

Leaping Into the Future
Where Have We come From and Where Are we Going



Donald Deptowicz & Paul Finelt
ICI-AM Subcommittee Update
August, 16th 2023

Welcome to:
"Thinking Outside the Box"

Subcommittee Activity Update – The Why



To help accelerate the understanding and impact of advanced manufacturing (AM) capabilities and the application of these tools to our casting businesses and supply chains.

- ✓ Team Re-Energized in June 2022
- ✓ Live AM4IC Symposium March 14th-15th 2023 in Cleveland Ohio
- ✓ Virtual RoundTable held on June 14th “What Does it Take to Get Customer Buy-In”
- ✓ “Before Attempting to Change or Influence the World, One Must First Begin by Changing or Improving Oneself” – Socrates
 - ✓ ICI participated in several America Makes workshops to influence next project calls
 - ✓ Nine focus areas announced at a value of ~\$11.7M
 - ✓ ICI Submitted a proposal on Topic Area 2 - *Mature AM ceramic technology and promote adoption for rapid, low volume production of investment castings for defense applications*
- 2023 ICI Technical Conference and Expo August
- Virtual RoundTable scheduled for September 27th (topics TBD)
- Next steps being identified at the pull of the customer

Thoughts from Colonel Gadson's Keynote



History and the Demise of General Custer

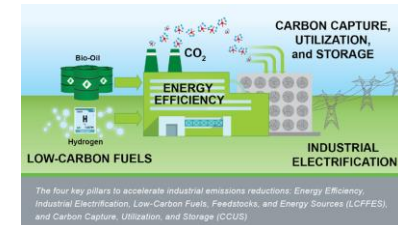
- The Troops did not Know the Terrain
- They had Poor Intelligence
- They Underestimated the Enemy
- They were Over Confident
- They did not Fight on their Home Ground

So, What Does this Mean to Us?????

Technology Can be Your Best Friend



- Are you involved with Technology in your activities today?
 - Additive Technologies are Promising and Unique
 - Application of Technologies is a Differentiator
- Technology can Reduce Your Carbon Footprint through Waste Elimination



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- There have been Laws of Physics that we have each been taught.
 - Then, there are those New Laws that we are about to Discover, that will Replace Those from the Past.

So, What are you Doing Next?

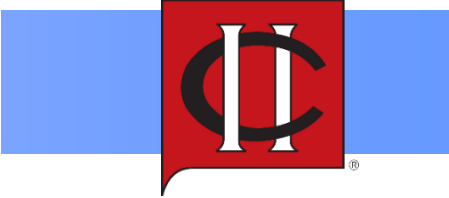
There is NO Silver Bullet!!!!



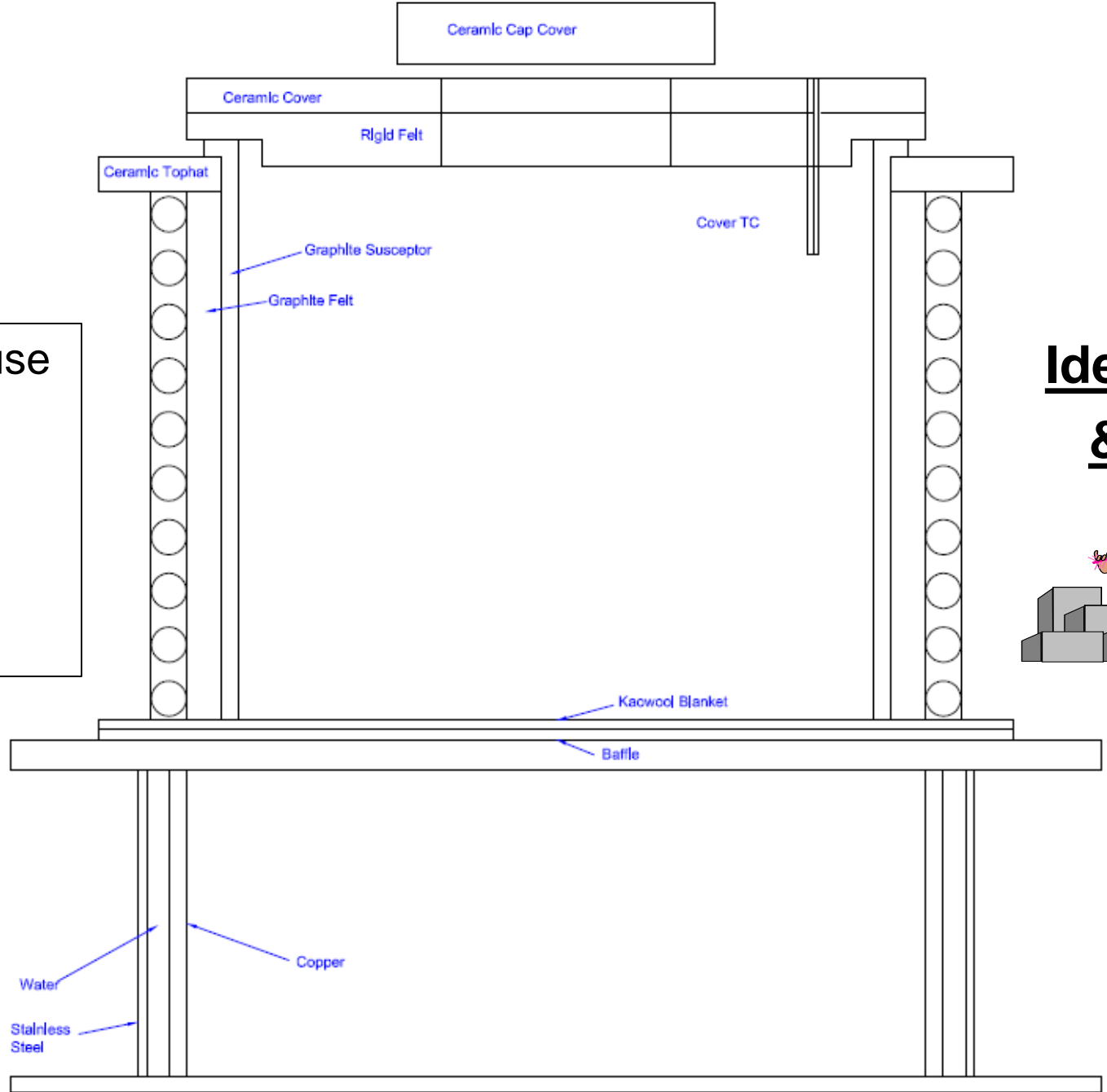
We must recognize that no single Process is going to provide a solution to every opportunity!

1. An Integrated Technology Roadmap
2. A Relentless High Velocity Culture
3. Understand the Root Cause of the Opportunity.
4. Fundamental Change
5. A Visionary Approach with a Living Process
6. A Step Change in Creative Thinking and Innovation

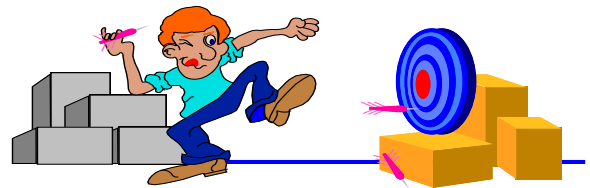
For Industrial Base Sustainment,
Imagination is More Important than Knowledge



- Understand the Root Cause
1. Define (Observe)
 2. Measure
 3. Analyze
 4. Improve
 5. Control



Identify Variation & Eradicate It



AM4IC Symposium– Report Outs (4)



1. Making Castings From Printed Patterns

1. Shrink Not Often Understood
2. Process Controls for Printed

2. Using AM in Non-Pattern IC Applications

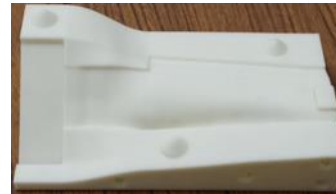
1. Setters
2. Tooling Setups
3. Evaluating Multiple Technologies
4. New Product evaluation
5. “On Demand” repairs
6. Natural disaster recovery
7. Specialty Tools

3. Setting Up AM in the Foundry

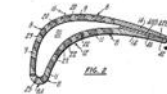
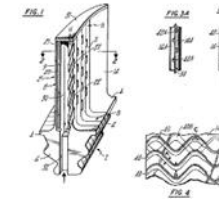
1. Environmental Control
2. Labor-Design-Post Processing
3. Knowledge Transfer
4. Commercial Considerations
5. Management Expectations
6. Quality Assurance

4. Moving AM from Development to Production

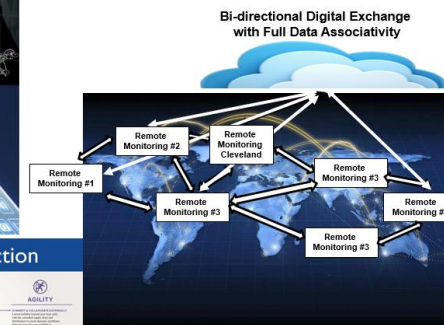
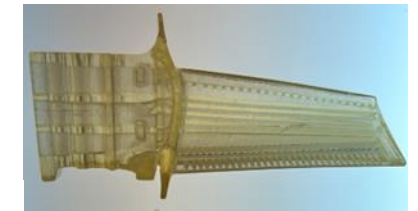
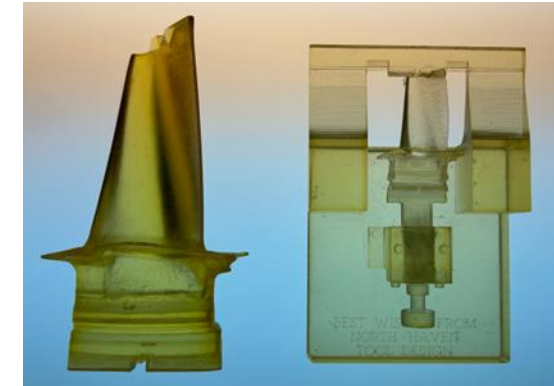
1. Payback Analysis
2. Integration into existing foundry processes
3. Human Resource Requirements
4. Preventative Maintenance (IIoT)



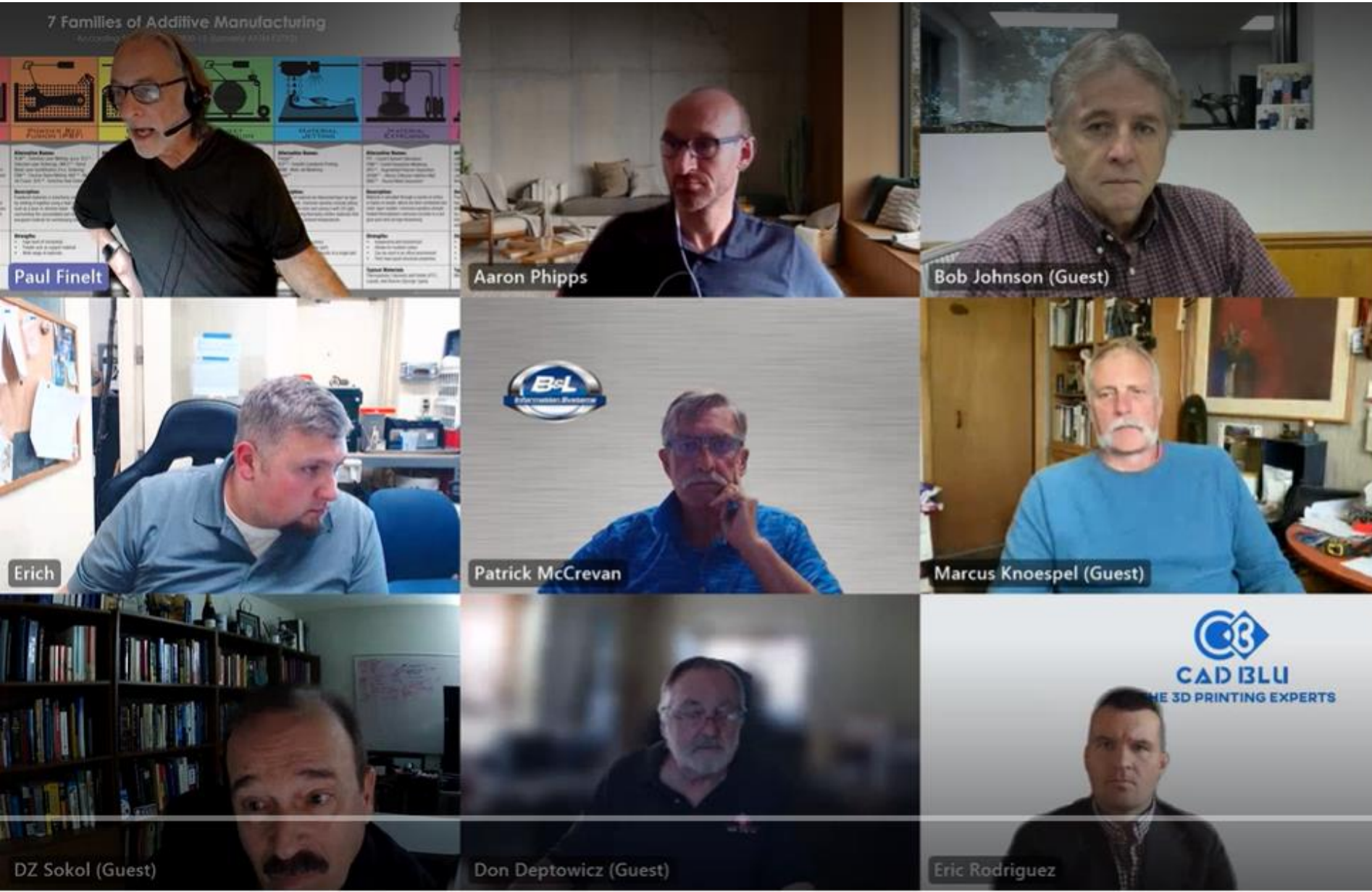
U.S. Patent May 20, 1988 4,203,706



Modular/Wafer Designs



First Virtual RoundTable “What Does it Take to Get Customer Buy-In”



Collaborative Discussion

1. 32 Registered
2. 28 Participants

America Makes/Deloitte Functional Analysis Summary



Workshop Results

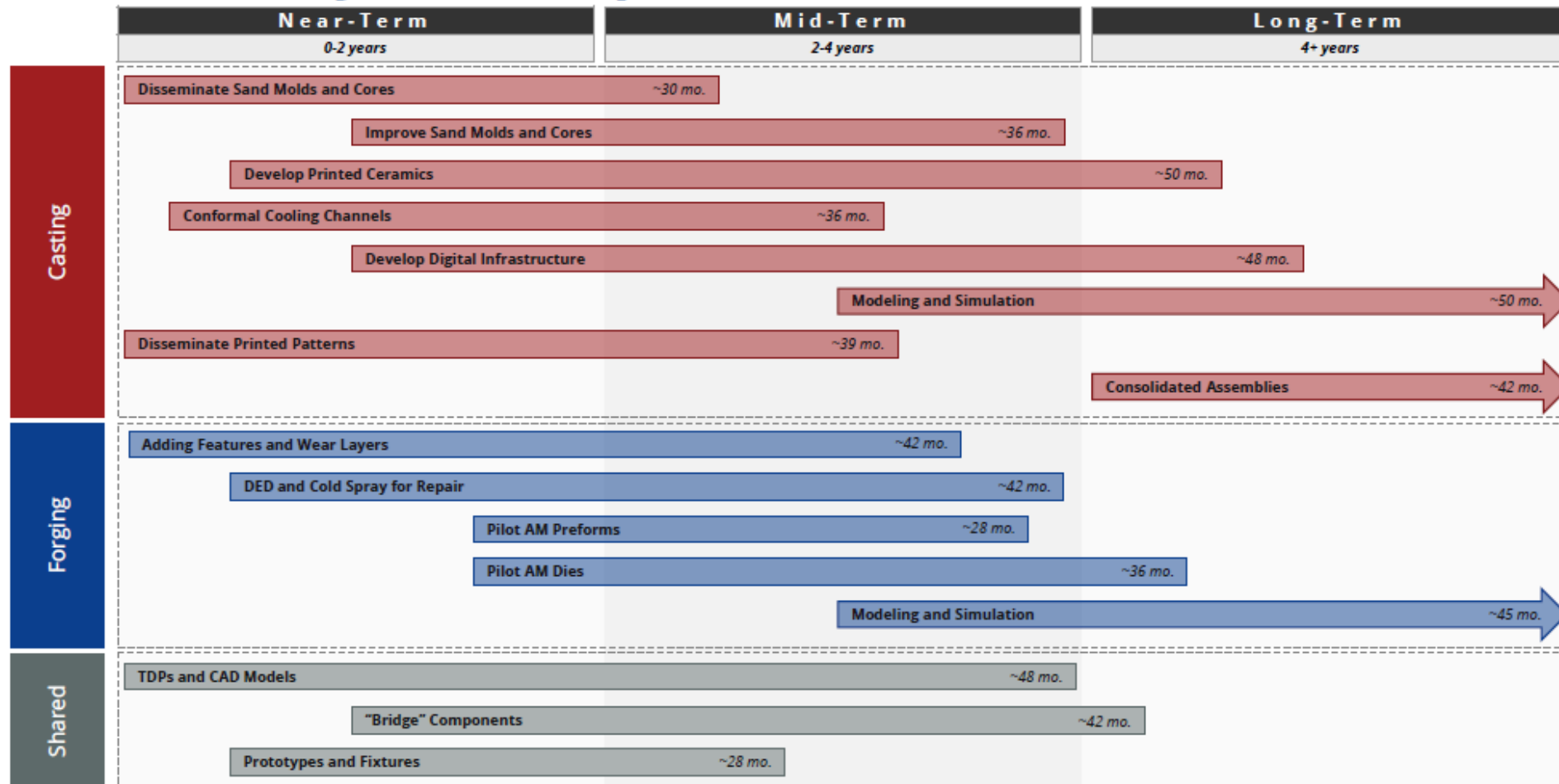
Data across workshops has been synthesized into preliminary priorities and focused projects

	Top Preliminary Priorities	Key Deliverable	Impact
Casting	1. Sand molds and cores	Standardized binder burnout cycles	<ul style="list-style-type: none"> • Reduced NRE cost • Reduced variation • Removed bottlenecks with parallel path • Improved confidence in AM outcomes
	2. Printed ceramics	Guidance for production testing and control	
	3. Conformal cooling channels	High tolerance surface treatment techniques	
	4. TDPs and CAD models	Common TDP structure(s)	
	5. AM simulation	Database(s) with AM material properties	
Forging	1. "Bridge" components	Risk-based assessment framework for acceptance	<ul style="list-style-type: none"> • Extended tooling life • Simplified supply chain • Reduced cost/time of tooling repair • Increased process flexibility
	2. Adding features and wear layers	Process guidance for mating dissimilar materials	
	3. DED and cold spray for repair	Framework for AM tool repair	
	4. AM preforms	DoD test part pilot	
	5. AM dies	AM die/insert pilot	

America Makes/Deloitte Functional Analysis Summary



Preliminary Roadmaps *(Note: Casting and Forging will be separated)*



*Projects above were adjusted based on synthesis of Youngstown and Milwaukee workshops

Wrap Up Actions



1. We have just shown novel, new combinations, more than the sum of the parts that is different from the past.
2. As the Words of Einstein Resonate “*The principle will be beautiful and simple.*”

We Will See What We Want to See

Our People Are The Source of Creativity

We Will be Humble and Discover Nature’s True Driving Forces

It Is All About Attitude!!!!

Development of a Prime Reliant Thermal Barrier Coating System for Turbine Hot Section Components



Project Goals

- Demonstrate direct production of nano-composites for extreme applications in the Air Force

Technology Challenges

- Integration of precisely controlled nano-composite depositions

Use Nano-coatings for Turbine Hot Section Components to control heat transfer.

Technical Approach

Technical Approach:

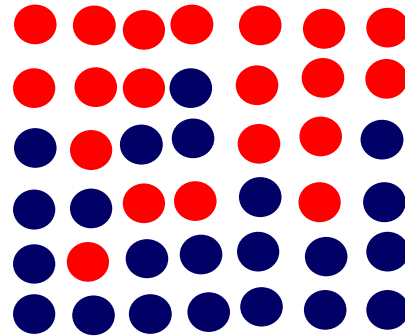
- MEMS, Deposition of nanoceramics while retaining grain structure

Business Impact:

- other DoD/National Security applications: Avionics at high temperature

Nano-coatings and nanoceramic devices

Technology Description



Nanoceramic coatings for gradation composition

Requested Budget and Schedule: \$TBD.

Anticipated Performance Metrics

Already demonstrated nanoceramics while retaining the nanograins;

Deliverables and date:

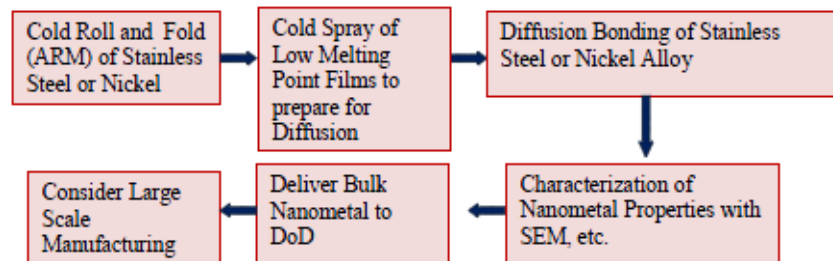
- Deliverable #1 Deliver nanoceramic device for DoD (12/01/09)

Partner: None

An Additive Manufacturing Approach for Low Cost & Efficient Investment Cast Tools



Flow Chart Highlighting the Essential Tasks Involved in the Production of Bulk Nanometal



PROBLEM

Nanometals can dramatically improve the capabilities of existing weapons systems by replacing poorly performing metals and materials. Nanometals can also enable the development of breakthrough new weapons systems. For example, tool molds made from nanometals can also lower the costs of producing parts while increasing their operational temperatures and lifetime. Nanometals can also be produced using “greener” production methods than conventional production processes.

OBJECTIVE

- Reduce time and cost of complex turbine airfoil core and wax tooling.
- Improve level of geometric detail to deliver a repeatable tool targeted at nominal.
- Identify pervasiveness of using nanometals in other applications.
- Initial MRL: 2; Targeted MRL upon completion: 7.

APPROACH

- Produce nanosteel laboratory specimens for validating nanograin structure
- Produce an airfoil tool (wax or core die) using nanometal steel (low risk).
- Produce at least one turbine blade made from a nanometal nickel super-alloy to demonstrate pervasiveness of concept.

BUSINESS STRATEGY

Project Task	FY13	FY14	FY15	
Model Accumulated Roll Bonding (ARB)		■		
Use Cold Spray to Deposit Low Temp Film		■		
Perform Diffusion Bonding for Prototype		■		
Characterize Bulk Nanomaterial		■		
Produce Tool/Die and Turbine Blades		■		
Propose Scale-up of ARB Process			▲	
Contract Dollars in (\$K)	FY13	FY14	FY15	Total
TBD	25	234	75	334K

BENEFITS

- Reduced tooling cost and lead-time
- Reduced density material allows structural weight reduction in engine components.
- Potential to perform portable field repairs.
- Reduced New Product Introduction time and cost.

IMPLEMENTATION

Systems

- Broad opportunities across all DoD systems
- Impacts engines, airframes, ground vehicles and space
- Engine depot maintenance simplified on out of production parts

**Reducing Development & Production Costs,
Saving Fuel & Supporting Timely Deployment**

The Year is 2033. We Achieved our Goals.
Now, Let's Look Back to See How We got Here!!



It's hard to
beat a person
who NEVER
GIVES UP.

— Babe Ruth
POSITIVEMOTIVATION.NET

1. **We Need Your Input**
2. Next Virtual Roundtable Scheduled for Sep 27th
 - a. What would you like to learn about in these discussions?
 - b. Any recommendations on speakers?
 - c. How can you help?
 - d. How can we help you?
3. Our workforce must be properly prepared for the digital world, which requires a new outlook and educational strategies.

Collaboratively, We Can Define a Resilient
Manufacturing Supply Chain

It Rides On You