First International Conference on
3-D Printing and Transportation

NOVEMBER 20–21, 2019
Keck Center, NAS, Washington, D.C.

Convened by
Transportation Research Board

Organized by
TRB Design and Construction Group (AF000)
Aviation Group (AV000)
Operations and Preservation Group (AW000)
Freight Systems Group (AT000)
The 13th National Conference on Transportation Asset Management (TAM) provides an opportunity for all practitioners involved in their agency’s asset management initiative to build core competencies and generate new ideas.

- Looking for both practical and innovative presentations.
- Selected abstracts will be featured in either poster or technical podium sessions.
- Presenters will be required to register and attend the conference to be included in the final program.

Presentation tracks and crosscutting issues:

- Track 1: Implementation
- Track 2: Data Governance/Tools
- Track 3: Managing Risk
- Track 4: Partners and Peers
- Track 5: Sustaining Asset Management in your Organization
- Crosscutting Issue 1: Transit
- Crosscutting Issue 2: Resilience
MESSAGE FROM THE CONFERENCE CHAIR  
First International Conference on 3-D Printing and Transportation

Welcome to the Keck Center of the National Academies of Sciences, Engineering and Medicine for the First International Conference on 3-D Printing and Transportation. Your participation in this conference helps TRB prepare for this Transformative Technology whether you are a sponsor, a member of the planning or scientific committee, a speaker, or a session moderator. We are all inquisitive minds exploring 3-D printing and its impact on transportation.

This conference will provide you an opportunity to share knowledge and information and assess where this technology stands today and where we are going from here. We are fortunate to have representation from a number of public agencies, including different branches of the U.S. Department of Defense (Army, Air Force, Marine Corps), National Aeronautics and Space Administration (NASA), and the U.S. Department of Transportation. Oak Ridge National Laboratory, one of the national laboratories of the U.S. Department of Energy, is an active participant in this conference.

We will open the first day of the conference with a history and background of 3-D printing, followed by 3-D printing processes, materials and equipment, followed by 3-D printing applications, and then close the day by looking at the advances made by different branches of the U.S. Department of Defense. We will start the second day by examining the impact of 3-D printing on freight and then move on to examining its overall social impact (economics, environment, safety, security, legal). In the second-half of the day, we will highlight the synergistic efforts of various government agencies in advancing 3-D printing and finally close the conference with a look on the path forward for this technology.

Best regards,
Dr. Mohammad S. Khan
FIRST INTERNATIONAL CONFERENCE ON 3-D PRINTING AND TRANSPORTATION

Planning Committee
Mohammad S. Khan, High Performance Technologies, Inc.[HPTech]
David Ballard, Gellman Research Associates [GRA], Inc.
Michael P. Case, U.S. Army Engineer Research & Development Center
Rich Davies, Oak Ridge National Laboratory
Patricia Hu, USDOT, Bureau of Transportation Statistics
Tom Kazmierowski, Golder Associates, Inc.
D. Stephen Lane, Virginia Transportation Research Council
Lonnie Love, Oak Ridge National Laboratory
Robert Moses, NASA
Robert Mueller, NASA
Mark Reno, Quincy Engineering, Inc.
William Varnedoe, The Kercher Group

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Richard Buswell, Loughborough University, UK
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Raissa Ferron, University of Texas at Austin
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Mallory M. Johnston, Marshall Space Flight Center [MSFC]
Megan A. Kreiger, U.S. Army Engineer Research and Development Center
Eric L. Kreiger, U.S. Army Engineer Research and Development Center
Julian Leland Bell, Massachusetts Institute of Technology
Dirk Lowke, TU Braunschweig, Institute of Building Materials, Concrete Construction and Fire Safety, Germany
Viktor Mechtcherine, TU Dresden, Institute of Construction Materials, Germany
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Zofia K. Rybkowski, Texas A&M University
Florence Sanchez, Vanderbilt University
Peter Stynoski, U.S. Army Engineer Research and Development Center
Tim Wangler, ETH Zürich Institute for Building Materials, Switzerland
Philip F. Yuan, Tongji University, China
Hongyu Zhou, University of Tennessee, Knoxville

Staff List
Nelson Gibson, Transportation Research Board
Ashley Vaughan, Transportation Research Board
Ted Jamele, Transportation Research Board

The Transportation Research Board The Transportation Research Board is one of seven major programs of the National Academies of Sciences, Engineering, and Medicine. The mission of the Transportation Research Board is to provide leadership in transportation improvements and innovation through trusted, timely, impartial, and evidence-based information exchange, research, and advice regarding all modes of transportation. The Board’s varied activities annually engage about 8,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

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<th>TIME</th>
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<td><strong>SESSION 4: 3-D Printing in Defense Applications</strong></td>
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<td>Department of Defense Perspective</td>
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<td>- Deep-Space Transportation: Manufacturing for Performance, Persistence, and Resilience</td>
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<td>- The Impact of Additive Manufacturing in the Future Space Economy</td>
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CONFERENCE PROGRAM

WEDNESDAY NOVEMBER 20, 2019

7:00 am–8:00 am, Keck 100 Foyer
Registration & Breakfast

8:00 am–8:10 am, Keck 100
OPENING REMARKS
Mohammad S. Khan, Conference Chair, Executive Vice President, High Performance Technologies, Inc. (HPTech)

8:10 am–8:20 am, Keck 100
TRB WELCOME
Neil Pedersen, Executive Director, Transportation Research Board

8:30 am–9:00 am, Keck 100
OPENING KEYNOTE ADDRESS
David R. Winter, Associate Administrator (Acting), Research, Development, and Technology, Federal Highway Administration, U.S. Department of Transportation

9:00 am–10:00 am, Keck 100
SESSION 1: History and Background of 3-D Printing
Moderator: Scott Z. Jones, Mechanical Engineer, Engineering Laboratory, National Institute of Standards & Technology (NIST)

3-D Printing and Transportation: Past, Present, and Future
Mohammad S. Khan, HPTech

A Review of Reviews: Assessing the Viability of 3-D Printed Construction
Jeneé A. Jagoda and Steven J. Schuldt, Air Force Institute of Technology

10:00 am–10:15 am, Keck 100 Foyer
Morning Break

10:15 am–12:00 pm, Keck 100
SESSION 2: 3-D Printing Techniques—Processes, Materials, And Equipment
Moderator: Megan Kreiger, Lead Mechanical Engineer, U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers

The Properties of 3-D Printing Mortar and Development of 3-D Construction Printing (3-DCP) Delivery System

Early-Age Performance of 3-D Printed Carbon Nanofiber and Carbon Microfiber Cement Composites
M. Kosson, L. Brown, and F. Sanchez, Vanderbilt University

Examining the Effect of Cellulose Nanocrystals (CNC) on 3-D Printed Cement Composites
Yvette Valadez, Cameron Wilson, Mehdi K. Moradiello, and Jason Weiss, Oregon State University
Testing Procedures on Materials to Formulate the Ink for 3-D Printing
Malo Charrier and Claudiane Ouellet-Plamondon, Université du Québec, Canada

3-D Printing of Concrete: A Systems Perspective
Sven G. Bilén, The Pennsylvania State University

12:00 pm–1:30 pm, E-Street Conference Room
Lunch & Networking
Lunch Presentation: 3D Printed Concrete Infrastructure for Expeditionary Applications
Michael Case, Program Manager, U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers
Robert P. Mueller, Senior Technologist, Exploration Research and Technology Programs, National Aeronautics & Space Administration (NASA)

1:30 pm–3:15 pm, Keck 100
SESSION 3: 3-D PRINTING APPLICATIONS
Moderator: Kamal H. Khayat, Professor & Director, Center for Infrastructure Engineering Studies, Missouri University of Science and Technology

Large-Scale Additive Manufacturing for Transportation: A Review of State-of-the-Art Applications, Challenges And Opportunities
Mostafa T. Hesarkuchak, Ossama Salem, and Song He, George Mason University

Development of 3-D Printable Lightweight Functional Cementitious Composite
Adam Brooks and Hongyu Zhou, University of Tennessee, Knoxville; Zhenglai Shen, University of Alabama in Huntsville

3-D Printing Polymer Concrete for Infrastructure Applications
Daniel H. Murcia, Moneeb Genedy, and Mahmoud R. Taha, University of New Mexico

Experimental and Numerical Studies of 3-D Printable Steel Fiber-Reinforced Concrete
Jiaqing Wang, Qingli Dai, Ruizhe Si, and Yunxiang Ma, Michigan Technological University, presentation delivered by Hongyu Zhou

3-D Printing of Ultra-High Performance Concrete Formwork for Accelerated Bridge Construction
Atorod Azizinamini, Florida International University

3:15 pm–3:30 pm, Keck 100 Foyer
Afternoon Break

3:30 pm–5:00 pm, Keck 100
SESSION 4: 3-D PRINTING IN DEFENSE APPLICATIONS
Moderator: Michael Case, Program Manager, U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers

Advances Made by U.S. Army
Eric Kreiger, U.S. Army Corps of Engineers

Advances Made by U.S. Air Force
Karsten Lipiec, U.S. Air Force

Advances Made by U.S. Marine Corps
Captain Matt Audette, U.S. Marine Corps
Department of Defense Perspective
Lieutenant Colonel Aneel Alvares, U.S. Department of Defense

Evening Networking Reception

THURSDAY NOVEMBER 21, 2019

7:00 am–8:00 am, Keck 100 Foyer
Registration & Breakfast

8:00 am–8:30 am, Keck 100
KEYNOTE ADDRESS
Industry Significance of 3-D Printing to Transportation Logistics, Traffic Activities, Planning and Asset Management
William Ankner, Principal, Transportation Solutions

8:30 am–10:30 am, Keck 100
SESSION 5: Impact of 3-D Printing on Freight Movements
Moderator: Craig A. Blue, Director, Energy Efficiency and Renewable Energy Programs, Oak Ridge National Laboratory

Democratization of Manufacturing: Possibilities on the Horizon
Thomas Kurfess, Chief Manufacturing Officer, Oak Ridge National Laboratory

Additive Manufacturing Transforming Freight Transportation
Lonnie Love, Oak Ridge National Laboratory

Early Adoption of 3D Printing: Why and How
Megan Brewster, Vice President of Advanced Manufacturing, Launch Forth

Panel Discussion: Path Forward
Private sector perspectives: Dave Chapin, GE Additive
Jennifer Coyne, Wabtec

Public sector perspective: Caitlin Hughes, USDOT

Morning Break

10:30 am–10:45 am, Keck 100 Foyer

SESSION 6: Safety, Environment & Social Impacts of 3-D Printing
Moderator: Major Steven J. Schuldt, Assistant Professor of Engineering Management, Air Force Institute of Technology (AFIT)

Safety and Security Implications of 3D Printing
J. Luke Irwin, RAND Corporation

Using 3-D Printing, Commodity Hardware, Design Thinking, and Modular Architecture to Create Inexpensive Maritime Weather Stations to Extend Vessel Safety and Meteorological Data Gathering
Catherine T. Lawson, George Berg, Roberta Weisbrod, Eric Stern, University at Albany—State University of New York
3-D-printed Ultrathin-Wall Ceramic Microlattices for Catalytic Waste Gas Converters
Seok Kim and Turga Ganapathy, Massachusetts Institute of Technology; Wonpyo Kim and Young Tae Cho, Changwon National University, Republic of Korea; Nicholas X. Fang, Massachusetts Institute of Technology

12:00 pm to 1:30 pm, E Street Conference Room
Lunch & Networking
Lunch Presentation: Transformational Nature of 3-D Printing
Lonnie J. Love, Corporate Fellow, Energy & Transportation Science Division, Oak Ridge National Laboratory

1:30 pm–3:15 pm, Keck 100
SESSION 7: 3-D Printing and Space Transportation
Moderator: Robert Moses, Aerospace Technologist & Systems Engineer, National Aeronautics & Space Administration (NASA)

An Overview of In-Situ Construction Activities at NASA
Robert P. Mueller, Senior Technologist, Exploration Research and Technology Programs, National Aeronautics & Space Administration (NASA)

The Proving Ground: Using Low Earth Orbit as a Test Bed for In-Space Manufacturing Technology Development
Tracie Prater, Aerospace Engineer, Materials and Processes Laboratory, National Aeronautics & Space Administration (NASA)

Deep-Space Transportation: Manufacturing for Performance, Persistence, and Resilience
W. Keith Belvin, Center Chief Technologist, Langley Research Center, NASA

The Impact of Additive Manufacturing in the Future Space Economy
Ravi Chaudhary, Director, Advanced Programs and Innovation & Acting Director, Office of Spaceports, Office of Commercial Space, Federal Aviation Administration, U.S. Department of Transportation

3:45 pm–5:00 pm, Keck 100
SESSION 8: Path Forward for 3-D Printing
Moderator: Mohammad S. Khan, Conference Chair, Executive Vice President, High Performance Technologies, Inc. (HPTech)

Research Needs, Roadmap/Strategic Plan
S. Jack Hu, Senior Vice President, Academic Affairs & Provost, University of Georgia
Michael Gorelik, Chief Scientific and Technical Advisor, Federal Aviation Administration (FAA), U.S. Department of Transportation
Megan Kreiger, Lead Mechanical Engineer, U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers
Robert Moses, Aerospace Technologist & Systems Engineer, National Aeronautics & Space Administration (NASA)
**Education, Training & Workforce Development**
Karen A. Bobo, Director, Center for Transportation Workforce Development, Office of Innovative Program Delivery, Federal Highway Administration (FHWA)
Kamal H. Khayat, Professor & Director, Center for Infrastructure Engineering Studies, Missouri University of Science and Technology

**Policies, Regulations & Deregulations**
Ravi Chaudhary, Director, Advanced Programs and Innovation & Acting Director, Office of Spaceports, Office of Commercial Space, Federal Aviation Administration, U.S. Department of Transportation

5:00 pm–6:00 pm, *3rd Floor Atrium*

Evening Networking

EVENING NETWORKING RECEPTION

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NOTES
KECK CENTER FLOOR PLAN

Floor 1

- Conference Room
- Phone Booth
- PC Room
- Coat Room
- Restrooms

E-Street Conf. Room

Lobby

EXIT
Nanotechnology of Cement and Concrete (2NCC20)  
May 19-21, 2020  
Irvine, California  

Nanomodification and nanoengineering of concrete is capable of dramatically improving its tensile strength, toughness, ductility, and durability properties, which is vital for modern transportation infrastructure. The conference will explore the impact of nanotechnology on behavior and performance of cement based materials and concrete in these topical areas.

- Energy Efficiency, Low Carbon Footprint, Sustainable Materials, By-product Utilization
- Applications of Nanotechnology in Infrastructure
- Nanomaterial Production and Functionalization
- Nanoscale Internal Structure
- High-strength, High-performance, and Ultra-high Performance Concrete
- Films and Coatings, Fiber Reinforcement
- Special Applications: Photo Catalysis, Self-Repair, Biometric
- Modeling and Simulation

Gain exposure to the cutting-edge research conducted in the U.S., Europe, and other countries reported by the top investigators in the field. Become a part of the community evaluating and implementing this technology.
FIRST INTERNATIONAL CONFERENCE
ON 3-D PRINTING AND
TRANSPORTATION

Thank You
Patron

BRONZE

The National Academies of
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TRANSPORTATION RESEARCH BOARD