SCIENCE
IN THE AGE OF EXPERIENCE™

JUNE 18-21, 2018 | **BOSTON, MA**

ADDITIVE MANUFACTURING
SYMPOSIUM

MONDAY, JUNE 18, BOSTON, MA

ADDITIVE MANUFACTURING SYMPOSIUM
Monday, June 18, Boston, MA

Additive Manufacturing (AM) has progressed from its roots in prototyping applications to functional end-user production parts at enormous speed with transition; enabling lighter parts and shorter development cycles. Modern 3D design and modeling tools serve as powerful engines to come up with generative designs and bridge the gap between as-designed and as-manufactured parts. AM is being extended to new materials, processes and applications every day. However, the fast developing AM technology constantly confronts challenges such as how manufacturing affects design, quality control, process monitor and supply chain.

The AM Symposium at Science in the Age of Experience will be on June 18, 2018 in Boston, MA. Our theme will be Print to Perform with the following topics below:

- Design for AM
  - Function driven generative design
  - Lattice optimization
- Process simulations
  - Support structure optimization
  - Distortion prediction. Prediction and validation.
  - Residual stress and strain. Prediction and validation.
  - Print failure
  - Shape compensation
- Post-process for part yield and quality
  - Heat treatment
  - Post AM machining
  - Build plate removal
- In service part performance
  - Life time estimations
  - As built material property prediction
  - Part failure and durability
- Material design and modeling
  - Before print (material microscale modeling)
  - During print (material evolution)
  - After print (material performance)
- 3D printing in medical product creation
  - Medical devices, both implantable and non-implantable
  - Surgical and pre-surgical tools
  - Solid dosage drugs
  - Biological tissue structures

Goals and Objectives of the Symposium:
- Learn about AM from design to manufacturing and how DS technology can help your company optimize its AM experience
- Engage with the AM software and hardware developers
- Obtain hands-on experience through the Hackathon and network with the AM community
- Consult with industry experts to address AM challenges
- Learn about AM trends in new materials, new processes and new applications

Who attends AM Symposium?

- Software developers
- Hardware vendors
- Research professionals
- Corporate executives and business owners
- Product designers and engineers
- Manufacturing engineers and managers

SYMPOSIUM AGENDA

Plenary Session | Room: Back Bay

7:30	Breakfast in Gloucester
8:30	Workforce Development: The State of Women & Additive Manufacturing, Allison Grealis, Women in Manufacturing
9:00	Topology optimization of structures and infill for additive manufacturing, Ole Sigmund, Technical University of Denmark
9:40	**3D**EXPERIENCE Marketplace: introducing Make for on-demand manufacturing, and Part Supply for intelligent part sourcing Pierre-Edouard Planche, Dassault Systèmes
10:00	Coffee Break

Session A1: Design 1 | Room: Suffolk

10:30	Structural Optimization Developments for AM Designing, Claus Pedersen, Dassault Systèmes
11:00	Lattice and Topology: Two Sides of the Same Coin, Sean McCluskey, Joby Aviation
11:30	Generative design and fabrication—a One Touch Experience for Additive Manufacturing, Colin Swearingen, Dassault Systèmes / Andy Kalambi, RIZE
12:00	Industrial Use Case for Function Driven Generative Design, Ryan Benyshek, NIAR

Session B1: Manufacturing 1 | Room: Wellesley

10:30	Additive Manufacturing: predicting distortions, stresses,phase transformations and mechanical properties, Victor Oancea, Dassault Systèmes
11:00	Role of Process Simulation in Functional Metal AM Application—A Case Study on a Lawn Mower Engine, Guha Manogharan, Penn State University
11:30	Validation of a Generic Metallurgical Phase Transformation Framework Applied to Additive Manufacturing Processes, Tyler London, TWI
12:00	Virtual Printing: Simulating Different AM Processes to Produce Industrial Parts – Dassault Systemes/Renishaw/Stratasys, Akshay Narasimhan, Dassault Systèmes / John Laureto, Renishaw / Blake Courter, Stratasys

Session C1: Material | Room: Arlington

10:30	Material Challenges in Additive Manufacturing, Stephen Todd, Dassault Systèmes
11:00	AM Informatics—enabling digital thread and digital twin strategy for Additive Manufacturing, Najib Baig, Granta Design
11:30	Predicting the Future: Machine Learning, Materials Development, and their implications for advancing Additive Manufacturing, Dayton Horvath
12:00	Materials Modeling in Additive Manufacturing, Nick Reynolds, Dassault Systèmes

Session D1: 3D Printing in the Clinic | Room: Fairfield

10:30	Welcome, Steven Levine, Dassault Systèmes
10:45	From the Digital Thread to the Human Connection: Innovation in the Hospital Environment Through **3D**EXPERIENCE and Additive Manufacturing, Chris Meeker, Full Circle Systems Engineering LLC
11:15	3D Printing in Medicine and Education, Joe Crozier, Lifespan
11:45	3D Printing in Life Sciences—The Future is Already Here, Thomas Marchand, BIOMODEX
12:15	Q&A
12:30	Lunch

SYMPOSIUM AGENDA *(CONTINUED)*

Session A2: Design 2 | Room:Suffolk

1:30 Efficient Predictions of Thermal Stresses and Distortion of Metal Structures Fabricated
Using Additive Manufacturing, Devlin Hayduke, Material Science Corp

2:00 Topology optimization on tooling insert with conformal cooling channel by 3DE/GDE, Zhenhui Shen, Shanghai MAHLE

2:30 Data Structures for Modelling Complex Parts, Brad Rothenberg, nTopology

Session B2: Manufacturing 2 | Room: Wellesley

1:30 Improving Multi Jet Fusion (MJF™) printer design and print quality using validated process simulations, Dan Fradl, HP

2:00 Simulation of 3D Printed Polymers for Enhanced Fracture Properties, Jun Li, U Mass Dartmouth

2:30 Planning to Print: Engineering the Additive Manufacturing Process, Nc Kishore, Dassault Systèmes

Session C2: Manufacturing 3 | Room: Arlington

1:30 Additive Manufacturing Part Level Distortion Sensitivity Analysis within Abaqus on a Thin-walled,
Tubular Structure, Rick Deering, KCNSC

2:00 Advances in AM Process Simulation: Residual Stress Predictions for Laser Direct Energy Deposited Thin Components
and Overhanging Structures Manufactured via Selective Laser Melting, Stefanie Feih, SIMTech

2:30 3D Image Based Inspection and Finite Element Simulation of Additive Manufactured Parts, Kerim Genc, Synopsys

Session D2: 3D Printing with Biomaterials & 3D Printing in Medical Product Creation | Room: Fairfield

1:30 Advanced Manufacturing with Silk Proteins: Biopolymer Inks with Functional Structures, Maria Rodriguez, Tufts University

1:55 Medical 3D Printing: From Idea to Part, AJ Perez, Massachusetts Institute of Technology

2:20 A Medical Device Designed for You, Rob Stupplebeen, Optimal Device

2:45 Concluding Remarks, Steve Levine, Dassault Systèmes

3:00 Coffee Break

Plenary Session | Room: Back Bay

3:45 Workflow for First-time-right Design of Additive Manufactured Parts, Sjoerd Van-der-Veen, Airbus

4:30 AM Application of Xuberance in Architectural Practice, Steven MA, Xuberance

5:00 Panel Discussion: Andy Kalambi, RIZE; Eduardo Barocio, Purdue; Shawn Ehrstein, NIAR; Thomas Marchand, Biomodex;
John Laureto, Renishaw; Sean McCluskey, Joby Aviation

**5:30-
7:30** Cocktail Reception | Room: Atrium

ADDITIVE MANUFACTURING HACKATHON

Tuesday, June 19 – Wednesday, June 20

In conjunction with the Additive Manufacturing Symposium, we will host an Additive Manufacturing Hackathon. In this **FREE** event, participants will use **3D**EXPERIENCE roles to overcome design and manufacturing challenges in additive manufacturing. Dassault Systèmes software for Functional Generative Design, Process Planning and Simulation, Topology Optimization and Shape Compensation will be made available on workstations, with expert application engineers available for support. In teams, participants will use the software tools to analyze, evaluate, and optimize the AM designs of several realistic engineering challenges.

At the end of the Hackathon, teams will have the opportunity to print their designs and present their solutions to a selected panel of jurists. **The winning team will receive $5,000**. Winners of the Hackathon will be announced before the conclusion of Science in the Age of Experience.

Tuesday, June 19	8:30–9:00 AM	Introduction
	9:00–9:30AM	Function Driven Generative Design Lecture
	9:30–10:00AM	Manufacturing Planning Lecture
	10:00–10:30AM	Break
	10:30–11:00AM	Process Simulations Lecture
	11:00–12:00PM	Team Intros and Planning
	12:00–1:00PM	Lunch
	1:00–6:00PM	Hackathon
Wednesday, June 20	8:30AM–3:00PM	Hackathon
	3:00–5:00PM	Presentations, Judging, Prizes

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KEYNOTE PRESENTATIONS AND ABSTRACTS

Allison Grealis, President, Women in Manufacturing

Allison Grealis is founder and president of Women in Manufacturing (WiM), a national trade association focused on supporting, promoting and inspiring women in the manufacturing sector. She is also the vice president of membership and association services of the Precision Metalforming Association (PMA), a full-service trade association representing the metalforming industry. Since joining PMA in 2001, Grealis has held a variety of positions that included district, committee and division management; affinity partner relations; sponsorship sales; new product and service development; and member services. Grealis earned her Bachelor of Arts in English with a certificate in Women's Studies from Ohio University and a Masters in Public Administration from the University of Akron. Presently, Grealis serves on the boards of the Greater Cleveland Society of Association Executives, Our Lady of the Elms High School, the St. Raphael Home and School Association and the Flora Stone Mather Center for Women, Case Western Reserve University.

Workforce Development: The State of Women & Additive Manufacturing

Allison will speak to the great things that Women in Manufacturing (WiM), the association is doing in the general space of manufacturing to help with workforce development. She will then address this more specifically to additive manufacturing and how women can position themselves for success and opportunity in this rapidly expanding manufacturing sector. She will also address the following questions:

- While AM is requesting new workforce development, creating new job opportunities, how organizations/companies should support women in this new manufacturing sector;
- What are the changes that Additive brings to the world of Women in Manufacturing;
- What are the advantages/disadvantages for women in this field;
- Within Additive Manufacturing, what are the work areas that women could better fit into and use their advantage;
- How to educate, promote and inspire women for Additive Manufacturing;
- How to generate fair public view on women at work;

Ole Sigmund, Professor and Villum Investigator, Technical University of Denmark

Ole Sigmund is a Professor and Villum Investigator at the Department of Mechanical Engineering, Technical University of Denmark (DTU). He obtained his Ph.D.-degree 1994 and Habilitation in 2001 and has held research positions at University of Essen and Princeton University. He is a member of the Danish Academy of Technical Sciences and the Royal Academy of Science and Letters (Denmark) and is the former President (2011-15, now EC member) of ISSMO (International Society of Structural and Multidisciplinary Optimization). Together with Noboru Kikuchi and Martin Bendsøe, Ole Sigmund is one of the founders and main contributors to the development of topology optimization methods in academia and industry. Present research interests include theoretical extensions and applications of topology optimization methods to mechanics and multiphysics problems under the consideration of manufacturing constraints. Ole Sigmund has authored 190 international journal papers which are cited more than 11,000 times in the ISI Science Citation Index and his H-index is 50.

Topology optimization of structures and infill for additive manufacturing

Topology optimization (TO) and additive manufacturing (AM) constitute an idea marriage. Highly optimized designs coming out of TO or generative design approaches often have intricate or organic looking shapes that only can be manufactured using AM technologies. On the other hand, AM offers unique manufacturing capabilities such as complex lattice structures and infill that may have advantages over traditional solid structures but also require reformulation of TO approaches to release their full potential.

The talk gives an overview of recent TO developments, starting with a giga-voxel design study for a full airplane wing, requiring massively parallel computing efforts, and continuing to more efficient multi-scale projection approaches that allow design of open and closed-walled lattice or infill structures, directly aimed at AM-based realizations. Contrary to common belief, however, lattice structures are not stiffness optimal. Nevertheless, lattice structures may be a good choice if buckling stability, transparency, requirements to permeability or other alternative mechanical or multiphysics aspects play a role in the optimization problem. After a discussion of these aspects, the talk ends with a few examples of alternative TO/AM applications within thermofluidics and an outlook with regards to future developments in the field.

Pierre-Edouard Planche, Strategy & Business Development Manager, 3DEXPERIENCE Marketplace, Dassault Systèmes

Currently a Strategy & Business Development Manager at Dassault Systèmes with focus on the **3D**EXPERIENCE Marketplace, Pierre was previously a Product Manager with SOLIDWORKS on the Strategic Portfolio Group responsible for Manufacturing Strategy & web products. Pierre is passionate about both implementing and identifying emerging technologies that advance traditional processes and foster innovation. Primary areas of interest include: Advanced & Additive Manufacturing, Engineering Design, Enterprise Platforms & BI, Marketplaces, Industry 4.0, Supply Chain & Logistics, IoT, AR/VR, and the use of AI in these fields. He regularly attends or speaks at global industry events and am always interested in discussing the latest industry trends and the value of our solutions to meet these needs—so don't hesitate to reach out to him!

3DEXPERIENCE Marketplace: introducing Make for on-demand manufacturing, and Part Supply for intelligent part sourcing

Launched earlier this year, the Dassault Systèmes **3D**EXPERIENCE Marketplace empowers you to collaborate with qualified industrial service providers across a range of 'services' throughout your product innovation process. The first two Marketplace services consist of Make for on-demand manufacturing across all manufacturing processes, and PartSupply for intelligent 3D component sourcing. You can access Marketplace services directly from SOLIDWORKS, CATIA V5 and **3D**EXPERIENCE platform Apps—allowing for a seamless journey from within your design environment. Depending on your needs, each of the Marketplace services consists of both a 'community' offering which is public and accessible to anyone, as well as 'enterprise' services that offer organizations additional value and control over both their internal and external ecosystems for their design to manufacturing processes.

Sjoerd van der Veen, Expert in material modelling and manufacturing process simulation, Airbus

Sjoerd van der Veen obtained an MSc in mechanical engineering from Delft University in 1996. He held several positions in the metals industry before joining Airbus in 2006. He was appointed expert in material modelling and manufacturing simulation in 2010 and has been instrumental in the creation of a new dedicated manufacturing simulation team in Airbus in 2018. Going forward, his mission is to support the digitalization of Airbus' design and manufacturing system with physics-based modeling.

Workflow for first-time-right design of additive manufactured parts

In the last years, Airbus has put several 10's of thousands additive manufactured detail parts into service. An ambitious strategy has been put in place to increase the number of applications year-on-year, for polymers and metals. This calls for highly efficient methods and tools to (re-)design parts. This new toolset, implemented in 3Dexperience, starts with topology optimization and has already led to spectacular weight savings, obtained at a very acceptable (re-)design cost. The next step is integration of manufacturing simulation. The first stage of this integration, rapid and easy-to-use prediction of recurrent manufacturing problems like distortion and support cracking, is now complete. The ultimate step, in which extremely fast process simulation provides manufacturing constraints to the topology optimization, has already been prototyped. This technology can be used to fully optimize support structures for a given (weight-optimized) part design, or even to find new compromises between weight savings and total manufacturing cost, if the part design is also included in the design space. Design for manufacturing of additive parts is thus rapidly becoming reality.

Steven MA, Founder & Chief Design Officer, Xuberance.Co.Ltd.

Steven Ma [b.1981] is the founder and Chief Design Officer of Xuberance.Co.Ltd since 2008 in Vienna, Austria and moved to Shanghai in 2014, becoming China's first professional 3D-Printing Design Company provides customized design service, digital fabrication, professional training and 3D-Printing experience shop.

One of the leading expert in the field of addictive manufacturing industry pushing the boundary of 3D-Printed consumer products and b2b design service in Asia. Steven Ma has more than 10 years of architecture experiences including lead designer for Wolf Prix - Coophimmelblau in Austria and Hernan Diaz Alonso – Xefirotarch in Los Angeles. Steven holds a Master of Architecture degree from the Southern California Institute of Architecture [2008]. He has been teaching as an assistant professor at the University of Applied Arts Vienna, Institute of Architecture, Hong Kong University and Aalto University Digital Design Laboratory [ADD]. He is currently appointed as the Program Director for SCI-Arc (South California Institute of Architecture)Asia Program, as well as adjunct professor at Tongji University D&I in Shanghai and visiting professor at Guangzhou Academy of Fine Arts. He has been invited for numerous international digital workshop including Tsinghua University Digital Design, Tongji University DADA Digital Factory, AA London Summer Program Shanghai.

Steven Ma is the recipients of First Prize Winner for The SaloneSatellite Milan Award 2015 and China Interior Design Award for innovative design 2014. Recently the company lead by Steven Ma also won The Best Innovation Award in Shanghai Industrial Design Association 2017 and Gold Medal of 3D-Printing, China Creative industrial Design Competition 2016.

Well known digital design pioneer whose works have been widely published and included at the exhibitions of 9th ArchiLab: Naturalizing Architecture [Orleans, France 2013]. Steven Ma's work rests on the potentialities of digital tools distanced from any attempt at optimization in favor of baroque, excessive & abundant aesthetics.

Xuberance, as the Avantgarde digital design company in Shanghai, has applied numerous cases in Architecture, Design and construction application.

Xuberance work has gained international recognition for its excessive approach to 3D Printing Design; one that seamlessly integrates digital technology with an extensive consideration of form, novel tectonics and innovative materials. We aim to generate innovative spatial forms that actively engage, enhance and influences the body, constantly challenging its relationship to the environment akin to the complexity of contemporary life.

AM Application of Xuberance in Architectural Practice

By specializing in 3D-Printing design across multiple scales, from small objects to large installations, Xuberance tried to design jewelry, lights, fashion products and furniture with architectural geometry, printed by 3D printing technique. As an aesthetics result, our works produce innovative products and projects that are both exclusive and accessible, forward looking and distinctly contemporary in their formal and material aesthetics and unapologetically timeless in their functional and spatial performance. Our creative process involves an analytical approach to the specifics of each project, client and context, an imaginative philosophy and unique artistic sensibility to product design and a sophisticated technological solution to its fabrication and material tectonics.

In this symposium Xuberance interested in

1) sharing Xuberance application of 3DP Manufacturing during the past 10 years;

2) to discuss the advantages and disadvantage of 3DP technologies in Design area

3) to discuss the Intellectual Property protection of 3DP digital model

4) to discuss the remote manufacturing system in 3DP in PLM & ERP System

TECHNICAL PRESENTATIONS AND ABSTRACTS

Claus Pedersen, Technology Director at CTO Office R&D SIMULIA, Dassault Systèmes

Claus is Optimization Technology Director at the CTO Office of R&D SIMULIA, Dassault Systèmes where he has the job role of defining R&D strategies, inventing and examining the technology of new optimization methodologies, coding of CAE and optimization kernels, competitive intelligence, technical due diligence, coaching and knowledge sharing for core optimization technologies, research projects and numerical implementation with different commercial research partners, worldwide presale for customers and presenting at conferences, and corporations with leading international universities. Additionally, his role is highly interdisciplinary working with different teams and organizations involving crossover brand activities from R&D, marketing to international sales on latest technology.

He has continued to have a strong connection to applied science and research since he received his Ph.D. at Department of Mechanical Engineering, Solid Mechanics, Technical University of Denmark in 2002 and his work the following

2 years as Research Associate at Department of Engineering, Cambridge University, UK. He is reviewing for thirteen international journals, external examiner at several technical universities and supervisor of interns. He has published 12 articles in reviewed international journals and held more than 40 presentations at international conferences.

Structural Optimization Developments of AM Designing

The current work presents the latest industrial solutions and workflows offered and being developed by Dassault Systèmes for optimization. The following work will focus on some of the many new advances for industrial additive manufacturing (AM) designing.

Recently, several advances have been done for the Abaqus Multi-Grid (AMG) iterative solver addressing large scale simulations with high performance and high accuracy. The AMG solution has been implemented for both the structural solving of the primal solution as well as for the adjoint system for the sensitivities. Thus, the present solution addresses industrial large scale designing challenges, e.g. if one can print a minimum size of 0.5 mm and the design space is 20x20x20 cm then a minimum finite element resolution of 64 million elements is required. For such models designers expect a relative fast turnaround time and a relative small amount of memory consumption. The presented AMG solution brings realistic simulation and thereby, realistic optimization to designers as unstructured and arbitrary meshes can be simulated including contact modeling (penalty & augmented Lagrange method), gasket elements, pre-tension sections, constraints as tie, MPC, kinematic coupling and rigid body, and boundary conditions as symmetry and periodicity as well as a large number of boundary conditions.

Secondly, we demonstrate lattice and sheet designing for non-linear industrial sizing optimization for design responses of CAE results including material non-linearities, geometrical non-linearities for large deformations and contacts. To the best of our knowledge, this is the first work that shows results for non-linear sizing of shell thicknesses and lattice radiuses using adjoint sensitivities including simultaneously the three modeling non-linearities.

Thirdly, an overhanging constraint ensures that the optimized structures are printable up to a certain minimum angle, depending upon the material and printing technique as well as a lot of time-consuming and costly post-manufacturing after the AM printing can be reduced or eliminated. The overhanging constraint for topology optimization is formulated as a geometrical constraint. Most important for industrial CAE models the present geometrical constraint allows unstructured meshes (e.g. triangular or tetrahedral meshes), various objective functions and constraints typically applied in industrial applications (e.g. minimize mass with stiffness, strength and modal eigenfrequency constraints).

For all above three topics several industrial design applications will be shown.

Lattice and Topology: Two Sides of the Same Coin
Sean McCluskey, Joby Aviation
After graduating from Stanford University with a degree in Mechanical Engineering focusing in Additive Manufacturing, and a brief tenure in the medical device space, Sean transitioned to Carbon Inc where he was most recently Head of Production Engineering and Special Projects, over-seeing all aspects of advance design for additive. Sean is currently with Joby Aviation (http://www.jobyaviation.com) developing novel additive solutions for eVTOL applications.

While lattice and topology optimization clearly have significant benefits, they each also have significant drawbacks. Tools for lattice and topology optimization are also currently not located in the same software packages, which leads to an extremely challenging workflow for integration. This talk will look at the Venn diagram of the shortcomings of both design methodologies and explore the need for a unified optimization solution.

Topology optimization on tooling insert with conformal cooling channel by 3DE/GDE

Zhenhui Shen, FEA Engineer, Shanghai MAHLE Thermal System Co., LTD.
Zhenhui.Shen is a FEA engineer at Shanghai MAHLE Thermal Systems in Shanghai, China. He received his B.S from WUST and his M.S from SJTU before joining SMTS as a structural analysis engineer in 2015. His mainly works on structural analysis and optimization on cooling products and plastic parts in HVAC. His recent job includes topology optimization on tooling through 3DE/GDE platform.

Additive manufacturing offers designers more freedom to bring their ideas to life. Conformal cooling in tooling design is an exciting application of this kind, which boasts higher cooling efficiency and better product quality. In this work topology optimization task is performed on a tooling insert featured with conformal cooling in GDE to achieve a more economical distribution of the material, thus tackling the challenge of cost rise resulted from additive manufacturing. The optimized design will be carried out in real project to test its performance.

Generative design and fabrication – a One Touch Experience for Additive Manufacturing - Dassault Systemes / RIZE

This presentation will demonstrate the new Digital Engineer that is now empowered to design, simulate and fabricate an industrial additive part—all in one environment.

Colin Swearingen, Solution Consultant, Dassault Systèmes
Colin Swearingen brings an expertise in many Dassault Systèmes products from his time spent as a services consultant, with a strong focus in Light Weight Engineering and design for Additive Manufacturing. Since his time as a Solutions Consultant, Colin has set many high standards for executing projects with tact and technical ability. His keen attention to detail helps facilitate Dassault Systèmes unique solutions in a valuable and effective manner. Colin came straight to Dassault Systèmes after graduating from the Georgia Institute of Technology majoring in Aerospace Engineering.

Andy Kalambi, President, CEO, RIZE
Andy joined RIZE as President and Chief Executive Officer with more than 25 years' experience in executive and general management, sales and business development across industries and global geographies. Most recently, he built a distinguished career at Dassault Systèmes, where he served in multiple roles, including CEO of the ENOVIA brand and the global executive of the **3DEXPERIENCE** platform driving digital transformation initiatives within global enterprises. Prior to Dassault Systèmes, Andy also played a pioneering role in the introduction of ERP and SCM applications through SAP Asia. A qualified Mechanical Engineer, Andy is a passionate advocate for inclusive business practices, based on respecting the environment, as well as social and gender equality.

Efficient Predictions of Thermal Stresses and Distortion of Metal Structures Fabricated Using Additive Manufacturing

Devlin Hayduke, Aerospace Technical Lead, Material Science Corp

Mr. Hayduke joined MSC in 2005. His duties include design, analysis, and experimental testing of advanced materials, with emphasis on investigation of the shock and vibratory response of composite structures. Mr. Hayduke's skills include development of analytical models and utilizing various finite element and mathematics software tools for design and analysis of advanced material structures. He has served as principal investigator on several Phase I and Phase II SBIRs; his most recent projects include development of an efficient process model for optimization of the support structure of laser melt, metal powder-based builds ("Efficient Prediction of Thermal Stresses and Distortion In Complex Optimized Missile Structures") and developing multi-scale topology optimization analysis codes for metal powder-based additive manufacturing methods ("Cellular Architecture Optimization for Tailored Frequency Response"). Mr. Hayduke has also served as lead engineer on several initiatives that have focused on transitioning intellectual property developed through DoD/DoE funded research programs into commercial products. Recently this has resulted in the successful launch of the award-winning Bianchi Infinito CV© road bicycle featuring MSC's patented Countervail© technology.

Additive manufacturing (AM) technology offers the potential to fabricate complex geometries that cannot be realized using conventional subtractive methods. In current industrial AM processes, support structure is typically needed for complex geometries that contain overhangs. Determination of the type and distribution of support structure is often based solely on technician experience with a focus on maintaining structural stability throughout the build process. This process is far from optimal and does not take into account thermally-induced residual stress buildup and subsequent part distortion that can occur when the support material is removed. As a result, significant non-recurring engineering (NRE) costs are incurred to develop a repeatable AM fabrication process for production. A method for optimizing support structure to reduce distortion, while at the same time minimizing the amount of support material, is necessary to reduce build costs and improve build quality. Currently, a computational tool that is capable of optimizing the support structure design to minimize thermally-induced residual stress or distortion does not exist. MSC will present the details of a computational tool cable of simulating the residual stress and distortion of a realistic AM part in minutes for use in developing optimal support structure by employing a numerically efficient finite element (FE) based process simulation model.

Industrial Use Case for Function Driven Generative Design

Ryan Benyshek, Government Solutions Consultant, Dassault Systèmes,

Ryan Benyshek is a Solutions Consultant at Dassault Systems Government Solution Corp. He received his Bachelors and Masters in Aerospace at the Department of Aerospace Engineering, Wichita State University in 2017. He worked for the National Institute of Aviation Research (NIAR) at Wichita State University, where his primary focus was Reverse Engineering and Additive Manufacturing. The latest projects at NIAR included UAS design and testing, as well as aircraft accident reconstruction.

Last year, a joint effort between Dassault Systèmes and Wichita State was created to design a search and rescue small unmanned aerial vehicle (sUAS). The

drone was a technology demonstrator case for the future of UAV manufacturing on the 3DExperience platform. The full lifecycle of the program deeply incorporated additive manufacturing to accelerate the delivery timeline. Some examples of additive manufacturing's timeline acceleration was to produce the wind-tunnel model within two weeks. Additive manufacturing was alos used to create composite tooling, air ducting, and structural brackets. The highlighted use case will cover the role that topology optimization played in light weighting additively manufactured parts for a mission critical system of the sUAS.

Data Structures for Modelling Complex Parts
Bradley Rothenberg, Co-founder, CEO, nTopology, Inc.

Brad Rothenberg is the co-founder & CEO of nTopology Inc., a startup developing design software for industrial additive manufacturing. Brad has been working with 3D printing for 10 years & has a background in computational geometry in architecture. Brad received his B. Arch at Pratt institute in 2009.

There is now a need for data types capable of representing the complexity driven by advances in manufacturing. Additive manufacturing allows for a hyper-localized control of material. In order to drive this, we need a volumetric way of representing objects in 3D, one that is more closely related to analysis then traditional CAD. Volumetric data can be based off of a lightweight skeleton representation, stored over discrete voxels, or modeled with using continuous fields as a representation. In order to design structures in these new data types, algorithms can be deployed to assist in the design/production process.

Additive Manufacturing: predicting distortions, stresses, phase transformations and mechanical properties
Victor Oancea, Technology Director at CTO Office R&D SIMULIA, Dassault Systèmes

Victor Oancea is a Technology Director at Dassault Systemes SIMULIA Corp. He has over 20 years of industrial experience in finite element and numerical modeling development and analysis. He currently advises the core additive manufacturing process simulation team for advancement of physics-based predictive simulation tools. He received his Ph.D. degree in Computational Mechanics from Duke University.

The impetus of additive manufacturing (AM) technology in the last few years is significant. However, in many cases the reliability of the technology leads to parts that suffer from manufacturing defects and hence subpar strength and fatigue life when compared to parts manufactured with conventional technologies. Sustained experimentation is often required and computer simulations, like in many other fields before, are sought to provide significant insight into the process such that progress in raising the quality of AM parts can be achieved. The modeling framework leverages two approaches: 1) a more detailed thermo-mechanical approach, and 2) a faster executing eigenstrain-based approach. The framework allows for arbitrary meshes of CAD representations, accounts for the exact or approximate specification in time and space of machine tooling (e.g., powder addition, laser trajectories, dwell times, etc.).

For the thermo-mechanical approach it allows for precise integration of the moving energy sources (e.g., laser, electron beams), and automatic mesh independent computation of the continuously evolving convection and radiation surfaces. The constitutive models consider material-state transitions, solid-phase transformations and metal grain evolutions. In the heat transfer

analysis, temperature-dependent thermal properties are considered, as well as latent heat effects of fusion and vaporization. The state of matter (powder, liquid, solid, metallurgical phases) was updated at every increment of the simulation based on the computed temperature histories by leveraging solid-phase transformation kinetics models. The grain size and morphology are also estimated. Computed temperature distributions (space and time), material states, solid-phase composition, and grain structure serve as input into the mechanical stress analysis.

For the eigenstrain-based approach the inherent strains associated with the layered shrinking/expansion of the materials can be calibrated upfront for a simpler and faster simulation of the printing process. Several validation cases for several AM process are presented.

Validation of a Generic Metallurgical Phase Transformation Framework Applied to Additive Manufacturing Processes

Tyler London, Regional Team Manager, TWI Technology Centre (Northeast)
Tyler London is a Team Manager for the Numerical Modelling & Optimisation section at TWI Ltd. After graduating from the University of Oxford with a degree in Mathematical Modelling and Scientific Computing, Tyler joined TWI in 2010 and has been involved in a range of simulation activities covering fracture mechanics and structural integrity, the design of composite structures, computational weld mechanics and the permeation of gases in polymers. More recently, he has been involved in providing modelling support for TWI's additive manufacturing R&D programmes making use of topology optimisation and process simulations to predict distortion and residual stress. Tyler is a NAFEMS certified Professional Simulation Engineer, Chartered Mathematician and Chartered Scientist. Tyler is publishing a technical paper at this year's Science in the Age of Experience conference: "Process Modeling and Validation of Powder Bed Metal Additive Manufacturing".

While significant progress has been made in the last few years, the reliability of Additively Manufactured (AM) parts is often questionable as they suffer from manufacturing defects and hence subpar strength and fatigue life. Like in many other fields before, numerical methods are sought to provide insight into the process and help accelerate progress in raising the quality of AM parts, including predicting thermal evolutions, part distortions and residual stresses. In addition, in metal applications, assessing the amount of unfused powder, melt pool volumes, and metallurgical phase transformations are often of interest. In this work we introduce a generic framework for assessing metallurgical phase transformations, building on a previously developed general simulation framework for predicting temperature evolution, distortions and residual stresses. Phenomenological plasticity models based on the predicted microstructural evolutions are used to predict yield strength, ultimate strength and ductility limit. Experimental work was conducted in order to validate numerical predictions and included temperature measurements, EBSD/XRD microstructural examinations, and tensile tests on dogbone specimens. Additional publically available experimental test data was used to validate melt pool sizes and unfused powder predictions. Comparisons between experiments and numerical predictions suggest that such modeling techniques, with minimal calibration efforts, can be used to predict strength behavior including softening behavior beyond the uniform elongation limit.

Advances in AM Process Simulation: Residual Stress Predictions for Laser Direct Energy Deposited Thin Components and Overhanging Structures Manufactured via Selective Laser Melting

Stefanie Feih, Senior Scientist, SIMTech

Stefanie Feih is a Senior Scientist at the Singapore Institute of Manufacturing Technology (SIMTech). She is passionate about analysis and optimisation of lightweight structures and has published over 130 international journal and conference papers in this field over the past 20 years. Stefanie holds a Degree in Mechanical Engineering from Germany, a Masters Degree from Cornell University, USA, and was awarded her Ph.D. from Cambridge University, UK, in 2002. She worked for the National Laboratory Risø, Denmark, and RMIT University, Australia, prior to moving to Singapore in 2014. A member of the Executive Council of the International Committee on Composite Materials and an Editorial Board Member for Composites Part A, Stefanie also holds adjunct positions at RMIT University and the National University of Singapore. Industry applications for her work include wind, naval, O&G offshore and aerospace structures.

The rapid development of Additive Manufacturing (AM) technology has attracted considerable attention from the aerospace industry over recent years. In this presentation, we highlight recent simulation efforts to predict residual stresses and distortions in AM parts generated by (a) Laser Direct Energy Deposition (LDED) and (b) Selective Laser Melting (SLM). Study of the residual stresses on either micro or macro level requires detailed simulation of the heat transfer process with different heat source models and individual laser tool path movement. We simulate the effects of process parameters, material properties and build platform. For the SLM process, we can also consider the surrounding powder material. The presented simulation outcomes increase our understanding of the fundamental heat transfer processes and residual stress generation during additive manufacturing, and the findings are also considered transferrable to other powder-bed fusion processes.

Virtual Printing: Simulating Different AM Processes to Produce Industrial Parts – Dassault Systemes/Renishaw/Stratasys

An overview on how simulation can effectively predict distortions and residual stresses by collaborating with machine vendors thereby aiding manufacturers to produce industrial parts.

Akshay Narasimhan, Additive Manufacturing Senior Technical Consultant, Dassault Systèmes

Akshay Narasimhan is a Senior Technical Consultant at Dassault Systèmes in Johnston, RI. He completed his undergraduate program in Mechanical Engineering from National Institute of Technology, Jamshedpur India in 2008 and completed his Master's program in Mechanical Engineering from Clemson University in 2010. He has worked for Dassualt Systèmes since his graduation and has held several positions within the organization. His current role is with the Aerospace & Defense initiatives group with a focus on Additive manufacturing and materials.

John Laureto, Applications Engineer – Additive Manufacturing Products Division (AMPD), Renishaw

John Laureto M.S. received his Masters of Science in Materials Science and Engineering from Michigan Technological University, USA (2017). John has worked in a variety of manufacturing and engineering environments ranging from materials analysis laboratories, primary steel producing and additive manufacturing.

He joined Renishaw Inc. - Additive Manufacturing Products Division (AMPD) in 2017 as an Applications Engineer focused in process engineering and material development. John's areas of expertise are component metallurgy, laser parameter development and material qualification.

Blake Courter, Head of Software Research, Stratasys

Blake Courter had dedicated his career to innovation in computer-aided engineering. Blake started his career at PTC, where he created new CAD tools to assist with conceptual design and components to solve interoperability problems. In 2003, Blake founded SpaceClaim, whose direct modeling

paradigm heralded a new generation of mechanical CAD. In 2013, Blake joined GrabCAD to transform engineering data management an interactive, enjoyable team experience and to democratize CAD throughout engineering organizations. At Stratasys, Blake serves as Head of Software Research, where he is building a new generation of tools for functional additive manufacturing. In 2016, Blake received the Peter Marks Pioneer Award from the CAD society, which acknowledges visionary leaders in the engineering software industry. Blake holds a BS in Mechanical Engineering and a certificate in Materials Science from Princeton University.

Improving Multi Jet Fusion (MJF™) printer design and print quality using validated process simulations

Daniel Fradl, Expert Level Engineer, HP, Inc.

Daniel Fradl is an Expert Level Engineer at HP, Inc. HP, Inc builds printers, from small home printers to multi-ton industrial printers and AM printers, along with PCs and tablets. As part of a larger modelling and simulation team, he leads the structural analysis section of the team, working on printers and printing devices. For the last two years, Daniel has been primarily focused on predicting the thermal history of HP's new line of AM printers which use Multi-Jet Fusion techniques. Daniel has been using SIMULIA Abaqus to simulate this thermal process. Daniel published a technical paper at 2017 Science in the Age of Experience conference: "Finite Element Simulation of the Multi Jet Fusion (MJF™) Process using Abaqus".

Abaqus FEA simulations have been widely used across all product lines at HP, including PCs, tablets, laptops and printers. Last year, HP and Dassault Systèmes SIMULIA collaborated on developing process simulations for the Multi Jet Fusion (MJF™) printers. It was presented how the Abaqus Additive Manufacturing simulation framework and functionalities were applied for modeling the MJF™ processes. In this paper, we present how the Abaqus process simulations are used to improve the MJF™ printer design, print quality and customer outcomes. Also, we present validation of simulation results against actual parts for both temperature and deformation.

Simulation of 3D Printed Polymers for Enhanced Fracture Properties

Jun Li, Assistant Professor, U Mass Dartmouth

Dr. Jun Li is an Assistant Professor in Mechanical Engineering Department at the University of Massachusetts Dartmouth. He received his Ph.D. in Mechanical Engineering from the University of Illinois at Urbana-Champaign in 2012, where he also earned M.S. degrees in Mathematics and in Theoretical and Applied Mechanics. After that, he spent two years as a postdoctoral scholar in Aerospace at the California Institute of Technology and then worked in Dassault Systèmes Simulia Corp before joining UMass Dartmouth in 2016. He received the NASA RHG Exceptional Achievement for Engineering award in 2016 and the first place award of "Emerging Researchers in Biomedical Engineering" in 2011 ASME International Mechanical Engineering Congress and Exposition. His research interest includes modeling of hierarchical materials, multifunctional composites, biological tissues and additive manufacturing processes.

3D printed polymers are gaining popularity from customized prototypes to functional products. However, polymeric parts made by additive manufacturing usually exhibit low strain to failure, weak strength, and low fracture toughness, all of which limit their applications in functional components. A combination of finite element analysis and experimental investigation is performed to study 3D printed polymers for enhanced fracture properties. Single edge notched tension specimens made of acrylonitrile-butadiene-styrene (ABS) materials through fused deposition modeling (FDM) with variable build/raster orientations are studied, namely, horizontal builds with 45°/-45° (H45) or 0°/90° (H90) raster orientations, and vertical builds with layers perpendicular to the pre-crack (V90). Fracture toughness is determined using load and displacement measurements in the experiments. Crack kinking is found in H45 samples to follow the weak inter-filament weld-lines at 45°/-45°, with fracture toughness highest in V90 and lowest in H90 samples. The extended finite element method (XFEM) with user-defined anisotropic damage initiation criteria was developed in Abaqus to capture the crack propagation patterns and the dependency of fracture toughness on build/raster orientations observed experimentally. Both criteria for weak interfaces and for max principle stress were defined to predict crack growth under these two competing mechanisms. Parametric studies further show that the interface conditions could be tuned to create alternating crack trajectories for optimal fracture energy. In addition, toughening mechanisms induced by surface topology to deflect crack paths are explored. This study sheds light on simulation based design optimization of additively manufactured polymers for enhanced fracture properties.

Planning to Print : Engineering the Additive Manufacturing Process

NC Kishore, Fabrication Portfolio Senior Specialist, Dassault Systèmes

Nc Kishore has been in Dassault Systemes for 21 years. Nc has been involved in various manufacturing domains and worked on numerous customer projects over these years. Nc graduated from Michigan State University with a degree in Mechanical Engineering as well as an MBA degree.

When it comes to quickly and consistently setting up build parameters for a quality 3D metal parts, it is well known of the numerous printing factors that play a key role depending on the material and machine control parameters. Dassault's 3DEXP platform solution for planning print layout and slicing delivers a unique ability to coherently inherit design parameters from CATIA and from the Virtual twin of the real printing machine and enables controlled slicing of the part to generate a native machine readable output for printing.

This Planning to Print session will focus on the various elements of planning, reusable build set-up, support and scanned path rules that are instantly accessible from the platform to virtually engineer and validate the Additive manufacturing process for a given part.

Material Challenges in Additive Manufacturing
Stephen Todd, Senior Scientific Portfolio Manager, Dassault Systèmes
Stephen Todd is a Senior Scientific Portfolio Manager at BIOVIA, primarily focused on the Materials Science modeling and simulation technologies. He was previously involved with the BIOVIA Materials Studio product suite for over 15 years, focusing primarily on classical simulations and mesoscale. He is now focussing on the role of materials science in cross-brand and cross-industry initiatives.

An overview of some of the challenges in using different types of materials in additive manufacturing. This will focus on additive manufacturing for metals, polymers, and application in pharmaceutical development.

AM Informatics – enabling digital thread and digital twin strategy for Additive Manufacturing
**Najib Baig, Product Manager, Materials Innovation, Granta Design**
Najib Baig is responsible for product management and strategic product direction at Granta Design – the materials information technology company. Specific responsibilities include the Product Management of Granta's Materials Innovation products, including Additive Manufacturing, Simulation and Composites. He has worked with dozens of leading engineering organizations – in aerospace, automotive and other industries – to solve challenges related to materials and process information management.

AM programs generate vast amounts of data on material properties, process parameters, tests and simulation to qualify and certify parts. This raises many questions: what data to retain? How to analyze the data? How to keep the digital thread and data connectivity of the entire product lifecycle?

AM informatics addresses those questions with a framework using the latest technology to capture, manage, and analyze complete AM process information on powders, builds, machine parameters, and parts. This allows for instant analysis of the data to understand the optimal process parameters and enables connectivity and traceability of part design, manufacturing, testing and in-service usage.

Digital twin, the concept of keeping a virtual representation of physical products to predict performance, requires instant access to relevant data. AM informatics is prepared to deliver data when and where it is needed, for simulation or design. In addition, it provides a platform to compare empirical data with simulation data (e.g., for and from Abaqus) supporting in-depth study of the parameters affecting part quality and material model calibration.

Ultimately, to efficiently certify high quality AM parts, AM informatics plays a pivotal role by capturing and mining material and process information, supporting the digital thread and digital twin data exchange. This presentation will discuss and present the methodology and technology needed to implement AM informatics.
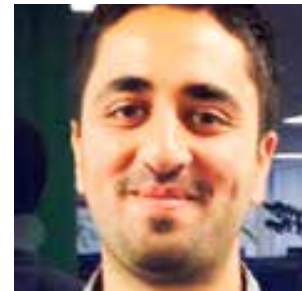
Recent advances in material property prediction using discrete models
Nick Reynolds, Senior Technical Sales Manager, Dassault Systèmes

Nick Reynolds received his Ph.D. in Polymer Science and Engineering from the University of Massachusetts, Amherst. He then worked as a Post-Doctoral Research Associate at the Max-Planck-Institute for Polymer Research in Mainz, Germany. He joined BIOVIA in 1992 as a member of the scientific support group providing customer support, training, and contract research. He currently manages the BIOVIA US Technical Sales team for materials science industries.

Dassault Système's BIOVIA Materials Studio and BIOVIA Pipeline Pilot enable the calculation of material properties from first principles using methods based on quantum mechanics. The most recent release has extended the tools to prediction of properties of high temperature alloys that are randomly mixed. This presentation will give an overview of the current state of the BIOVIA tools for alloy material property prediction.

Additive Manufacturing Part Level Distortion Sensitivity Analysis within Abaqus on a Thin-walled, Tubular Structure
Rick Deering, KCNSC

Rick Deering attended University of Illinois at Urbana-Champaign, graduating with a bachelor's degree in Mechanical Engineering. He has been working at Honeywell FM&T for the last 5 years; 4 of which have been within their simulations department. One of his primary roles within simulations is supporting AM modeling, especially part level distortion prediction for metals. As such, he has experience with several different commercial AM codes, but recently has shifted the bulk of his efforts to simulation within the Abaqus environment.

As additive manufacturing (AM) evolves to become a more viable production solution in terms of cost, quality, and time, the need for predictive simulation of the process grows as well. After testing several commercial offerings to see how well they could predict deformation of various parts, Abaqus was found to be the most promising option and chosen for a more in depth analysis. The scope of this particular project was to examine the effects of certain simulation choices – from basics (mesh, time stepping, element type) to unique AM convergence techniques (full/partial activation, expansion time constant, follow deformation, etc.). Hundreds of simulations were run in Abaqus with various permutations and the resulting response on the final deformation and stress state was tracked. The results will be presented with charts and images to showcase the patterns (or lack thereof) produced by isolating each of these modeling choices on a thin-walled, tubular structure. The findings and conclusions are of value to anyone using Abaqus to simulate part-level distortion due to AM: for some – the study can provide a model or launching point for other in-depth sensitivity studies, for others – confidence in established procedures, or others still – insight to the myriad of options available with Abaqus's AM capabilities.

Role of Process Simulation in Functional Metal AM Application – A Case Study on a Lawn Mower Engine
Guha Manogharan, Penn State University

Dr. Guha Manogharan is an Assistant Professor of Mechanical Engineering, College of Engineering at The Pennsylvania State University – University Park. He heads the Systems for Hybrid – Additive Processing Engineering, The SHAPE Lab located in Innovation Park, Penn State. His research thrust areas include

additive and hybrid manufacturing, material development, process modeling, reverse engineering and inter-disciplinary mechanical and aerospace applications. Dr. Guha received his Ph.D and M.S. in Industrial and Systems Engineering from North Carolina State University. He was awarded the 2017 Society of Manufacturing Engineers' Yoram Koren Outstanding Young Manufacturing Engineer Award and the 2016 Outstanding Young Investigator by Manufacturing and Design Division of Institute of Industrial and Systems Engineering.

Today, Additive Manufacturing (AM) offers a unique ability to fabricate complex geometries using a variety of materials without any special tooling or costly process engineering time for limitless low volume production applications, ranging from custom bio-medical implants to integrated lattice structures for fluidic and high-strength applications. For most functional metal AM applications, it is critical to accurately predict the expected distortion during AM processing in order to process plan for hybrid manufacturing, i.e. secondary post-processing. The focus of this talk is on presenting a case study on application of process simulation of laser powder bed fusion (L-PBF) AM process of 316L SS parts for a Briggs-Stratton single stroke lawn mower engine. A detailed overview of design for AM, process planning, process simulation, AM fabrication and hybrid manufacturing, and testing of the rebuild engine is presented. Finally, major findings and observations from implementing the process simulation software in this project as part of a new graduate program, MS in AMD (AMD and Design) at the Pennsylvania State University – University Park is presented.

3D Image Based Inspection and Finite Element Simulation of Additive Manufactured Parts

Kerim Genc, Synopsys

The uncertainties of AM parts in terms of accuracy, quality, strength and reliability are relatively high and therefor troubling to manufactures of critical components or systems. Simulation techniques are now being incorporated into the design process to help improve the quality of the AM design and ensure a high probability of successful builds. Despite these efforts, however, there is still uncertainty in the differences between as-designed versus as-built AM parts, which begs the following question: "What are the differences between my design and the part that is actually manufactured and how will these differences affect performance in reality?"

Companies already use 3D Computed Tomography (CT) scanners for inspection, non-destructive evaluation and reverse engineering of AM parts. CT scans can quantify porosity, crack/defect size, deviations from design etc. However, this information in and of itself, do not provide an understanding of how these defects and deviations from the desired design will affect performance in the real world.

Typically, due to the knowledge gap between the domains of CT-imaging, AM and FE simulation, the adoption of the workflow from the 3D scan to a realistic FE simulation can be tortuous with engineers using a mix of open source, in-house and/or commercial tools to create an inefficient, unrepeatable workflow that can be an expensive drain on internal time and resources. We will describe how the three domains are just now starting to connect because of a need to better understand the performance of the real as-manufactured part, not just a CAD design ideal.

Steve Levine, Director of Life Science Industry, Executive Director of the Living Heart Project, Dassault Systèmes

Dr. Steve Levine is Sr. Director of Life Science Industry and the Executive Director of the Living Heart Project at Dassault Systèmes SIMULIA. Since 2006, Steve has been responsible for driving the SIMULIA strategy towards its vision of enabling simulation to help harmonize Product, Nature and Life. His current focus is Virtual Human Modeling, which holds the promise to alter the cost-benefit profile of developing medical devices by extending proven technologies now standard in R&D at automotive & aerospace industries. Steve holds a Ph.D. in Materials Science and Engineering from Rutgers University and has been elected into the College of Fellows at the American Institute for Medical and Biological Engineering (AIMBE). Prior to joining Dassault Systèmes, Steve was Sr. Director of Corporate Development at Accelrys (now Dassault Systèmes BIOVIA), after holding a variety of technical and business positions over 16 years as it grew from $3M to over $125M in revenue from its life & materials science R&D software suites.

LS ADDITIVE MANUFACTURING—3D Printing in Medicine and Education
Joe Crozier, 3D Printing Coordinator, Lifespan Physician Group

At the Conclusion of this session, participants will:

1) Have a thorough understanding of the history of Craniofacial imaging

2) Understand the role 3d modelling plays in the healthcare setting

3) Grasp how 3d printing can be used in Virtual Surgical planning

4) Understand how 3d Printing is being used in Medical Education

5) Get a glimpse into the future prospects of medical 3d printing

"LS ADDITIVE MANUFACTURING" From the Digital Thread to the Human Connection: A Case Study of Innovation in the Hospital Environment using 3DEXPERIENCE and Additive Manufacturing
Chris Meeker, Principal, Full Circle Systems Engineering LLC

Virginia Mason Medical Center in Seattle, WA is an industry leader in transforming the delivery of health care and is the first medical center to integrate the Toyota Production System throughout its entire system. This is a case study of how Virginia Mason and Full Circle Systems Engineering leveraged **3D**EXPERIENCE to create engineered, user-tested, additive manufactured prototypes for eventual application in their daily medical work.

A physician leader recognized an opportunity to innovate in the laboratory workflow and reached out to the Virginia Mason Moonshine Lab. This innovation lab is based on a Toyota philosophy of developing new solutions "while the moon is shining", i.e. when production is not running. After an Innovation Day, two concepts, and three rapid design cycles with the technicians, the team had virtual mockups refined and vetted by end-users and analyzed for ergonomic use. These virtual mockups were 3D printed, assembled, and use-tested in the laboratory.

Rapid innovation cycles are used in other industries that have the infrastructure for design engineering. Here the **3D**EXPERIENCE Cloud platform integrated clinical and engineering expertise with the Virginia Mason culture of innovation. This enabled rapid innovation, collaboration, end-user engagement, and refined

prototypes for use-testing. The results demonstrate that the **3D**EXPERIENCE Cloud platform, with an innovative organization like Virginia Mason, can accelerate concepts, build engagement, and create refined, ergonomic innovations, with a minimum of infrastructure. With Full Circle, **3D**EXPERIENCE created real-world results from the innovative spirit of the Virginia Mason physicians, technicians, and the Moonshine Lab.

Predicting the Future: Machine Learning, Materials Development, and Their Implications for Advancing Additive Manufacturing

Dayton Horvath, Industry Analyst and Consultant

Dayton Horvath is an industry expert and consultant in additive manufacturing, materials informatics, and advanced materials. He previously led the Materials Design and Manufacturing coverage area at Lux Research, a strategic advisory and market research firm. Dayton specializes in emerging technologies market research and analysis with a particular focus on startups. Current areas of interest include printable materials, design software, and machine learning applications in materials research and development. He has spoken at various conferences including JEC World, RAPID+TCT, Pacific Design & Manufacturing, and contributes content regularly to 3D Printing Industry.

Machine learning software techniques have begun to help inform, optimize, and create tomorrow's products and services. These algorithmic approaches are changing how decisions are being made, and how products are designed from materials through concept and manufacturing. In this talk, machine learning applications in materials R&D and additive manufacturing optimization are introduced, associated challenges examined, and stage of development discussed. Activities in academia, startups, and corporates offer insight into the strategic implications these technologies will have for product development. This talk is based on technical and business interviews with industry experts and combined with secondary data to create valuable insights into an advanced manufacturing future.

Advanced Manufacturing with Silk Proteins: Biopolymer Inks with Functional Structures

Maria Rodriguez, PhD Candidate, Biomedical Engineering, Tufts University

Bio: A Biomedical Engineer (BME) currently finishing Phd in BME at Tufts University. My research focuses on biomaterials, 3D printing, advanced manufacturing processes, and evaluation of bioprocessing on mammalian cells. My projects have ranged from manufacturing of silk based grafts targeted for vascular regeneration to development of silk based bio inks for advanced manufacturing including 3D direct write printing and free form fabrication. My aim is to apply my technical engineering skills to biological and medical problems. My specific interest are in material characterization of medical devices.

My lab focuses on developing silk-based materials for tissue engineering and regeneration. My aim is to develop, study and apply silk protein-based inks useful for 3D printing. The features of these inks involve all aqueous nontoxic processing, cyto-compatible features, versatility in control of mechanical properties, avoidance of chemical or photochemical crosslinking requirements, and the FDA-approved nature of the protein. These features support a range of studies related to biomaterials and tissue engineering, as well as cell delivery and related themes. Our most recent advances in building complex 3D structures using silk-based approaches will be reviewed, including new processing methods, underwater silk printing inks, and new modes to functionalize biomaterials.

Rob Stupplebeen, President and CEO, Optimal Device

Rob Stupplebeen has a masters degree in mechanical engineering focused on biomechanics. He has analyzed the following for profit or pleasure: composite naval vessels, composite ballistic helmets, lenses for the eye. He is also the owner of Optimal Device, an engineering consultant firm and Dassault Systems Value Added Reseller for the Simulia and Catia brands. Today he is presenting 'A Medical Device Designed for You'.

AJ (Alfonso) Perez, General Manager, Cincinnati Incorporated

AJ (Alfonso) Perez is the General Manager of Cincinnati Incorporated's NVBOTS business unit. AJ was previously the Chairman, CEO, and Founder of New Valence Robotics Corporation (NVBOTS), an MIT 3D printing spin-off that invented automated 3D printing, cloud 3D printing, and ultra-high speed multi-metal 3D printing (spun off to form Digital Alloys). AJ holds a BS '13 in Mechanical Engineering and Masters of Engineering in Advanced Manufacturing '14 from MIT. His academic interests, lectures, and research focus on mechanical design, manufacturing processes automation, robotics, and entrepreneurship. AJ has developed and taught several classes during his career. Most recently, he co-developed the first graduate level 3D printing / Additive Manufacturing class for the department of Mechanical Engineering at the Massachusetts Institute of Technology. AJ is the final Lemelson-MIT Inventor Fellow, was selected as one of Boston Globe's 25 under 25, and won the prestigious Lemelson-MIT "use it" student prize. AJ is the primary inventor on 30+ inventions in the fields of additive manufacturing, mobile manufacturing, industrial IoT, and surgical devices. AJ chases opportunities that leverage his MIT engineering background, expertise in intellectual property, management experience, and international network of investors.

The purpose of this presentation is to familiarize the audience with Cincinnati Incorporated's additive manufacturing solutions. In addition, the audience will learn the basics of the additive manufacturing design to part process with specific attention paid to the challenges and opportunities for medial applications. The presentation will also cover the intersection of medical device design, CI's additive solutions, and other post processing techniques that can be utilized in order to make strong, durable medical additive manufactured parts.

PANELISTS

Shawn Ehrstein, Director Emerging Technologies and CAD/CAM, NIAR

As the Director of NIAR's Emerging Technologies and CAD/CAM, Shawn Ehrstein specializes in product lifecycle management (PLM) curriculum design and research and supervision of the NIAR network and application support group. He oversees the 3D Experience Center located on the Innovation Campus at Wichita State University which encompasses Immersive Technologies, Robotics and Automation, Reverse Engineering and Additive Manufacturing. He has developed nationally recognized training manuals and teaches courses at Wichita State University and various companies within the aerospace industry. He has worked in the CAD/CAM Lab since 1990, previously as Associate Director.

He has a Master in Business Administration, an M.S. and a B.S. in Electrical Engineering from Wichita State University. He has over 25 years of experience with CAD software with over 20 years of CATIA experience.

Since 2004, he has served as a Co-Chairman on the Product Committee Chair – Drafting/MBD and AM for the CATIA Operators Exchange (COE).

Andy Kalambi, President, CEO, RIZE

Andy joined RIZE as President and Chief Executive Officer with more than 25 years' experience in executive and general management, sales and business development across industries and global geographies. Most recently, he built a distinguished career at Dassault Systèmes, where he served in multiple roles, including CEO of the ENOVIA brand and the global executive of the **3D**EXPERIENCE platform driving digital transformation initiatives within global enterprises. Prior to Dassault Systèmes, Andy also played a pioneering role in the introduction of ERP and SCM applications through SAP Asia. A qualified Mechanical Engineer, Andy is a passionate advocate for inclusive business practices, based on respecting the environment, as well as social and gender equality.

John Laureto, Applications Engineer – Additive Manufacturing Products Division (AMPD), Renishaw

John Laureto M.S. received his Masters of Science in Materials Science and Engineering from Michigan Technological University, USA (2017). John has worked in a variety of manufacturing and engineering environments ranging from materials analysis laboratories, primary steel producing and additive manufacturing.

He joined Renishaw Inc. - Additive Manufacturing Products Division (AMPD) in 2017 as an Applications Engineer focused in process engineering and material development. John's areas of expertise are component metallurgy, laser parameter development and material qualification.

Sean McCluskey, Joby Aviation

After graduating from Stanford University with a degree in Mechanical Engineering focusing in Additive Manufacturing, and a brief tenure in the medical device space, Sean transitioned to Carbon Inc where he was most recently Head of Production Engineering and Special Projects, over-seeing all aspects of advance design for additive. Sean is currently with Joby Aviation (http://www.jobyaviation.com) developing novel additive solutions for eVTOL applications. While lattice and topology optimization clearly have significant benefits, they each also have significant drawbacks. Tools for lattice and topology optimization are also currently not located in the same software packages, which leads to an extremely challenging workflow for integration. This talk will look at the Venn diagram of the shortcomings of both design methodologies and explore the need for a unified optimization solution.

Eduardo Barocio, Graduate Research Assistant, Purdue University

Eduardo is currently a research assistant at the Composites Manufacturing and Simulation Center led by Professor R. Byron Pipes at Purdue University. He holds a bachelor's degree in Mechatronics Engineering from Tecnologico de Monterrey, Mexico. Eduardo's current research is focused on the extrusion deposition additive manufacturing process with composite materials, particularly on the prediction of inter-layer bonding and failure of printed parts. In his research work, Eduardo utilizes the additive manufacturing process simulation capabilities developed by Simulia together with custom developed subroutines to simulate the printing process of composites.

Thomas Marchand, Co-founder & CEO
Thomas Marchand is a 34 years old french entrepreneur who co-founded BIOMODEX in 2015 after a successful exit in the service space. BIOMODEX is a medtech startup that develops neurovascular & structural heart planning solutions thanks to 3D printed artificial organs.

SYMPOSIUM SESSION CHAIR
Derek Luther
Senior Manager Future Engineering
adidas Group

Derek is a Senior Engineer for the adidas Future team focusing on computational engineering and additive manufacturing. He has spent the past 7 years working in the sporting goods industry with the adidas Group. His area of expertise is modeling of dynamic impact simulations, compressible structures, and optimization. Derek has a B.S. and a M.S in Mechanical engineering from the University of Southern California.

HACKATHON CHALLENGES

Applications used

| Functional Gen. Design | Powder Bed Fabrication | Additive Mfg Simulation | Virtual to Real Shape Morph. | Digitized Shape Preparation |

Challenge 1: Customized Knee Implant
Introduction: Customized knee implants have the potential to remove less bone, eliminate pain, and improve recovery and function, as compared to traditional knee implants used in total knee replacement surgery.

Problem statement: Customized implants have tight tolerance requirements, as they are designed to replicate the patient's natural knee. We need to understand if these manufacturing tolerances can be met with a given additive manufacturing process.

Evaluation criteria: Design a build setup that minimizes distortions in the as-manufactured knee implants, by varying support structures, build orientation, and shape compensation.
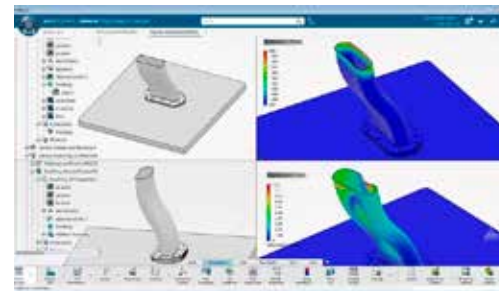
Challenge 2: Buckling of a Thin-Walled Structure
Introduction: Thin-walled structures are used heavily in automotive and aerospace industries. With additive manufacturing, these structures can eliminate Design for Assembly constraints for components such as ducting or manifolds.

Problem statement: During the build of these thin-walled structures, buckling can occur and must be predicted and controlled.

Evaluation criteria: Assess if buckling during print will be an issue for a given duct component and modify the design to mitigate the buckling distortions.
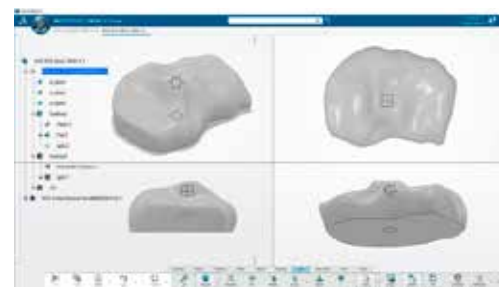
Challenge 3: Functional Generative Design of an Aerospace Bracket

Introduction: Design in the aerospace industry is heavily focused on light-weighting of individual components.

Problem statement: Given an initial design space and some standard load cases, use either topology optimization tools or lattice optimization tools to generate an optimal bracket design. Different manufacturing constraints in the optimization can be employed to validate whether or not additive manufacturing is the best choice for this component.

Evaluation criteria: Ensure that the design meets in-service performance and abuse load bearing. The design will be evaluated based on strength and weight savings.

Challenge 4: Shape Compensation of an Impeller

Introduction: Many parts benefitting from additive manufacturing have complex geometric features, which exhibit different distortion behaviors caused by the thermal cycling that occurs during a build.

Problem statement: Determine an impeller design, such that the as-manufactured part is equivalent to the as-designed part.

Evaluation criteria: Minimize deviation between as-manufactured and as-designed parts, using process simulation and shape compensation tools.

Challenge 5: Xuberance 3D Chair Optimization

Introduction: Recent advances in large scale additive manufacturing allow direct printing of non-linear architecture designs from CAD models. Bin Lu from Xuberance 3D originally designed this chair in 2009 in Studio Hadid. The design is part of the "total fluidity" collection, in which all elements of architecture become fluid and ready to engage with each other, with diverse contexts leading to an overall intensification of relation.

Problem statement: Using the existing design as the initial design space, given material properties, and loading conditions, optimize the chair design using topology optimization tools to minimize the weight of the chair.

Evaluation criteria: Light-weight the current design, while ensuring the design meets in-service performance and abuse loads. The optimal chair design should be functional, comfortable, elegant, and fluent.
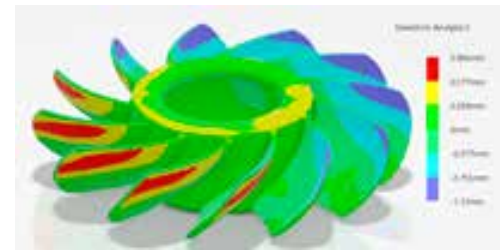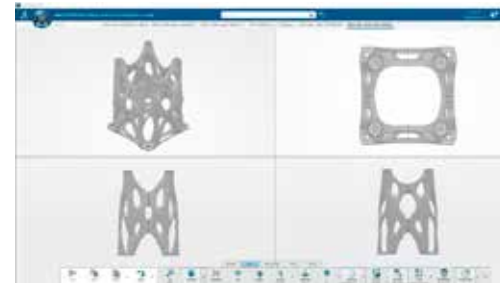
HACKATHON JUDGES

Claus Pedersen
Technology Director at CTO Office R&D SIMULIA, Dassault Systèmes

Claus is Optimization Technology Director at the CTO Office of R&D SIMULIA, Dassault Systèmes where he has the job role of defining R&D strategies, inventing and examining the technology of new optimization methodologies, coding of CAE and optimization kernels, competitive intelligence, technical due diligence, coaching and knowledge sharing for core optimization technologies, research projects and numerical implementation with different commercial research partners, worldwide presale for customers and presenting at conferences, and corporations with leading international universities. Additionally, his role is highly interdisciplinary working with different teams and organizations involving crossover brand activities from R&D, marketing to international sales on latest technology.

He has continued to have a strong connection to applied science and research since he received his Ph.D. at Department of Mechanical Engineering, Solid Mechanics, Technical University of Denmark in 2002 and his work the following 2 years as Research Associate at Department of Engineering, Cambridge University, UK. He is reviewing for thirteen international journals, external examiner at several technical universities and supervisor of interns. He has published 12 articles in reviewed international journals and held more than 40 presentations at international conferences.

Derek Luther
Senior Manager Future Engineering
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Derek is a Senior Engineer for the adidas Future team focusing on computational engineering and additive manufacturing. He has spent the past 7 years working in the sporting goods industry with the adidas Group. His area of expertise is modeling of dynamic impact simulations, compressible structures, and optimization. Derek has a B.S. and a M.S in Mechanical engineering from the University of Southern California.

Stefanie Feih
Senior Scientist, Singapore Institute of Manufacturing Technology (SIMTech)

Stefanie Feih is a Senior Scientist at the Singapore Institute of Manufacturing Technology (SIMTech). She is passionate about analysis and optimisation of lightweight structures and has published over 130 international journal and conference papers in this field over the past 20 years. Stefanie holds a Degree in Mechanical Engineering from Germany, a Masters Degree from Cornell University, USA, and was awarded her Ph.D. from Cambridge University, UK, in 2002. She worked for the National Laboratory Risø, Denmark, and RMIT University, Australia, prior to moving to Singapore in 2014. A member of the Executive Council of the International Committee on Composite Materials and an Editorial Board Member for Composites Part A, Stefanie also holds adjunct positions at RMIT University and the National University of Singapore. Industry applications for her work include wind, naval, O&G offshore and aerospace structures.

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