Materials Engineering & PLM for the Auto Industry

CIMdata PLM Leadership Webinar Series—9 June 2016

PLM Leadership

Materials Engineering & PLM for the Automotive Industry

CIMdata PLM Leadership Webinar Series
9 June 2016
#cimdatawebinar

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CIMdata® | Global Leaders in PLM Consulting
www.CIMdata.com

Presenter's Profile

Your presenter's professional background

- Peter A. Bilello, President
  - More than 27 years of experience in the development of IT solutions for research, engineering, and manufacturing organizations worldwide; has run numerous projects in PLM analysis, selection, implementation & management, synchronous and lean manufacturing consulting & software engineering
    - B.S. in Computer Science (minor in Physics) & M.S.E. in Manufacturing Systems Engineering

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Our Mission...

Strategic management consulting for competitive advantage in global markets

CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on the PLM market.

We are dedicated to maximizing our clients' ability to design and deliver innovative products and services through the application of PLM.

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Our Services...

Creating, disseminating, and applying our intellectual capital

Research

- *Market research & analysis*
- *Technology research & analysis*
- *Reports & publications*
- *Market news*
- *Member services...*

Education

- Executive seminars
- PLM Certificate Programs
- Technology seminars
- Int'l conferences & workshops
- Best practices training...

Consulting

- Strategy & vision
- Needs assessment
- Solution evaluation
- Best practices
- Quality assurance
- Program management
- Market planning...

Delivering strategic advice and counsel through a comprehensive, integrated set of research, education, and consulting services

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Our PLM Transformation Clients…

A sampling of CIMdata's international industrial clients

A&D

ALLEN VANGUARD · Vought · BELLTIS · AIRBUS GROUP · BOEING · Bell Helicopter · NORTHROP GRUMMAN · ZODIAC AEROSPACE · BOMBARDIER · Litton TASC · Fokker · Gulfstream · CAE · RAFAEL · CURTISS WRIGHT Controls · United Defense · EMBRAER · LOCKHEED MARTIN · Rolls-Royce · GENERAL DYNAMICS · BAE SYSTEMS · THALES · NASA Ames Research Center · Sandia National Laboratories · Orbital ATK · Los Alamos · GIAT industries

Auto

RENAULT · ASTON MARTIN · MANN+ · DLRA · DELPHI · NISSAN · JAGUAR · GM · TOYOTA · VOLVO · Johnson Controls · BOSCH · TIMKEN · MAHLE · E·T·N · faurecia · HONDA · HARLEY-DAVIDSON · BRIDGESTONE · LEAR · Visteon · BMW · Ford · The Ultimate Driving Machine · MAN · YAZAKI · CHRYSLER · FIAT · TENNECO · GRUPO ROCAR · FURUKAWA · NEXTEV · nemak · RICARDO · Autoliv · AVL · RIETER · INTIER · COOPER STANDARD

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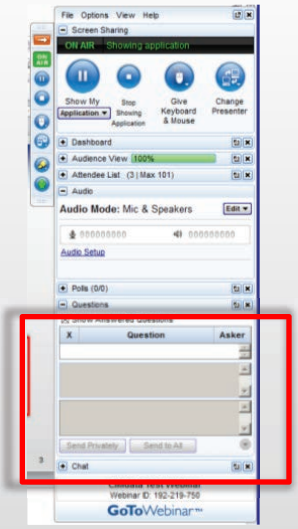
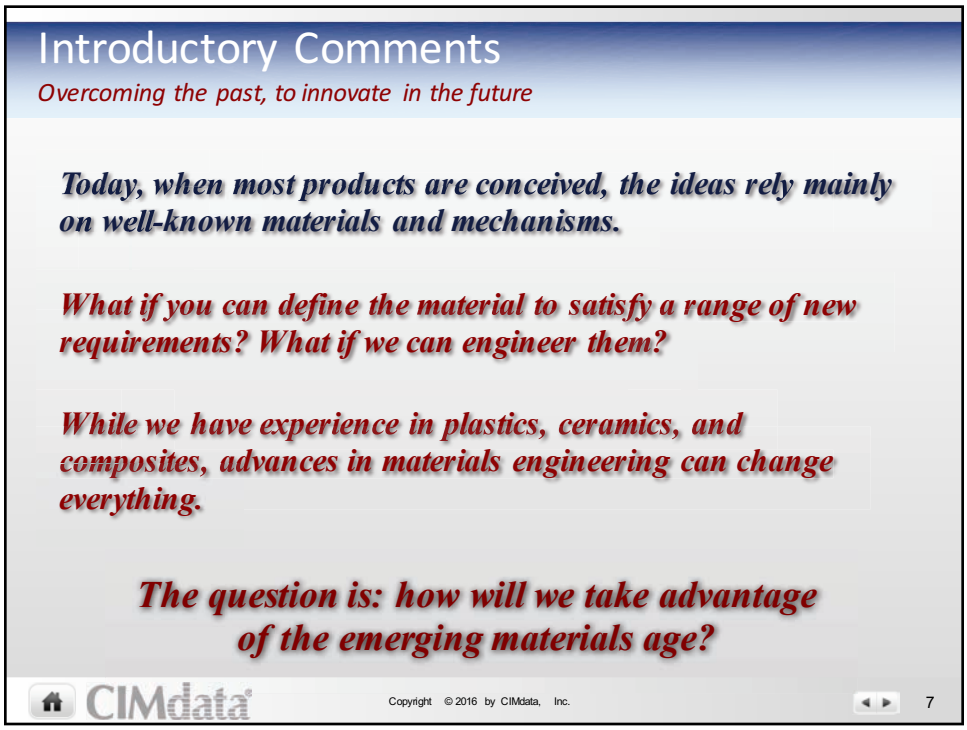
AMD · Microsoft · SHURE · PHILIPS · Applied Materials · Seagate · ERICSSON · IBM · OKI · rakon · ALCATEL · GIGABYTE TECHNOLOGY · Sun microsystems · MINOLTA · tellabs · BOSE · BANG & OLUFSEN · BenQ · NOKIA · Veeco · Waters · XEROX · LEXMARK · STORAGETEK · 3Com · opnext · Pulse · Raytheon · hp · DELL · FLUORWARE · SONY · NXP

Questions?

Please use the GoToMeeting chat panel

- We're hoping that the anonymity of the chat window might help participants ask more questions
- If you want to ask a question on the record, we'll certainly let everyone know you're asking
- The most important thing is interaction – let us hear from you on the call





Agenda

- Introducing the Materials Age
- An Historical Example
- Lifecycle Areas of Interest
- Concluding Remarks

The Materials Age is Upon Us

This changes everything—so how will we respond? (1 of 2)

"…the concepts of space, time, matter, energy, and information are essential…because living systems exist in space and are made of matter and energy organized by information.

…Matter [material] is anything that has mass and occupies physical space.

…Mass and energy are equivalent as one can be converted into the other.

…Information refers to the degrees of freedom that exist in a given situation to choose among signals, symbols, messages, or patterns to be transmitted."

Miller, James Grier, 1,102-page volume to present his living systems theory, 1978.

The Materials Age is Upon Us

This changes everything—so how will we respond? (2 of 2)

…Material

…Energy

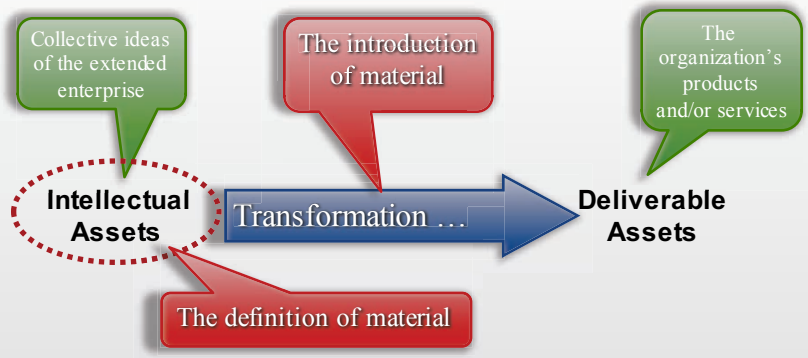
…Information

The three fundamentals of life…in the product lifecycle energy is provided by people, finances, and facilities...information is managed

...and what about material?

The Basics: the Product Lifecycle

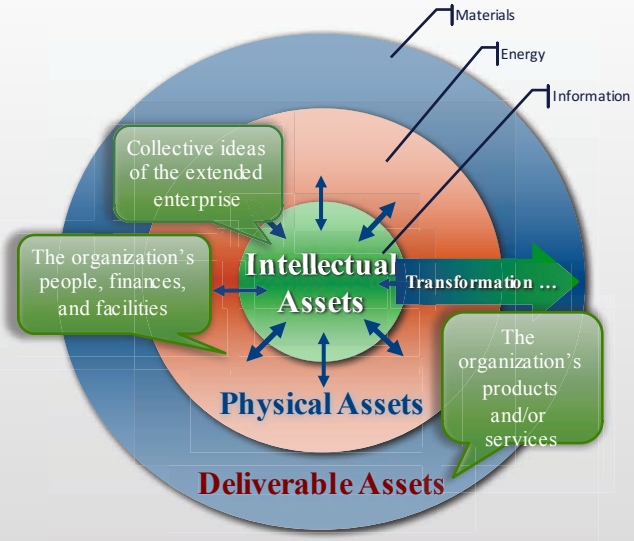
The transformation of information and material through the application of energy



Fundamentally, the product lifecycle creates and uses information and transforms material into a final state through the use of energy.

The Basic Organizational Model

Fundamentally, the organization's information is at the core



The Advent of the Information Age

Material, energy, and information—the three legs to the stool

"During the information age, the phenomenon is that the digital industry creates a knowledge-based society surrounded by a high-tech global economy that spans over its influence on how the manufacturing throughput and the service sector operate in an efficient and convenient way."

https://en.wikipedia.org/wiki/Information_Age

…Information Age, …has brought us the tools, techniques, and processes in PLM that support the way we define, design, engineer, produce, and support a wide range of products.

…What impacts will the apparent change in our ability to design and use new materials have on the lifecycle?

The Next Materials Age

"Engineered" materials—the next material age is emerging

The emergence of "new" materials like plastics, ceramics, composites, and other "engineered" materials requires collaboration across new methods, analytics, testing & other skills…

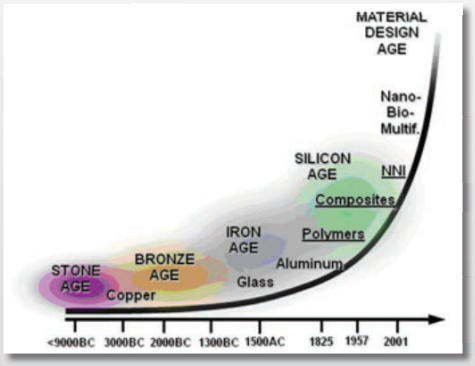


Image: http://simulatemore.mscsoftware.com/the-stone-age-the-bronze-age-the-composite-age/

- *… specialists are emerging—services and software solutions*
- *… simulation & analysis is expanding—up & down the "Vee"*
- *… additive manufacturing is spawning a renaissance of materials and manufacturing capabilities*
- *… new materials are being engineered to have specific properties*
- *… systems engineering goes to a new level where materials are engineered and validated*

Enabling the New Materials Age

The response to new materials-–enabling the third leg of the stool

…solution providers are responding with organic investments and partnerships in materials innovation & molecular modeling

…new materials and their related processes require significant work throughout the lifecycle, e.g., new design and analysis methods, new manufacturing process definition & tools, as well as new support & cost/profitability analysis services & tools, to name a few

…as PLM practitioners we must respond to help our organizations optimize the adoption and use of new materials and our associated design, manufacturing, and support processes.

Predicting the Future

The future of engineered materials: it will happen and be a differentiator for many

Don't worry about what anybody else is going to do… The best way to predict the future is to invent it. Really smart people with reasonable funding can do just about anything that doesn't violate too many of Newton's Laws!

Alan Kay, 1971 (PARC)

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Materials Engineering: Definition

Perhaps more than a science? (1 of 2)

The design of tailored materials with optimized characteristics, e.g., superior weight to strength ratio, given cost to produce, maintain, and re-X.

Often a combination of mechanical, chemical, and electrical properties that make other advances possible.

A balance of performance, properties, structure, and processing that don't violate physical laws.

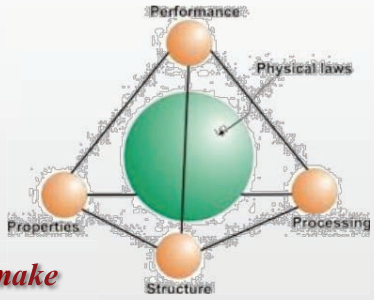

Image: http://www.cme.engineering.ualberta.ca/Undergraduate/MaterialsEngineering.aspx

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Materials Engineering: Definition

The General Materials Engineering Process (2 of 2)

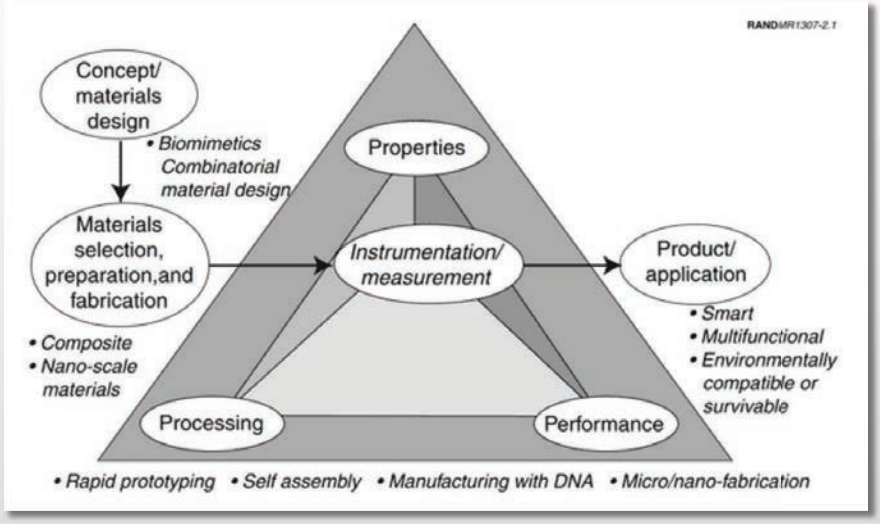

Image: http://fas.org/irp/nic/rand/mr1307.ch2.html

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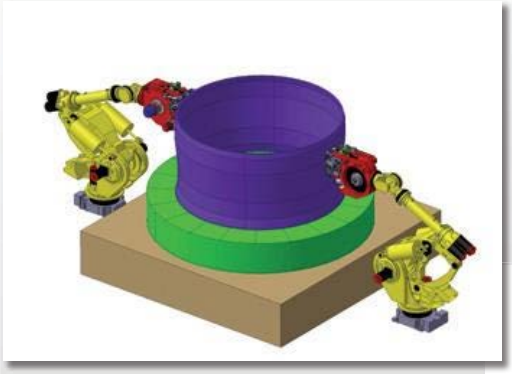
New Materials Require New Methods

Historical example: carbon fiber

- New machinery
  - Automated Fiber Placement (AFP)
  - Automated Tape Layup (ATL)
- New tooling
- New & enhanced computer applications
  - Numerical Controlled Layup and Placement
  - Simulation
- New industrial applications
- New support models

New Machinery

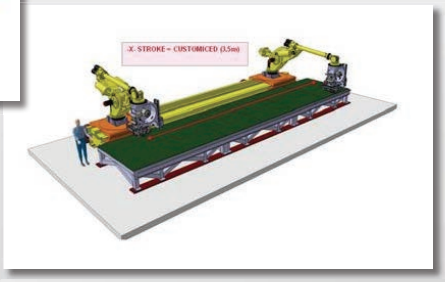
Carbon fiber composites drove development of new machinery (1 of 3)



Small, robot-based ATL

Automated Tape Laying

Robot-based flat ATL



Source: MTorres

New Machinery

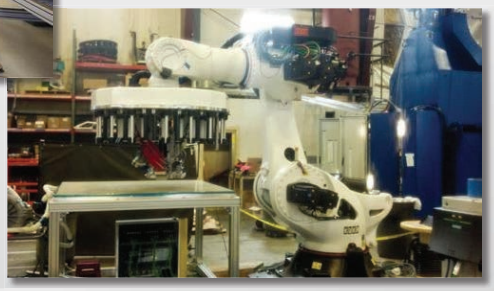
Carbon fiber composites drove development of new machinery (2 of 3)

Source: Coriolis Composites

Automated Fiber Placement

Robotic AFP

Robotic AFP with 16-tow AFP head



Source: Electroimpact

New Machinery

Carbon fiber composites drove development of new machinery (3 of 3)

Source: MTorres

Automated Fiber Placement

Small, robot-based AFP

Cantilever-gantry AFP

Source: MAG IAS

New Tools

Boeing 787—industrial scale example (1 of 2)

Boeing 787 composite nose being manufactured (width: 18 ft 11 in (5.77 m))

http://www.aerospaceweb.org/aircraft/jetliner/b787/pics01.shtml

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New Tools

Boeing 787—industrial scale example (2 of 2)

At one of the newest Boeing manufacturing locations, a new machining technology will be used to process a new choice of material within a new aircraft. Starting early next year, Boeing South Carolina will mill and drill composite fuselage sections for the 787 Dreamliner through **cryogenic machining**.

http://www.mmsonline.com/blog/post/cryogenic-machining-of-787-fuselage

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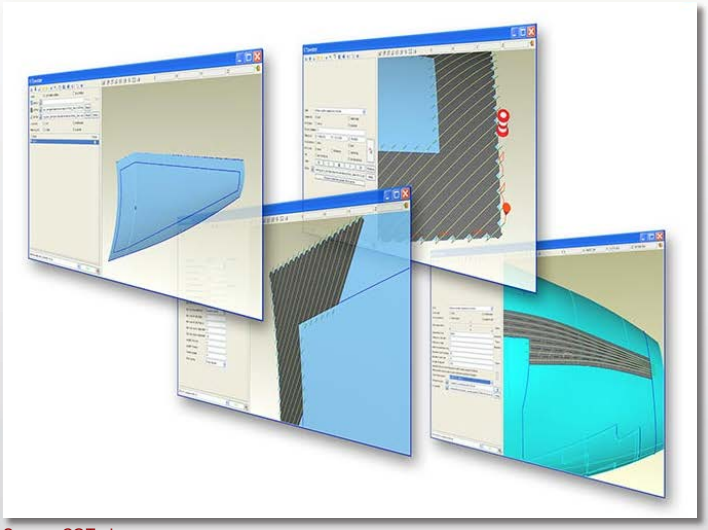
New & Enhanced Computer Applications

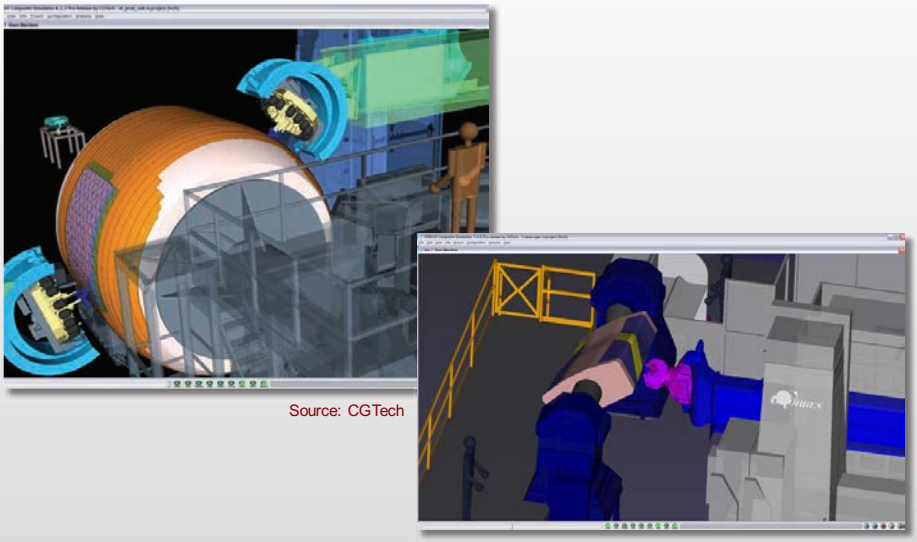
Lay-up machine programming – Simulation & CAM (1 of 2)



Source: CGTech

New & Enhanced Computer Applications

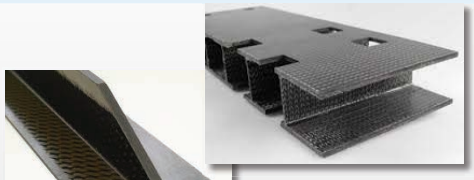
Layup machine pre-production simulation (2 of 2)



Source: CGTech

New Industrial Applications

The ability to design and manufacture new materials drives additional applications



Structural Parts Applications

Pressed Metal Applications

Forged Parts Applications

Cast Part Applications

New Support Models

Just print the part or tool when and where needed—no longer need to ship & store

3D Printing in Space

As is the case everywhere else, 3D printing has its merits in space–tremendous merits, in fact. With self-sustainability being a key bonus element to the incredibly progressive technology, 3D printing is a highly attractive idea to NASA.

http://3dprint.com/87416/3d-printing-space-supports/

The Age Old Question

New materials or new manufacturing processes or new applications?

http://monkeysocietyblog.blogspot.com/2013/06/what-came-first-chicken-or-egg.html

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Materials Engineering: Where in the Lifecycle?

From requirements through re-X—almost all steps impacted

PLM Solutions—Information Management across Media, Process, Time, Geography & Enterprise

Factors Changing Product Development

Demanding improved tools and different workflows (1 of 2)

- Design
  - "Designed" at the atomic and molecular levels
  - Optimized with the part design (composites)
  - Not homogeneous, not isotropic
  - Advanced high-strength alloys, biofidelity, as manufactured, …
- Testing
  - The purpose of simulation is not to reduce (or eliminate) testing
  - As you improve simulation capability, the nature of testing will change
  - Leveraging new materials and manufacturing processes requires enhanced test capabilities (for materials properties)

"A world-class simulation capability must be accompanied by a world-class test capability"
(James Welton, General Motors)

Factors Changing Product Development

Demanding improved tools and different workflows (2 of 2)

- Optimization (wrapped around simulation)
  - Topology (shape)
  - Subsystems (multi-body dynamics)
  - Systems operation (model-based)
  - Robust design (stochastics)
- Additive manufacturing (including 3D printing)
  - Is not a panacea
  - Brings in a new slate of constraints and considerations

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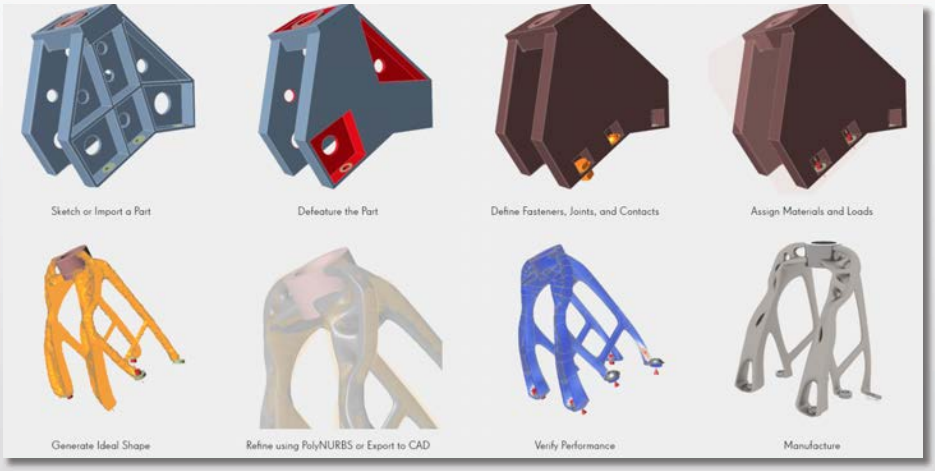
The Topology Optimization (TOp) Process

An illustration from Altair's solidThinking Inspire



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What is Additive Manufacturing?

3D Printing is just one part of this varied market

Additive Manufacturing (AM) is an appropriate name to describe the technologies that build 3D objects by adding layer-upon-layer of material, whether the material is plastic, metal, concrete…

The term AM encompasses many technologies including 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), layered manufacturing, and additive fabrication.

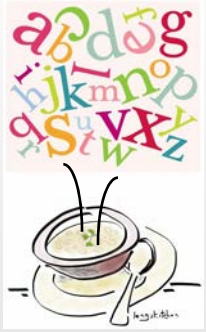
http://additivemanufacturing.com/basics/

Additive Manufacturing

3D printing best known—creating 3D objects by adding layer-upon-layer of material

- AM Technologies
  - Stereolithography (SLA)
  - Digital Light Processing (DLP)
  - Fused Deposition Modeling (FDM)
  - Selective Laser Sintering (SLS)
  - Selective Laser Melting (SLM)
  - Electronic Beam Melting (EBM)
  - Laminated Object Manufacturing (LOM)
  - *Including combined with subtractive*
- Materials
  - Plastics
  - Metals
  - Ceramics
  - Paper
  - Bio materials
  - *other and multiple materials*

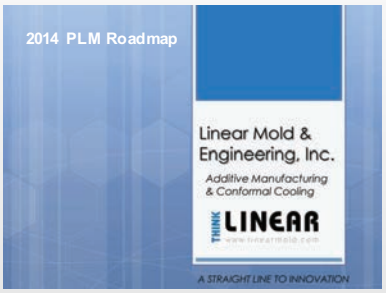
Alphabet Soup of Technology Acronyms



Flood of 3D Printers

Combining Additive & Subtractive

Another application that can make what cannot be made by subtractive alone



Lou Young, Director of New Business Development – Tooling & Mfg., Linear Mold & Engineering 2014 CIMdata PLM Road Map

- Effective mold cooling improves both quality and throughput
- Subtractive processes limit where cooling channels can be placed in mold inserts
- Used additive processes (SLS, DMLS) to enable conformal cooling, subtractive for finishing
  - Highly accurate
  - Simulate to find hot spots, design cooling
  - Stress relief/heat treatment, limited finishing required
- Case #1 – 12% scrap to 2%
- Case #2 – all scrap to no scrap, cycle time from 35 to 16 seconds

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GE Aircraft Engines Committed to AM

Part simplification, large scale production using AM, advanced ceramics

- LEAP engines from CFM International, a 50-50 JV of GE and Snecma (France)
  - Targeted to single-aisle aircraft, fastest growing segment (Boeing)
  - Both 3D-printed parts and components from advanced ceramic materials
    - 19 3D printed fuel nozzles (used DMLS), each replacing 20 part assembly, 5x more durable, 1/3 weight of steel
    - Heat-resistant ceramic matrix composites (CMCs) and carbon fiber fan blades woven in all three dimensions at once; 2/3 lighter, 20% higher operating temp than metal
  - Variants for the Airbus A320neo family, Boeing 737 MAX, ad COMAC C919
    - LEAP-1A (Airbus) received joint FAA, European Aviation Safety Agency certification in November 2015
  - Orders for more than 10K engines valued at $140 billion
- 3D printed parts on the GE9X, the largest jet engine ever built, for the Boeing 777X

Engine image from https://commons.wikimedia.org/wiki/File:Engine_of_Jet_Airways_Boeing_777-300ER.jpg

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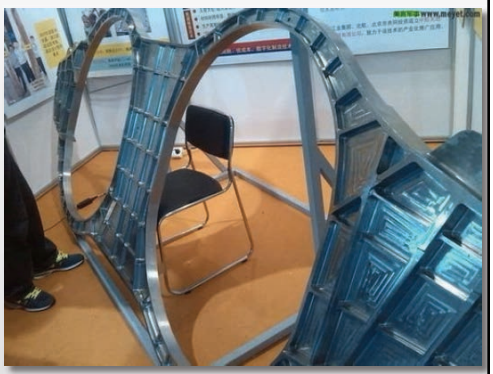
What Can We Make?

A comparison of two ways of manufacturing

- Envelopes expanding, make larger parts more feasible
- Chinese team printed titanium alloy load-bearing structure for a production aircraft
  - 6 meters in length
- Took 55 days to print at $200,000 vs. 2 years and $2 million using subtractive alone
- Totally changes manufacturing engineering economics
  - How do these numbers really compare?



http://www.3ders.org/articles/20140207-china-dev elo ping-world-largest-3d-printer--prints-6m-metal- parts-in- one-piece.html

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Concluding Remarks

PLM: Enabling the Materials Age (1 of 2)

- Materials Engineering: What's needed to support this emerging topic…
  - Standard engineering tables and design parameters
  - The management of system, sub system, environmental, and other requirements
  - Simulation and modeling of systems, structures, properties, and their interactions
  - Cost (and hopefully profitability) analysis and management
  - Design and simulation of manufacturing processes and tools
  - Design and simulation of maintenance and end-of-life processes and tools
  - Capture and management of lessons learned
- There are already a number of good examples in the automotive industry, but which comes first?

Concluding Remarks

PLM: Enabling the Materials Age (2 of 2)

- Materials engineering cannot be optimally supported without utilizing a systems modeling & simulation approach that starts with ideation and extends through the product lifecycle
  - Materials engineering seeks to optimize performance, properties, structure, and processes
  - Materials engineering is much more than materials selection
  - Materials engineering is a lifecycle discipline that must be supported throughout the product lifecycle
  - PLM platforms must support it in a holistic (i.e., lifecycle) manner

So, how will you and your company take advantage of the emerging materials age?

PLM Road Map™ 2016

for the Global Automotive Industry and their Supply Chain Partners

- Please join us at CIMdata's PLM Road Map™ 2016 to learn and network
- Date: November 3, 2016
- Location: The Inn at St. John's Plymouth, Michigan

Special Discount: 20% off!
Register and pay by July 6th 2016

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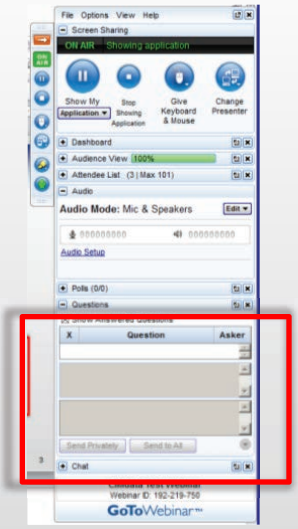

Next CIMdata Leadership Webinar

- Please join us on June 23, 2016 for the next Complimentary CIMdata Educational Webinar
  - "Ensuring the Dependability of Smart Connected Products"
  - Dr. Venkatesh "Venki" Agaram, Director - Quality & Reliability Engineering Practice, CIMdata
- Next monthly webinar scheduled for July 14, 2016
  - "Using Agile Methods to Speed Time to Value in a PLM Deployment"
  - Tom Gill, Practice Manager, PLM Enterprise Value & Integration, CIMdata

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