xsl:variable name="outputText"/>
45|xsl:value-of select="$modelAttributeNames"/><xsl:text> = </xsl:text>
46|xsl:choose>
47|xsl:when test="$attr/fe:simpleValue"><xsl:apply-templates select="$attr/fe:simpleValue"/></xsl:when>
48|xsl:when test="$attrDefinition/fe:attributeType='functional'><xsl:value-of select="$functionName"/></xsl:when>
49|xsl:otherwise><xsl:value-of select="$noValue"/></xsl:otherwise>
50|xsl:choose>
51|xsl:choose>
52|xsl:choose>
53|xsl:when test="$attrDefinition/fe:Units/@name"><xsl:value-of select="$attrDefinition/fe:Units/@name"/></xsl:when>
54|xsl:otherwise><xsl:value-of select="$noUnit"/></xsl:otherwise>
55|xsl:choose>
56|xsl:text>&#xA;&#xA;</xsl:text>
57|xsl:variable>
58|xsl:value-of select="xtn:escapeApos(string($outputText))"/>
59|
60|</xsl:template>
61|
62|xsl:template name="writeFunction">
63|xsl:param name="functionName"/>
64|xsl:param name="functionName"/>
65|xsl:param name="functionalValues"/>
66|xsl:param name="parameterValues"/>
67|xsl:param name="ordinateName"/>
68|
69|<!-- Write the yield stress function -->
70|xsl:text>BEGIN DEFINITION FOR FUNCTION </xsl:text>
71|xsl:value-of select="$functionName"/>
72|xsl:text>&#xA;</xsl:text>
73|
74|xsl:choose>
```

Summary

- We are not yet exporting AM data
 - Nobody else really seems to be either!
- ...But we ARE exporting data in other databases
- We will use this experience to carefully critique the AM schema and how we add/use data
- The exporters are likely being built, and we may have the ability to help build them
- In addition to the technical aspects of coding an exporter that is most useful to end users, we are cognizant of other modes of data sharing and of the administrative/permission concerns