



*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*

## **Workshop Objectives & New Developments**

**Victor Champagne, Jr.**

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**Henry Morton, 1880**, president of the Stevens Institute of Technology, called Edison's electric light bulb invention a "conspicuous failure".

"Fooling around with alternating current is just a waste of time. Nobody will use it, ever." - **Thomas Edison, 1889**

"Heavier-than-air flying machines are impossible." - **Lord Kelvin, 1895** president, Royal Society.

"Who the hell wants to hear actors talk?" - **H.M. Warner, Warner Brothers, 1927**.

"There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will." - **Albert Einstein, 1932**

"Caterpillar landships are idiotic and useless. Those officers and men are wasting their time and are not pulling their proper weight in the war" - **Fourth Lord of the British Admiralty, 1915**, in regards to use of tanks in war.

"640K ought to be enough for anybody." - **Bill Gates, 1981**

"You will never see the use of Cold Spray on our systems", **Mr. Anonymous, 2007**

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Fielded SH-60 Seahawk with Cold Spray Mg Repair  
Operating Since August, 2009-Australian Navy  
ARL/JSF/DSTO Collaboration



Three Fielded Blackhawk Medvac Units with Cold Spray Al  
Repair Operating Since August, 2009  
ARL/AMCOM/Ft. Hood Collaboration



Fielded B-1 Bomber with Cold Spray Ti and Al Repair  
Operating Since September 2009- Tinker AFB  
ARL/Ellsworth AFB/VRC/SDSM Collaboration



Two Expeditionary Fighting Vehicles with CS Mg Repair  
Fielded and Operating Since September, 2008  
ARL/Allison Transmissions Collaboration



- Power Transfer Module - PTM
  - 10 Magnesium Castings
- Transmission
  - 13 Magnesium Castings

# Recent Fielded Applications of Cold Spray

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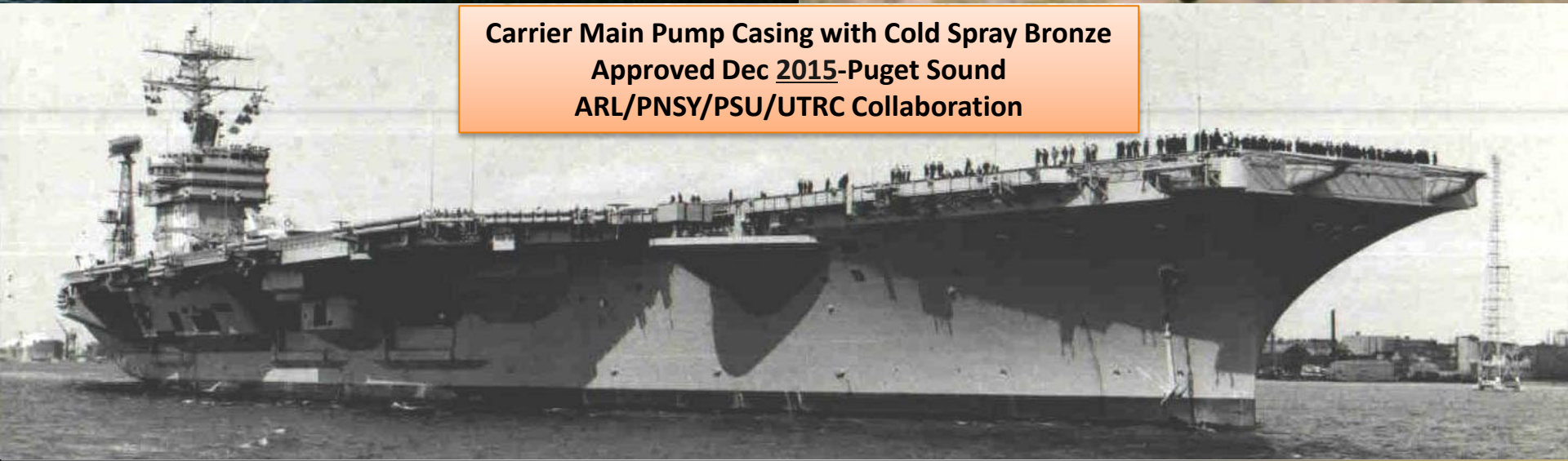
**Submarine TD 63 Actuator with Cold Spray AI Repair  
Operating Since May, 2014  
PSNSY/ARL/VRC/MOOG/PSU Collaboration**



**Apache Intermediate Gear Support-AI Repair  
Production Part-Casting Defect Repair-Fielded in 2014  
Boeing/MOOG/ARL Collaboration**



**Carrier Main Pump Casing with Cold Spray Bronze  
Approved Dec 2015-Puget Sound  
ARL/PNSY/PSU/UTRC Collaboration**



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Chafing Wear on Operational Panel

Main Landing Gear Line

Chafing Point  
Wear Tested

8 panels per aircraft  
Four panels per side  
Lt and Rt sides

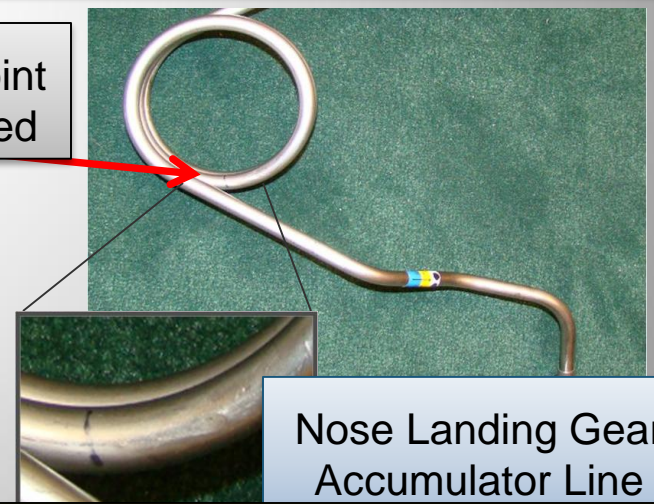
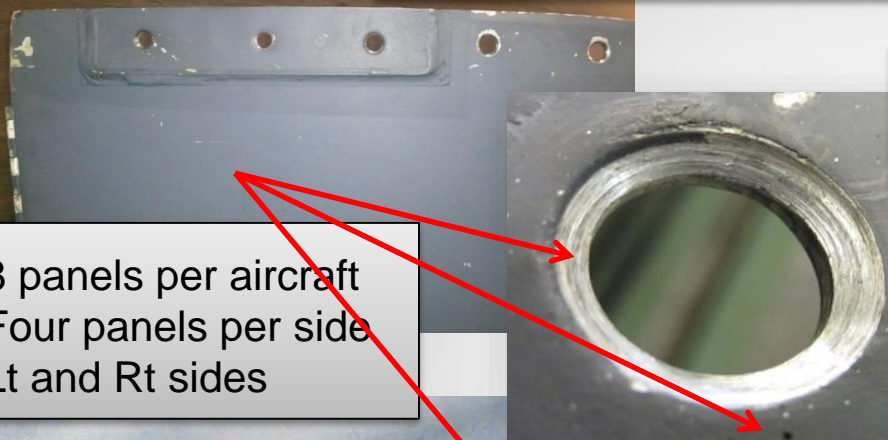
CS Applied Jan 2011 (2 A/C)  
~5 Years 4151 Combined Flt Hrs

Chafing Point  
Wear Tested

Nose Landing Gear  
Accumulator Line

CS Repaired June 2012  
4+ Years, 155 Flight Hours

CS Applied Mar 2009  
6+ Years, 2202 Flight Hours



Approved for public release; distribution is unlimited

Component	Qty	Value (\$)
1. Bell AH-1 Elevator Horns1	2	
2. KC-135 IDG Housings	15	
3. Submarine TD-63 Actuator	3	
4. <b>T-700 Front Frame(recent)</b>	1	
5. H-60 Sump	2	
6. B-1 FEB Panel	1	
7. <b>UH-60 Main Gearbox Housing (present)</b>	1	
8. T700 Shafts (ARL)	40	
9. <b>Aircraft Carrier Main Pump Housing(recent)</b>	1	
10. F-18 AMAD (PSU)	4	
11. Class 688 Submarine Cone Assembly	1	
12. AH-64 Static Mast Support	2	
13. AH-64 Intermediate Gear Support	2	
14. <u>B-1 Hydraulic Tubing</u>	2	



**77 Military Components**

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Component	Qty	Value (\$)
1. CH47 Case & Rotor	4	
2. S-92 Sump & Hydro Hsgs	12	
3. PT6 Housings	3	
4. AW-139 Upper Scissor Lever	1	
5. S-76 Components	9	



## 29 Commercial Components



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Component	Qty	Value (\$)
1. KC-135 IDG Housings	15	
2. H-60 Sump	21	
3. UH-60 Main Gearbox Housing	50	
4. F-15 AMAD	10	
5. F-16 ADG	4	
6. B-1 FEB Panels	12	
7. LA Class Submarine Stern Tube	1	



**113 Pending Military Parts  
Waiting Final Qualification**





## Winter 2015 in MA



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### What is CSAT?

Government

**Mr. Victor Champagne**  
ARL Center for Cold Spray  
Weapons and Materials Research Directorate  
Aberdeen Proving Ground, MD  
[victor.k.champagne.civ@mail.mil](mailto:victor.k.champagne.civ@mail.mil)  
410-306-0822

Engineer

Industry

Technician

Academia

Policy Maker

Sales

Mechanic

Research

Manager



## Learn about Cold Spray Implementation & Development

- **Army-Navy-Air Force Roadmaps**
- **Structural Repair**
- **Additive Manufacturing - Near Net Parts**
- **Aerospace Applications (Boeing, Honeywell, PSNSY, MOOG & more)**
- **Structural Cold Spray Aluminum Alloy Development**
- **Powder Development, Processing, Storage and Handling**
- **Cold Spray Operator Certification Program**
- **Helium Recovery**
- **Nondestructive Inspection**
- **Research & Development**
- **OSD Mantech Cold Spray Helium Recovery System Demo**

### **Exchange Data**

- *Structural Repair & Additive Manufacturing*

### **Opportunities for Collaboration**

- *Between Government, Industry and Academia*



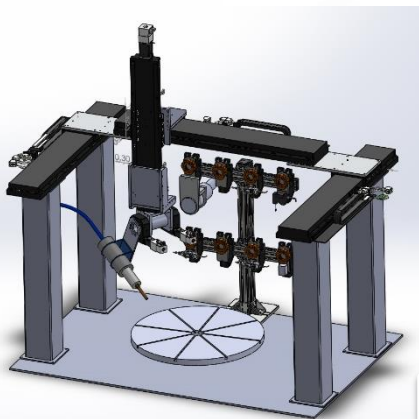
# ARL Vision for Cold Spray Development



## DMS&T Phase I

**Enabled Cold Spray Production Capability for High Volume**

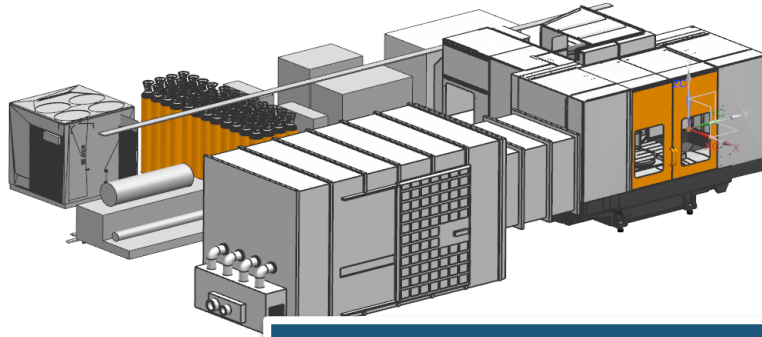
**2012-2014**



## DMS&T Phase II

**Increased Operating Envelope & Established Helium Recovery to Reduce Costs**

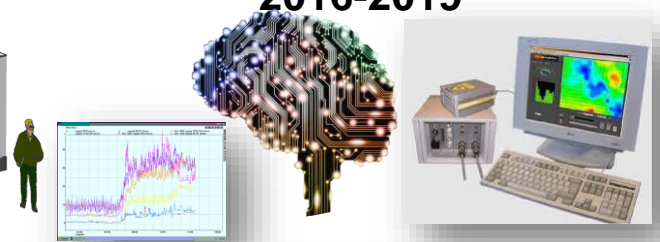
**2014-2016**



## DMS&T Phase III

**Incorporate Advanced Automation & System Controls**

**2016-2019**



**Intelligent Automation & Controls**

**In-flight Particle Temperature, Velocity, and Particle Size Measurement**

**Advanced Motion and Path Planning Capability and Automated System Process Controls**

**Ensure Predictable, Repeatable and Reliable Material Properties/integrity of AM and Structural Applications**

- **World Class Research and Development Facility Recognized Internationally as the most well equipped and sophisticated cold spray facility in the world**

- ARL Center for Cold Spray est. 2000 (10 dedicated employees, 13 CS systems)

The direct link is: <http://www.arl.army.mil/www/default.cfm?page=369>

The link from

the homepage is: [Doing Business with ARL | Center for Cold Spray](#)

- **Cold Spray Team consists of over 75 researchers from industry, labs and academia**

- Work with over 150 companies, as well as DOD, DOE, Foreign Countries

- Aerospace, automotive, petrochemical, medical & electronics applications

- CS Additive Manufacturing (Donor Tubes, Projectiles, Sputter Targets, Shaped Charges)

- Patent pending on **first high pressure/temperature Hybrid Cold Spray System, “VRC Gen III”**

- Developed the **first Cold Spray Process Specification** (MIL-STD-3021, titled “MATERIALS DEPOSITION, COLD SPRAY), August 2008 and **first approved CS processes for DoD.**

- Developed the **first Cold Spray Powder Specification** (MIL-DTL-32495, titled “ALUMINUM-BASED POWDERS FOR COLD SPRAY DEPOSITION”), May 2014.



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## ARL Cold Spray Materials Development Enabling Additive Manufacturing and Structural Repair Capability



Structural Repair



PRODUCTION

**Honeywell**

Aerospace

Field Use



NEAR NET PARTS



**LOCKHEED MARTIN**  
Space Systems

**RUAG**  
Aerospace



**VISION: Non-structural Repair** → **Structural Repair** → **Near-net Parts**

- Industry
- AF & Army RIF **TRL 9**
- RDECOM **TRL 8**
- TMR
- OSD & Army Mantech **TRL 7**
- NAVAIR **TRL 6**
- AFRL **TRL 5**
- Navy-TIPS
- ESTCP **TRL 4**
- DLA **TRL 3**
- SBIR
- SERDP **TRL 2**
- ARL,ONR **TRL 1**

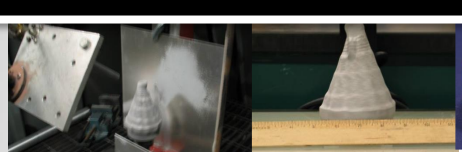


**PRODUCTION SCALE-UP**



Flexible Robot Environment  
EM Gun Rails-Donor Tubes

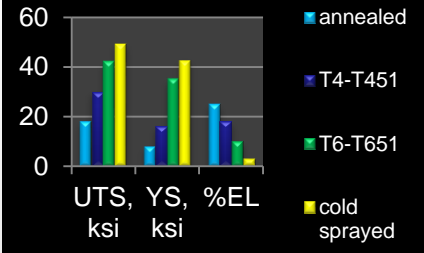
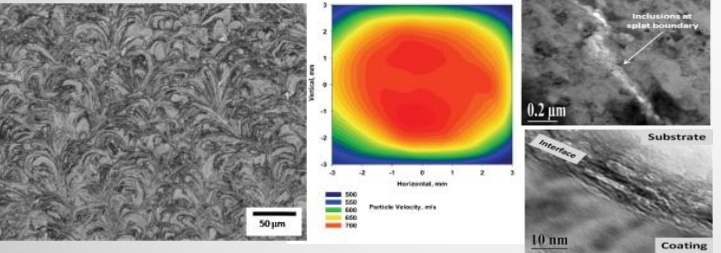
**First Approved Army-Navy & Air Force Applications**



FEB Panels & Hydro

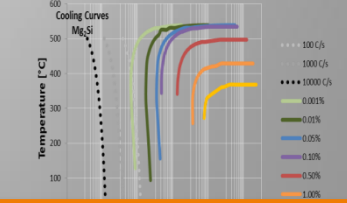
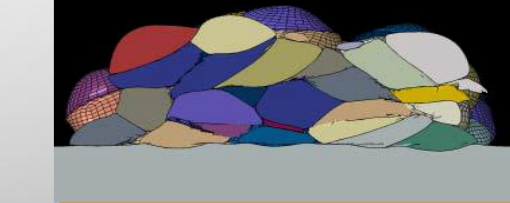
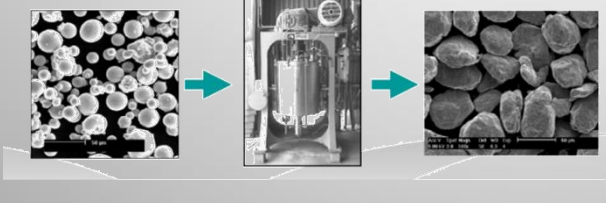
**CHARACTERIZATION & TESTING**

**PROCESS DEVELOPMENT**



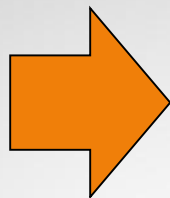
**POWDER SYNTHESIS**

**MODELING & SIMULATION**



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## IMPROVE DUCTILITY



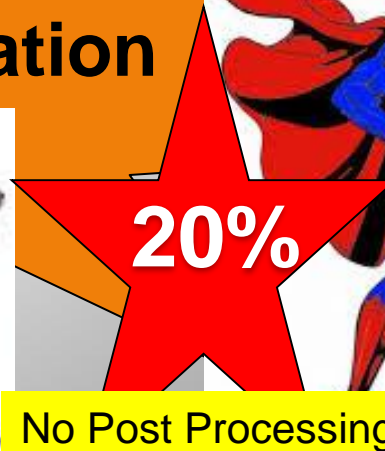
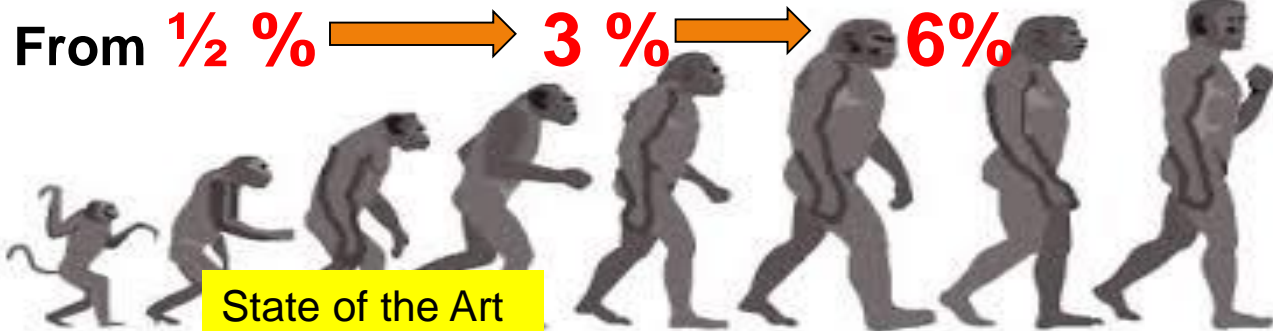
## MATERIALS BY DESIGN APPROACH



Aerospace Aluminum

Modeling & Simulation  
Powder Synthesis

Intelligent Processing & Controls  
Alloy Development/Optimization



No Post Processing

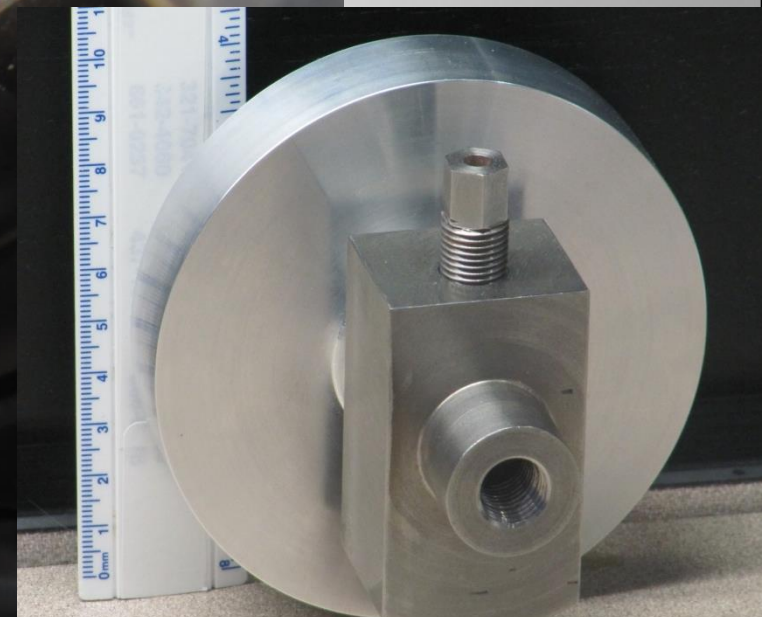


# Gun Barrel Inside Diameter CS Coatings

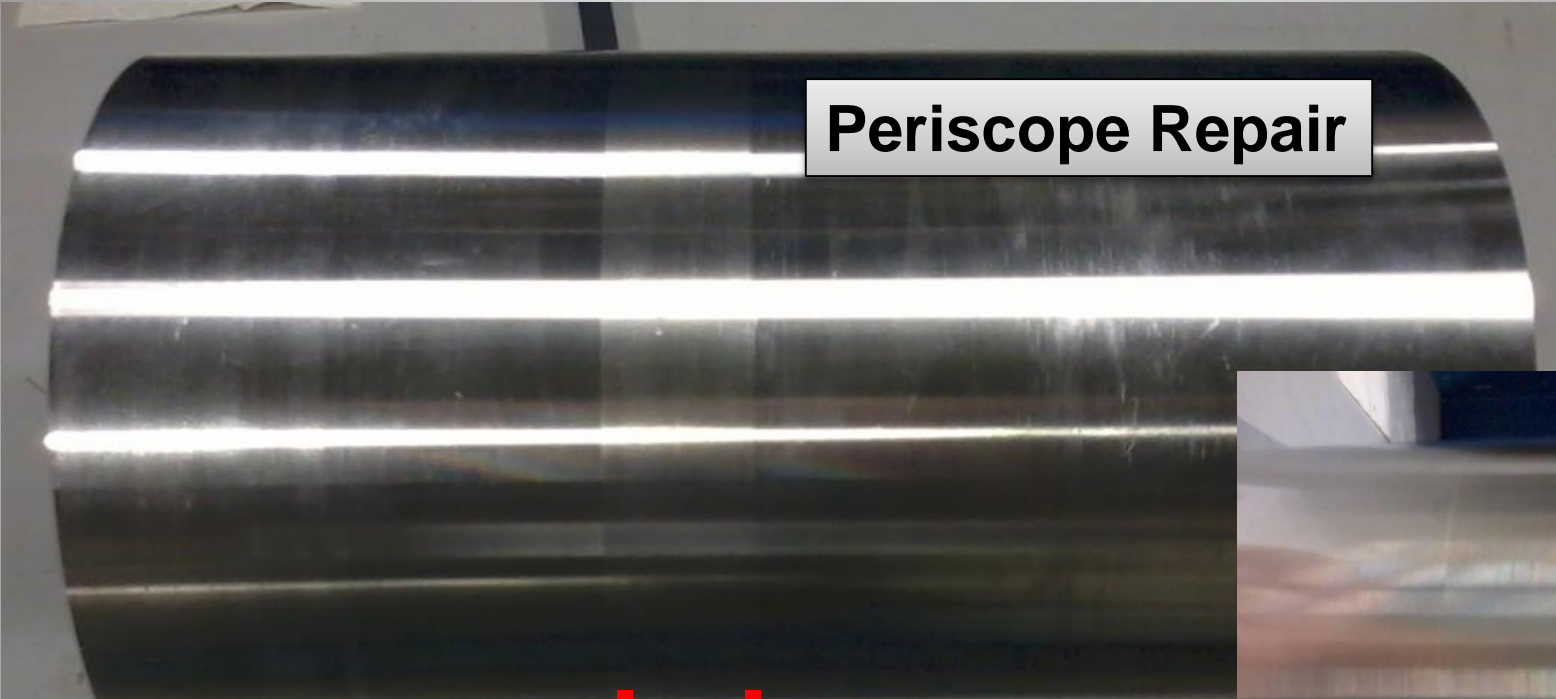
Approved for public release; distribution is unlimited

Cold Spray Refractory Gun Barrel Coating

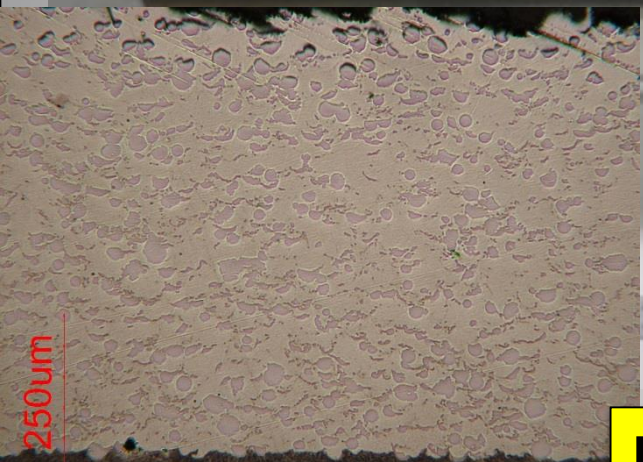
3 ¾ inch dia.



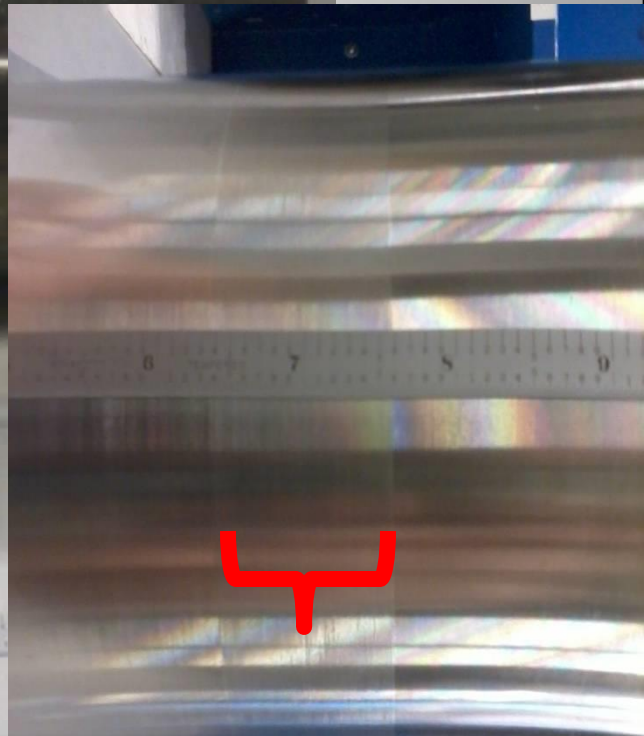
Cold Spray Donor Tube-50 Caliber



**Periscope Repair**



CrC-NiCr Cold Spray Fill  
0.02 inches thick



**FIELD OR PRODCUTION USING AIR**

Approved for public release; distribution is unlimited



## From Whence We Came



**1998-Congressional Funds \$1.2M**



**2000-Ktech Cold Spray System**

Approved for public release; distribution is unlimited

## Cold Spray Transition Locations for FY16-18

- **Corpus Christi Army Depot**
- **Letterkenny Army Depot**
- **Anniston Army Depot/Honeywell**
- **Ellsworth AFB**
- **Hill AFB**
- **Tinker AFB**
- **Puget Sound Naval Shipyard**
- **Portsmouth Naval Shipyard**

“Storage, Analysis,  
Failure Evaluation and  
Reclamation” (SAFR)  
at CCAD



**Fleet Readiness Center (FRE-East)**  
**MOOG-Webster, MA and Fargo, ND**

# Vision for the Future

Approved for public release; distribution is unlimited

**Structural Repair &  
Additive  
Manufacturing**

**Stay Focused  
Don't Oversell**



**Nuclear power  
Munitions  
Electronics  
Medical**

**"Storage, Analysis,  
Failure Evaluation  
and Reclamation"  
(SAFR) at CCAD**

**Helium Repair  
Costs Plummet**

**Air Force  
Enterprise  
Approval**

**HOW**



**ARL-SERDP-ONR-TMR-DLA  
Air Force & Army RIF Program**

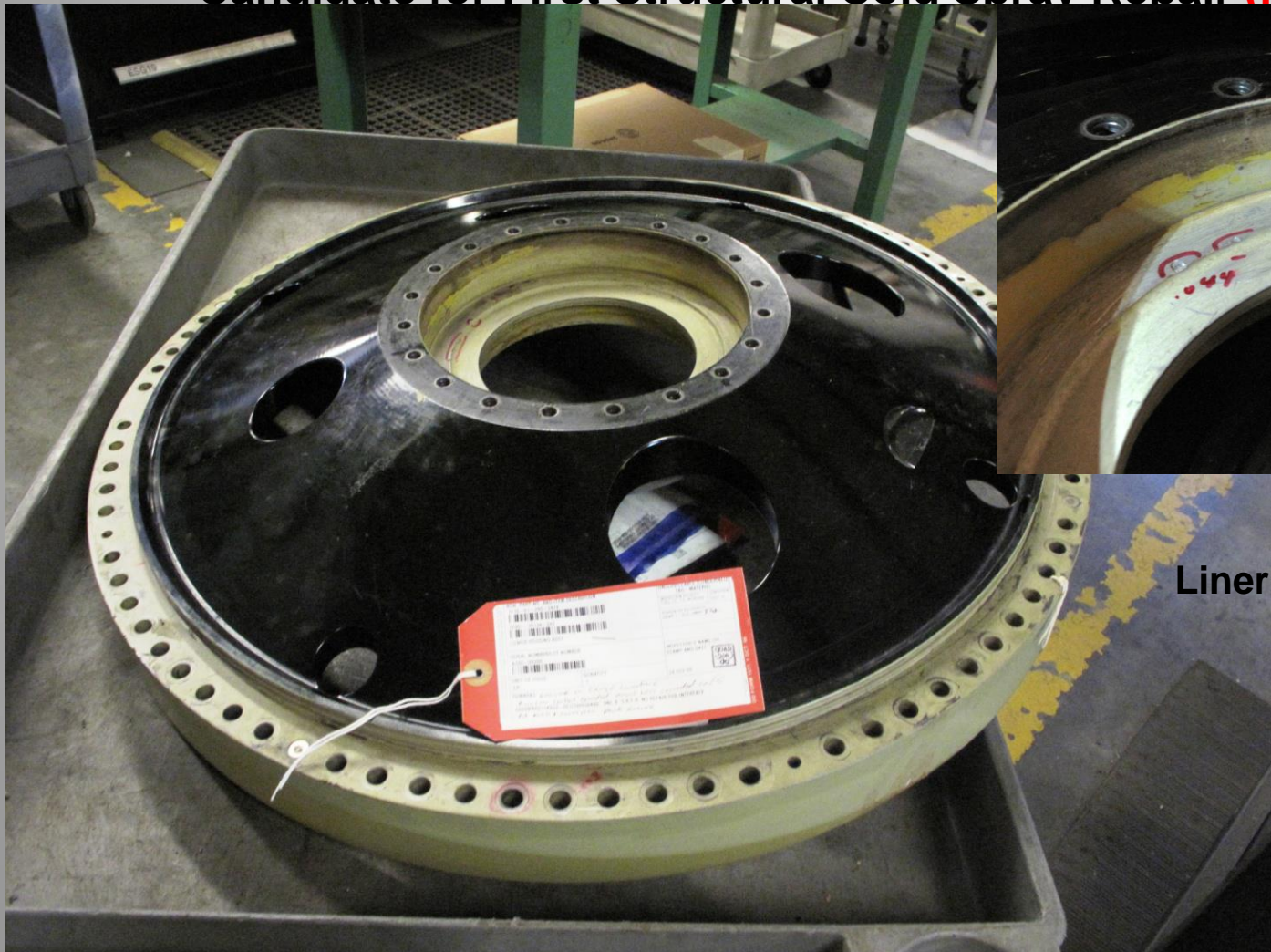
# BACK-UP SLIDES



# Cold Spray Structural Repair of UH-60 **ARL** Main Gearbox Lower Housing Assembly

Approved for public release; distribution is unlimited

50 Pieces @ \$55K each- PN 70351-38134-42  
"Storage, Analysis, Failure Evaluation and Reclamation" (SAFR) at CCAD  
Candidate for First Structural Cold Spray Repair **(No current Repair)**



**Liner Bore Seat Damage**

Approved for public release; distribution is unlimited



As Received



Prepared for CS



As Sprayed



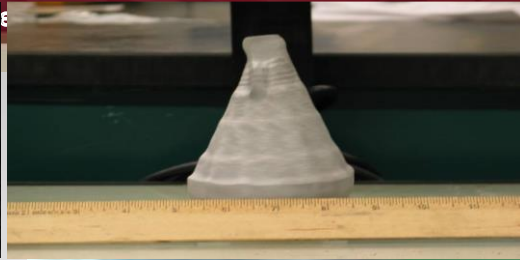
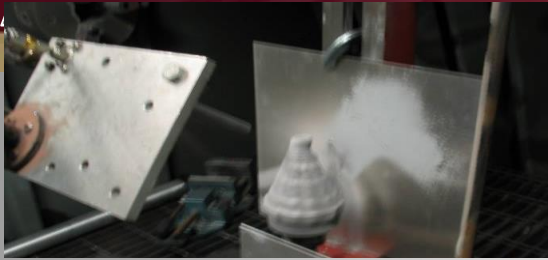
Finish Machined



# Structural Rebuild of Parts

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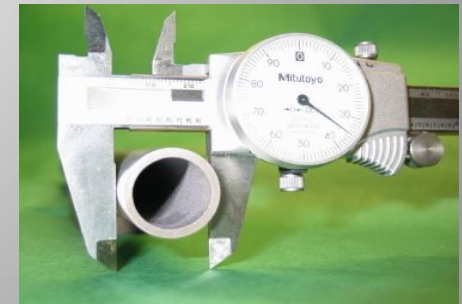
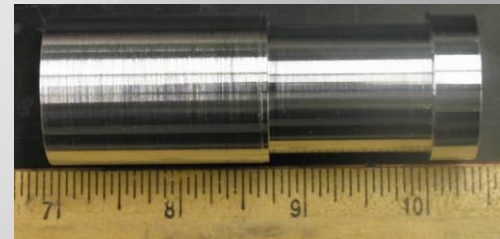
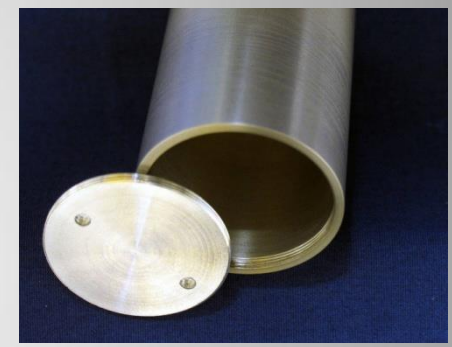
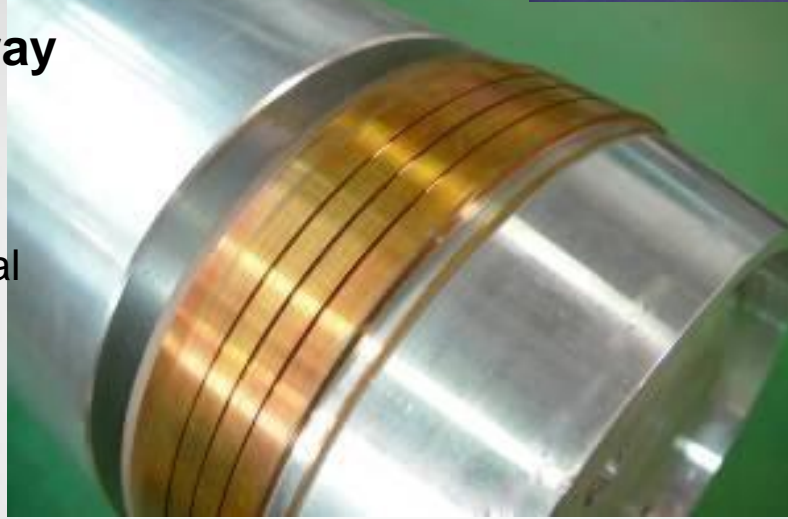


**fine  
machined  
threads**



## Conventional Cold Spray

- Cold spray is a proven technology
- has demonstrated potential as a means of producing near-net shape complex components.
- Upgrade conventional CS systems for near-net fabrication.
- New powders and processes are required.



**CAD/CAM**

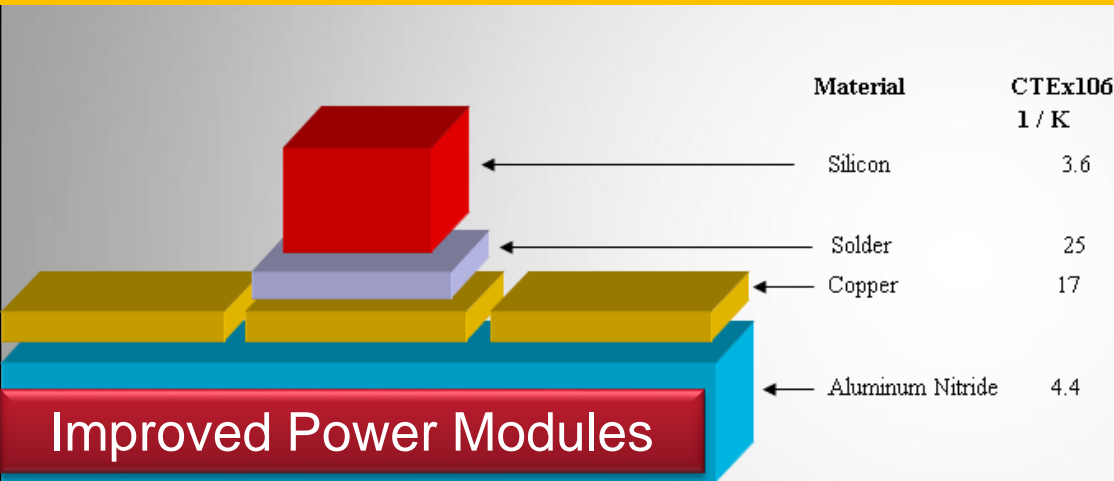


**Antimicrobial Coatings**

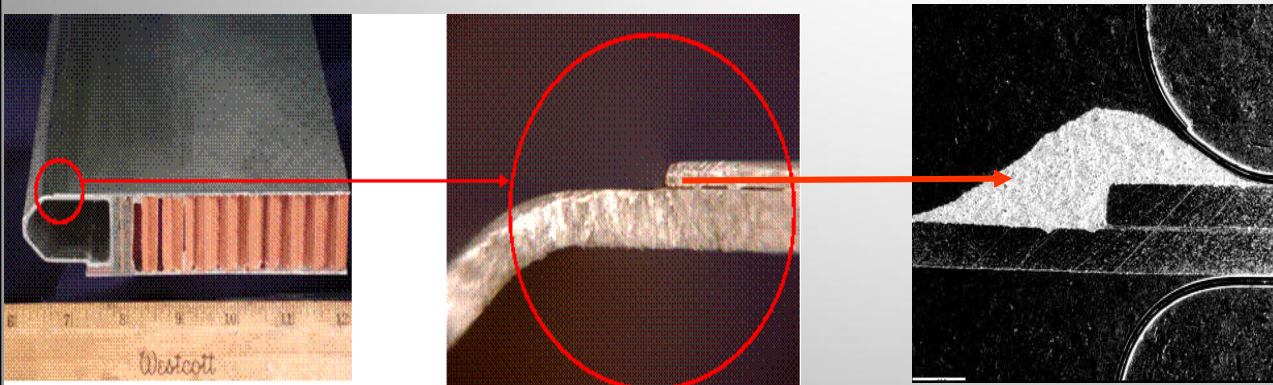
Cold Spray Copper Coating has demonstrated UP TO >99.999% (log 10 >5.8), of Staphylococcus aureus-Methicillin resistant (MRSA) (ATCC 33592) following 2 hour exposure period at room temperature (23.0° C)



Thermally conductive copper coatings on steel.



Improved Power Modules



Provide adequate EMI shielding for HMMWV Shelters



Approved for public release; distribution is unlimited.

## Goal of the Effort

Identification of Areas for the Use of Copper or Copper-Based Coatings in the Army Standard Family of ISO Shelters to Prevent the Growth of Micro-Organisms in a Hospital/Surgical Setting Through Laboratory and On-Site Testing/Evaluation

## Collaborators

**ARL-Advanced Materials and Processing Team**

Vic Champagne, Dr. Dennis Helfritch

**NRDEC-Composite Structures Team**

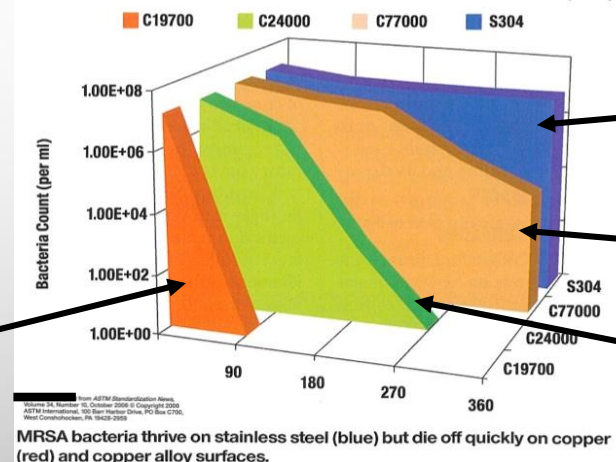
Melvin Jee



## Participating Organizations:

- Copper Development Association
- Medical University of South Carolina
- Fort Detrick
- Memorial Sloan Kettering-Cancer Institute
- Edgewood Chemical Biological Center
- Ralph H. Johnson Veterans Affairs Medical Center
- Worcester Polytechnic Institute

Figure 2—MRSA Viability on Copper Alloys and Stainless Steel at 20°C (68°F)



99% Cu Alloy

Stainless Steel

Brass 80/20

Nickel Silver

MRSA bacteria thrive on stainless steel (blue) but die off quickly on copper (red) and copper alloy surfaces.

# Cold Spray Copper Antimicrobial Coating **ARL** for use on Hospital Overbed Tables

Approved for public release; distribution is unlimited



Cold Spray Copper  
Overbed Table



Surgical Unit In An Army Deployable Medical Shelter