

Advanced Manufacturing for Nuclear Workshop & Advanced Methods for Manufacturing Annual Program Review

Oak Ridge National Laboratory
Manufacturing Demonstration Facility
Knoxville, TN
December 4-6, 2018



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Workshop Summary

The 3-day workshop was attended by more than 60 researchers from industry, government, regulators, academia, and national laboratories. The event was structured around sessions that included presentations, discussions, panels, and facility tours.

The specific focus of the workshop included:

- Understand the needs of nuclear industry and developers' plans for the use of advanced manufacturing
- Identify the opportunities, future needs, and challenges for a range of advanced manufacturing techniques in a nuclear context
- Summarize the state-of-the-art effort, identify gaps and future needs, and report on current research

For brevity, summaries of the presentations are not included in this note of the meeting. All presentations are available for downloading from the GAIN website at <https://gain.inl.gov/SitePages/Workshops.aspx>

The workshop was judged to be a success, in particular:

- State of the art update on activities, developments, needs
- Integration of GAIN and industry into the annual AMM meeting
- Networking opportunities across the researchers, supply chain, and vendors
- Location and opportunity to visit operating, large facilities associated with advanced manufacturing

Attendees encouraged the hosting of future similar integrated workshops, as well as specific workshops on key topics e.g., concrete, modular construction, Hot Isostatic Pressing (HIP).

Key Takeaways

What is the potential for advanced manufacturing in relation to advancements in nuclear technology?

- Produce components cheaper and faster/more efficient manufacturing
- Licensing paradigm shift
- Enable components with enhanced performance and unique geometries
- Rapid commercialization of new technologies, including more agile production
- Rapid prototyping
- Produce legacy replacement parts without development of complex supply chain
- Lower the long-term costs by limiting the number of required maintenance activities and inspections
- Accelerate the deployment of SMRs
- US competitiveness and new job opportunities

Remaining Key Challenges

1. Qualification of methods
 - a. “Prioritize funding for measurement science and standards development to speed the transition from R&D to commercial practice”
 - b. Continue to engage the NRC and other regulators
2. Extend Automated Manufacturing to Nuclear
3. Develop actionable deliverables
4. Develop methods for technology transfer
5. Integration of research, development, and deployment, including researchers, supply chain and vendors
6. Cross fertilization across the federal efforts
7. Multiple methods – too many to dedicate funding to all
8. Forge private-public partnerships
9. Identify what the common issues are, prioritize them and work towards solutions
10. Demonstrate an “early-win”
11. Promote the capabilities and current activities
12. Demonstrate the full value
13. Leverage experience from other industries

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AGENDA

Day 1 – Tuesday, December 4, 2018

Time	Topic	Chair /Presenter
	The Vision For Advanced Manufacturing In Nuclear	GAIN - Chair
8:00 AM	➤ Arrival and Badging	
8:30 AM	➤ Objective of Workshop	A. Worrall, GAIN
8:45 AM	➤ AMM Program Direction	A. Caponiti, DOE-NE
9:05 AM	➤ GAIN Initiative Direction	R. Baranwal, GAIN
9:25 AM	➤ Where Is Advanced Manufacturing Heading?	S. Babu, UT/ORNL
10:05 AM	Break/Networking	
10:35 AM	➤ Welcome Remarks	A. Icenhour, ORNL
10:55 AM	➤ Advanced Manufacturing of Materials for Extreme Environments	R. Dehoff, ORNL
11:15 AM	➤ NRC Perspectives on Advanced Manufacturing	J. Christensen, NRC
11:35 PM	Working Lunch “Food for Thought”	
	➤ Transformational Challenge Reactor (TCR)	J. Cirtain, ORNL
	Tours	
1:05 PM	➤ Manufacturing Demonstration Facility 2 & 3 Tours	
	Advanced Manufacturing And The Supply Chain	NIC - Chair
2:05 PM	➤ Industry Vision for Advanced Manufacturing in Nuclear	D. Blee, NIC / M. Nichol, NEI
2:35 PM	➤ SMR Supply Chain Readiness	S. Wolbert, NuScale
2:55 PM	➤ Non-LWR SMR Supply Chain Readiness	R. Rickman, Terrestrial
3:15 PM	Break/Networking	
3:45 PM	➤ PANEL: Manufacturers Interest In Advanced Manufacturing	NIC - Chair
4:45 PM	➤ Summarize Day	A. Worrall, GAIN
5:00 PM	Adjourn	
6:00 PM	Post-Workshop Networking Reception	Sponsored by
7:30 PM	Chesapeake’s Restaurant (~5mile/10minute drive from the meeting venue)	US Nuclear Industry Council

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AGENDA

Day 2 – Wednesday, December 5, 2018

Time	Topic	Chair /Presenter
	Advanced Manufacturing – AMM Project Reviews	Bruce Landrey, AMM - Chair
8:00 AM	➤ SMR RPV Manufacturing & Fabrication Technology Development	D. Gandy, EPRI
8:40 AM	➤ Development of Low-Temperature Powder Spray for Fuel Cladding	K. Sridharan, University of WI
9:10 AM	➤ Additive Manufacturing of Fuel Assembly Components	G. Pabis / C. Gramlich, NovaTech
9:40 AM	➤ Pulsed Thermal Tomography Non-Destructive Evaluation	A. Heifetz, ANL
10:10 AM	➤ Irradiation Testing of Materials Produced by Additive Mfg.	J. King, Colorado School of Mines
10:40 AM	Break/Networking	
11:10 AM	➤ Enhancing Irradiation Tolerance of Steels via Nano-Structuring	H. Wen, ISU/MUST
11:40 AM	➤ ICME and In-situ Monitoring for Rapid Qualification of Components	D. Gandy, EPRI
12:10 PM	Working Lunch “Food for Thought”	
	➤ Advanced Manufacturing at ORNL including MDF Business and Operating Model	B. Peter, ORNL
	Tours	
1:40 PM	➤ Manufacturing Demonstration Facility 2 & 3 Tours	
	Additive Manufacturing – Other Activities	EPRI - Chair
2:40 PM	➤ Data Analytics and Computing for Advanced Manufacturing	V. Paquit / A. Plotowski, ORNL
3:10 PM	➤ Feedstock Supply for Additive Manufacturing	D. Novatnak, Carpenter
3:40 PM	Break/Networking	
4:10 PM	➤ PANEL - Challenges for Development and Deployment of Advanced Manufacturing	NIC – Chair
5:10 PM	➤ Summarize Day	A. Worrall, GAIN
5:25 PM	Adjourn	

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AGENDA

Day 3 – Thursday, December 6, 2018

Time	Topic	Chair /Presenter
	Welding / Joining / Cladding – AMM Project Reviews	Bruce Landrey, AMM – Chair
8:00 AM	➤ Advanced Surface Plasma Nitriding for ATF Cladding	L. Shao, Texas A & M University
8:40 AM	➤ Improving Weld Productivity and Quality Through Real-Time Monitoring	J. Chen, ORNL
9:10 AM	➤ All Position Cladding by Friction Stir Additive Manufacturing	Z. Feng, ORNL
9:40 AM Break/Networking		
	Qualifying & Certifying Advanced Manufacturing Nuclear Components	Bruce Landrey, AMM – Chair
10:10 AM	➤ Pre-Fabricated High Strength Rebar and Concrete for Accelerated Construction	Y. Kurama, Notre Dame
10:50 AM	➤ PANEL - Qualifying & Certifying Advanced Manufacturing Nuclear Components	NEI – Chair
	Summarize and Close Workshop	GAIN - Chair
11:50 AM	➤ Summarize key items from workshop, findings, key actions, gaps, needs, etc.	GAIN
12:20 PM Working Lunch “Food for Thought”		
	➤ Private Public Partnership In Advanced Manufacturing	J. Jones, Volunteer Aerospace
1:20 PM Adjourn		

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ACRONYMS

AMM	Advanced Methods for Manufacturing
ANL	Argonne National Laboratory
ATF	Accident Tolerant Fuel
BWXT	BWX Technologies, Inc.
DOE-NE	Department of Energy-Nuclear Energy
EPRI	Electric Power Research Institute
GAIN	Gateway for Accelerated Innovation in Nuclear
GE	General Electric
ICME	Integrated Computational Materials Engineering
ISU	Idaho State University
LWR	Light Water Reactor
MDF	Manufacturing Demonstration Facility
MUST	Missouri University of Science & Technology
NEI	Nuclear Energy Institute
NIC	Nuclear Industry Council
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
RPV	Reactor Pressure Vessel
SMR	Small Modular Reactor
TCR	Transformational Challenge Reactor
UT	University of Tennessee

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