

MOOG



Cold Spray Repair of the CH-47 Accessory Cover

**Christopher Howe
Product Engineer**

Moog/Mid-America Aviation

(701)738-4284

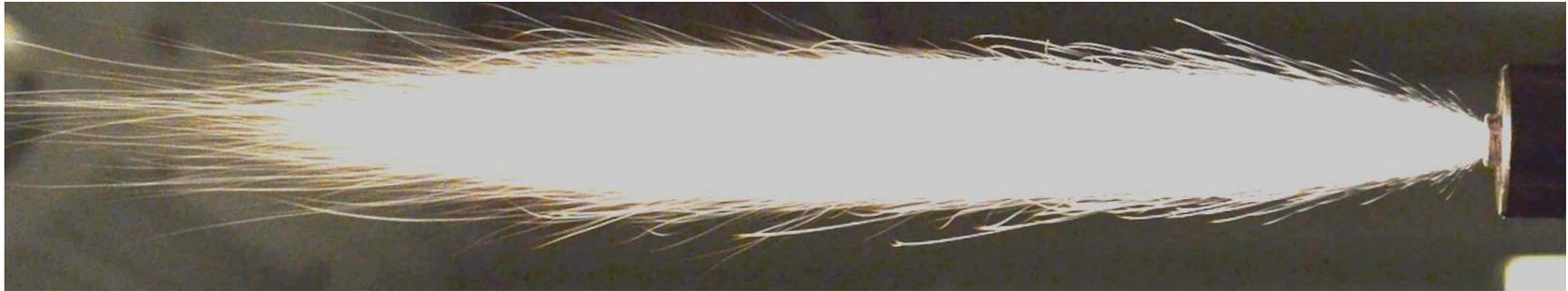
chrish@midamericaaviation.com

CURRENT REPAIR SOLUTIONS

- New part manufacturers and end users have tried for decades to find repair solutions for corroded and damaged parts
- Replacement parts are expensive and often have long lead times; as a result, maintainers prefer repairing vs. replacing
- Current processes induce undesirable stresses which can result in premature failure

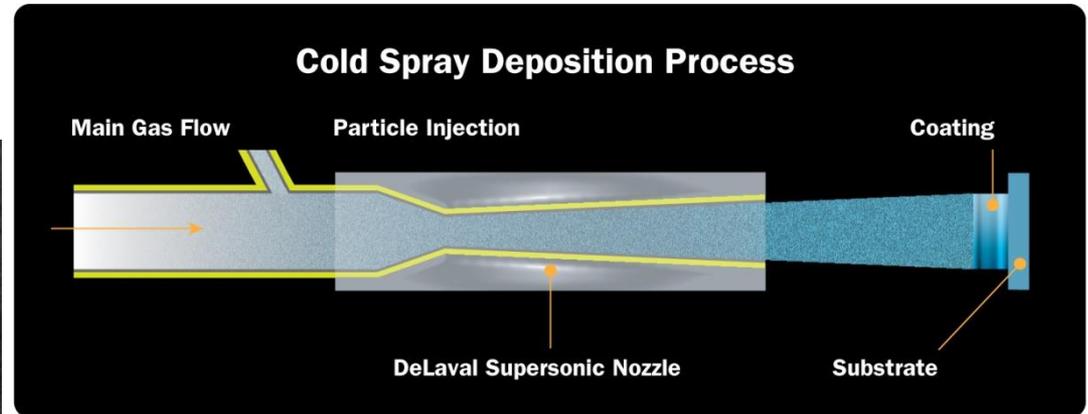
The search for alternate solutions continues...

COLD SPRAY



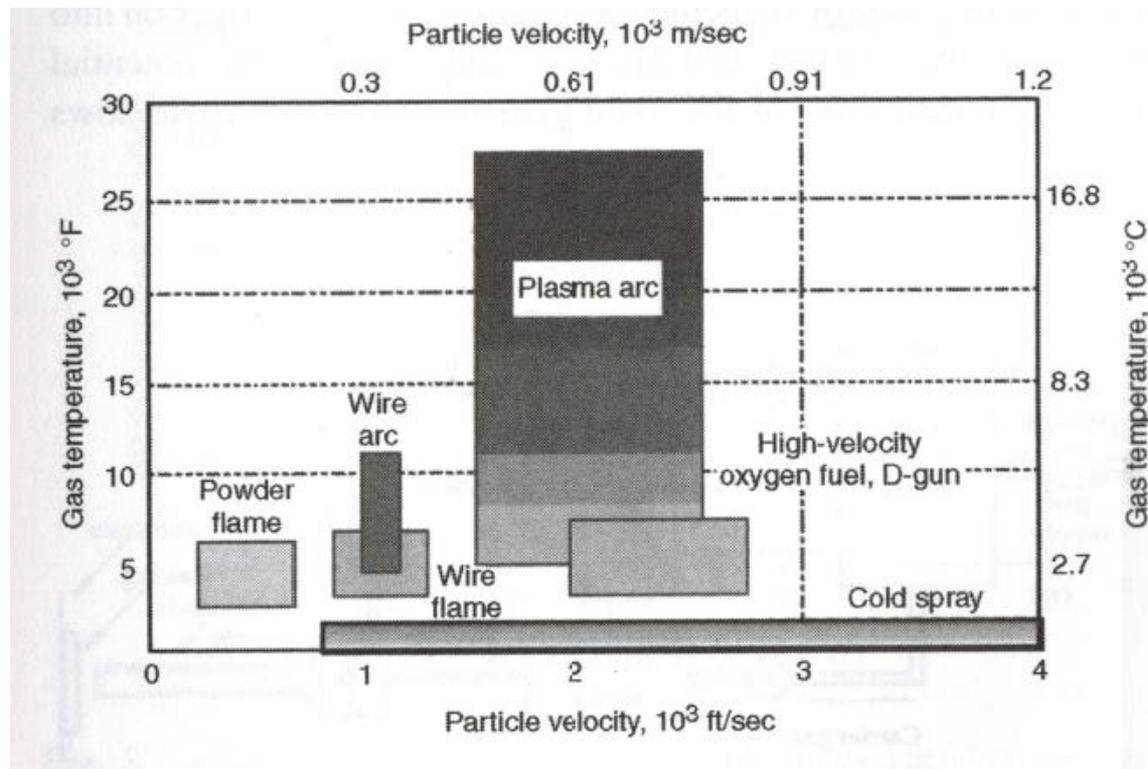
COLD SPRAY DEFINED

Cold spray is an additive manufacturing method where micron sized, metallic powder material is driven to high speed by a compressed carrier gas through a nozzle and directed at a substrate material. The resulting impact and associated particle/substrate's plastic deformation build a coating of the feedstock material onto the substrate. The resultant coating can be machined, heat treated or otherwise handled like stock material.



COLD SPRAY COMPARED

- Lowest operational temperature in thermal spray family
- Capable of highest particle velocity in thermal spray family
- Does not rely on melting/solidification of feedstock for adhesion



Ref R.C. McCune, A.N. Papyrin, J.N. Hall, W.L. Riggs and P.H. Zajchowski, An exploration of the Cold Gas-Dynamic Spray Method for Several Materials Systems, Advances in Thermal Spray Technology, ASM International, 1995, p1-6

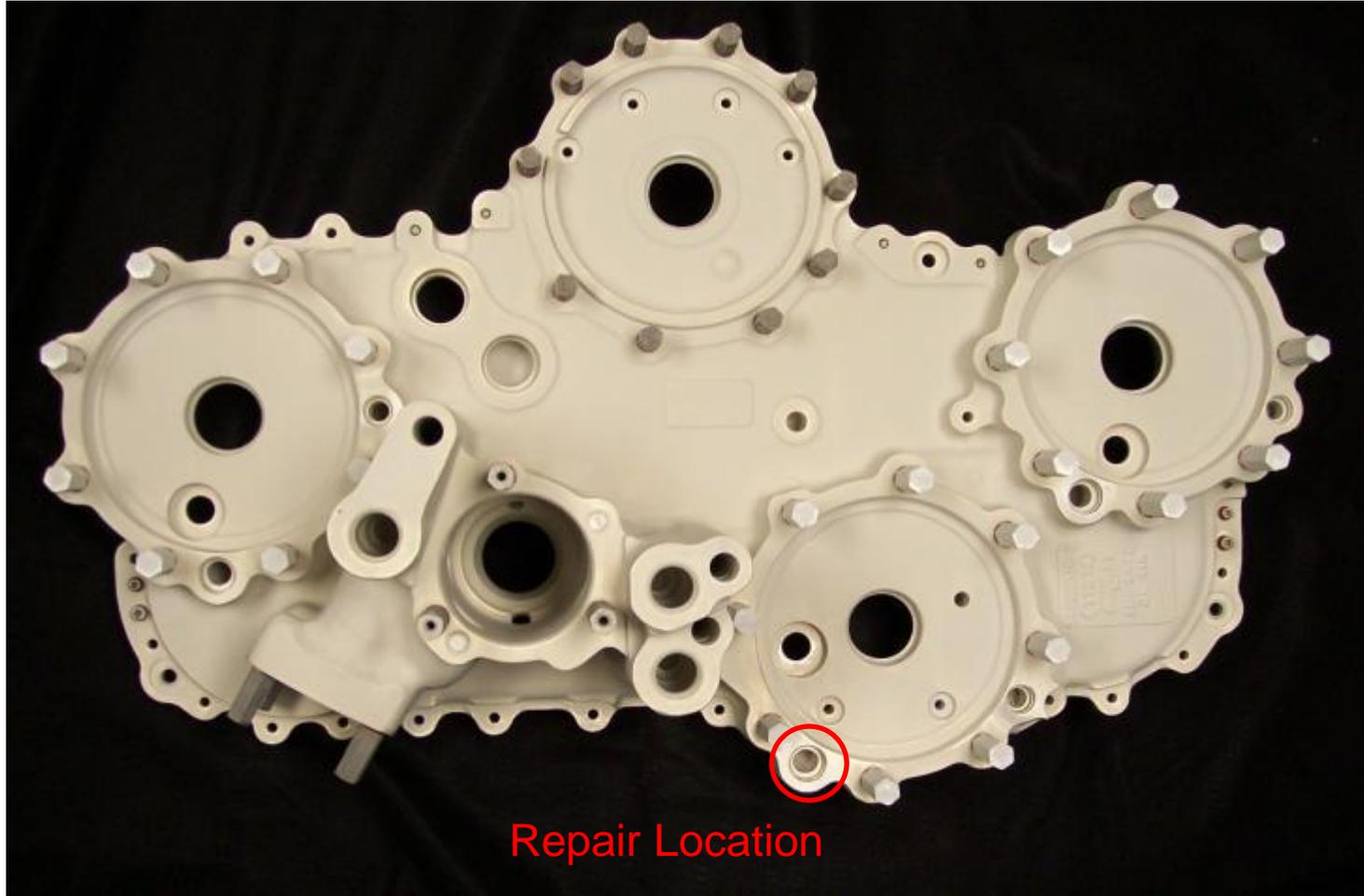
COLD SPRAY ADVANTAGES

- HP (High Pressure) Bond strengths observed around 12-15ksi
- No oxidation
- Produces compressive residual stress
- Strain hardening
- High density – low porosity
- Thick coatings can be achieved
- Heat treatable free forms
- Minimal surface preparation
- No distortion of substrate
- Limited masking
- Low substrate heat input <250F

CH-47 CHINOOK



CH-47 ACCESSORY COVER



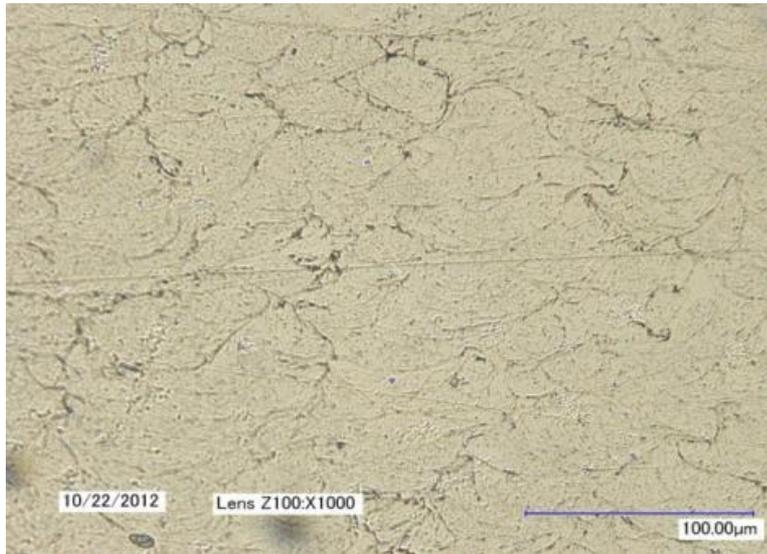
CH-47 ACCESSORY COVER DAMAGE

- Part failed inspection due to corrosion damage to snap ring groove in one of the oil tube bores.

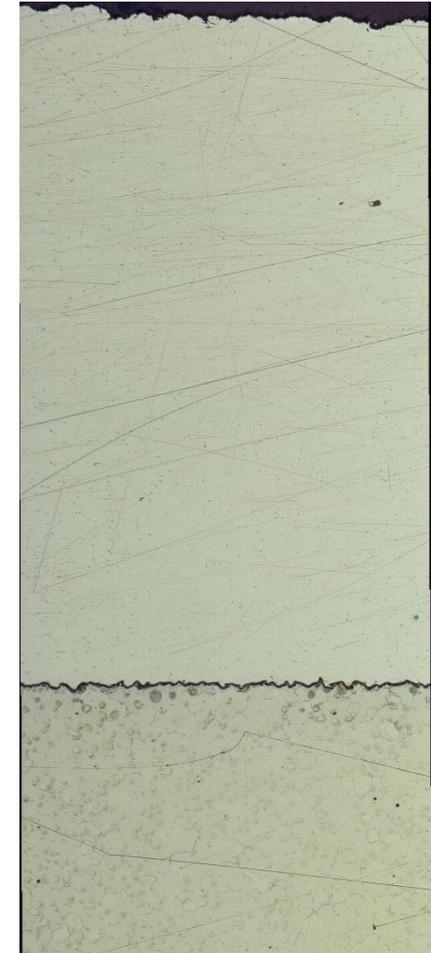


COLD SPRAY REPAIR

- 6061 aluminum deposited on ZE41 magnesium
- Porosity: **<1%**
- Adhesion Strength (ASTM C633-01)
 - Nitrogen: 6,860 psi
 - Helium: **>11,000 psi** (limited due to glue)



6061 coating etched to reveal splat deformation
(1000X)



6061 cold spray coating
(200X)

CH-47 ACCESSORY COVER REPAIR



As Received



Prepared

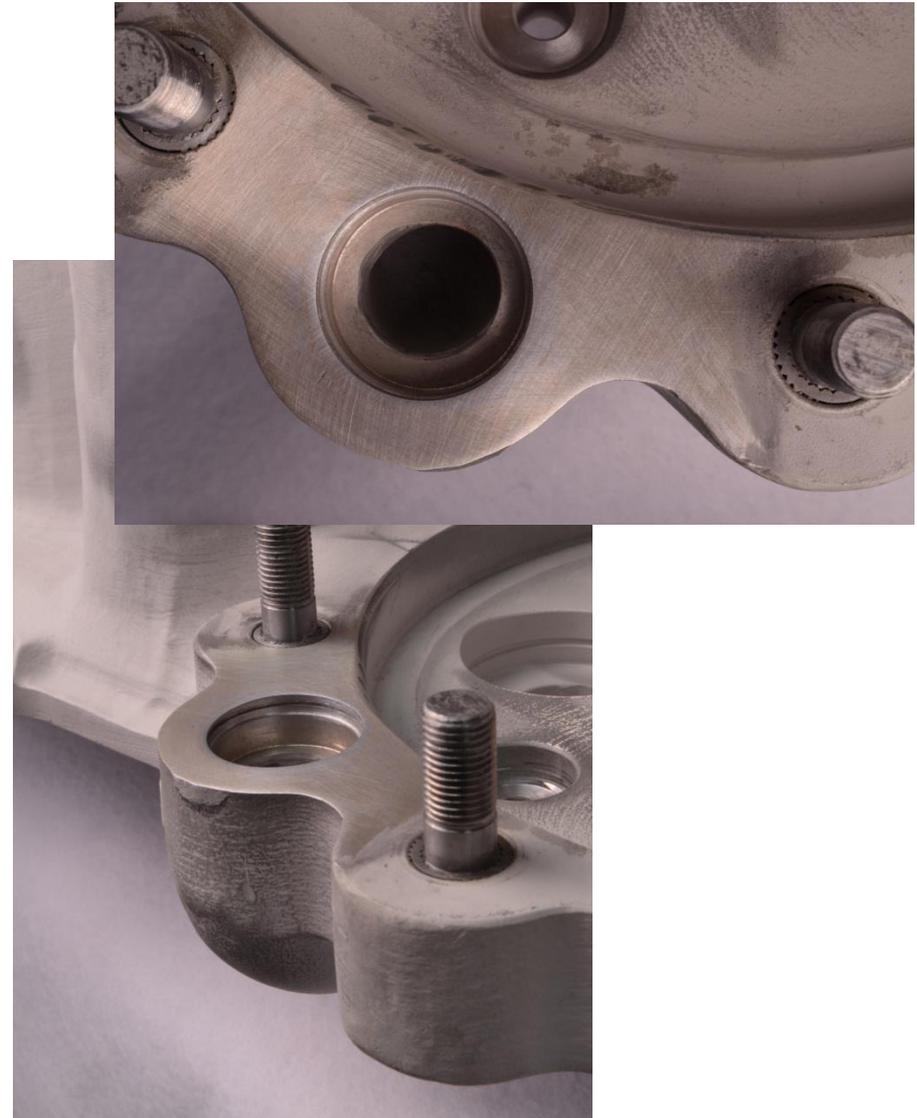


As Cold Sprayed



Machined

REPAIRED CH-47 ACCESSORY COVER



COLD SPRAY APPLICATIONS



- Wear resistance
- Repair corrosion damage
- Prevent corrosion damage
- Recover parts with machining errors or other manufacturing defects
- Surface build up
- Conductivity
- Dielectrics
- Thermal management

MID-AMERICA COLD SPRAY REPAIR: CONSTANT SPEED DRIVE

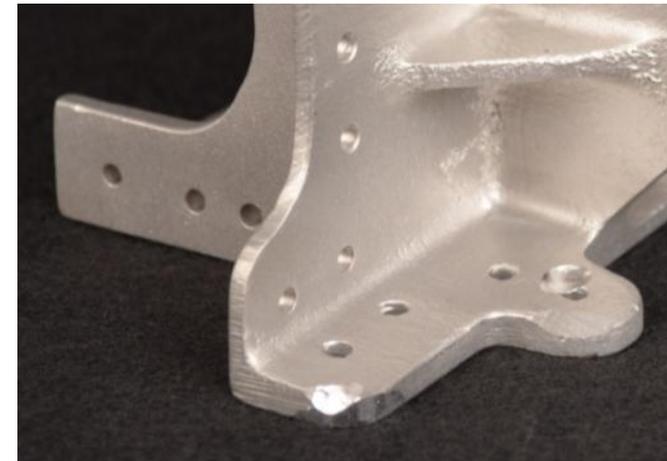
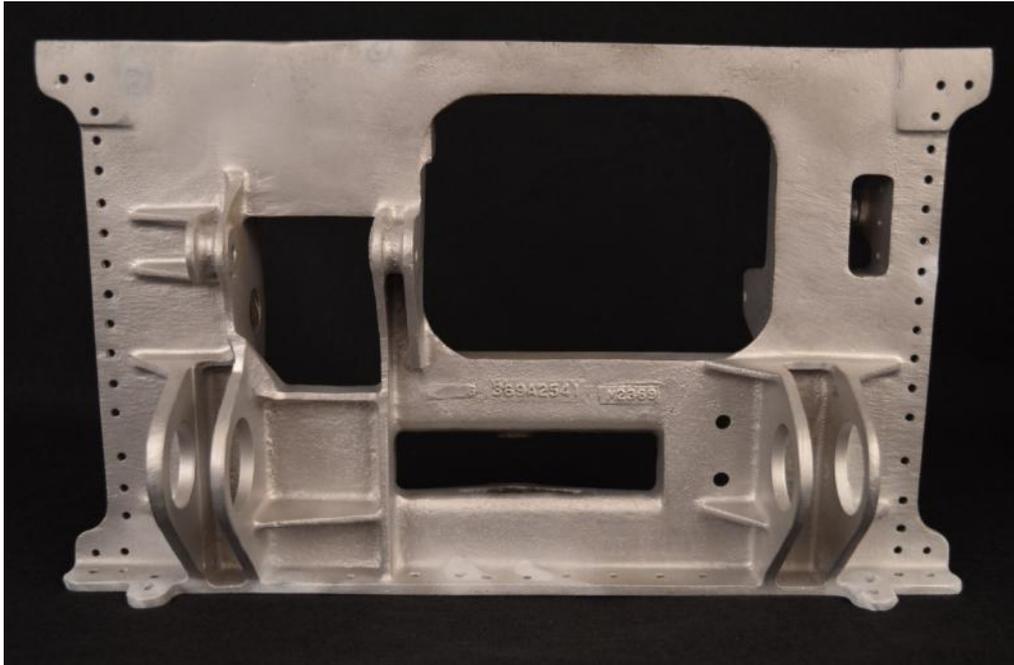


As-Received → Pre-Machined → Cold Sprayed → Finish Machined



MID-AMERICA COLD SPRAY REPAIR: CYCLIC SUPPORT BRACKET

- Cyclic Support Seat Bracket
- Multiple corrosion sites
- Removed, sprayed, blended



MID-AMERICA COLD SPRAY REPAIR: NOSE WHEEL STEERING HOUSING



- Nose Wheel Steering Component
 - Refurbished with corrosion resistant cold spray material

MID-AMERICA COLD SPRAY REPAIR: FLAP DRIVE HOUSING



Defective Housing



Machined Housing



Cold Sprayed Housing



**Finish ground
Housing
Surfaces**



**Housing
Protected by TAGNITE**

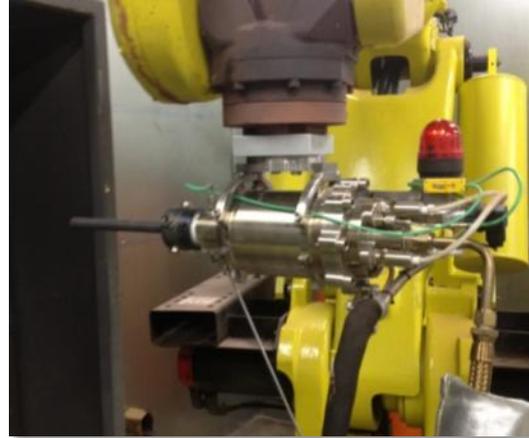


**Housing
Finished w/Rockhard**

MID-AMERICA AVIATION COLD SPRAY REPAIR CAPABILITIES



Plasma Giken PCS-1000
(Pueblo, CO)



CGT-4000 (Webster, MA)



SST EP and P (Grand Forks, ND)

COLD SPRAY DEDICATED STAFF

- Product Line Engineering
 - FAA DER on Staff
 - FAA DER Major Repairs Systems/Equipment, Propulsion Accessories, Repair Specifications
 - Delegations for fixed wing and rotorcraft (Parts 23, 25, 27, 29)
- Experienced Cold Spray Engineers –all Degreed engineers with 5+ years cold spray specific experience
- Metallurgical Engineer Ph.D. on Staff
- AS9100 and AS9110 Certified
- FAA 145 Repair Station Certificate(s)
- Cold Spray Equipment - CGT HPCS, Plasma Giken HPCS, Centerline LPCS and MPCS
- Other – 5-Axis CNC, 3-Axis CNC's, Tooling Fixtures, CNC Lathes, NDT Capability, Full Metallurgical Lab Facilities

BENEFITS OF COLD SPRAY REPAIR

- Significant total cost savings
 - Save on inventory, lead time and labor costs
- Repair time reduction
 - Can be used in-situ
- Improved production yield
 - Salvage parts with manufacturing defects
- Versatile coating method
- Numerous Coating/Substrate combinations
- Engineered coating properties
- Moog has complete Cold Spray Repair capabilities

ACKNOWLEDGEMENTS

- **Jarrold Schell**, Product Engineer
Mid-America Aviation
Grand Forks, ND
- **Ranko Todorovic**, Chief Metallurgist
Mid-America Aviation
Grand Forks, ND
- **Ben Hoiland**, Project Engineer
Mid-America Aviation
Grand Forks, ND
- **Bill Gorman**, Director of R&D
Technology Applications Group, Inc.
Grand Forks, ND
- **Victor Champagne**, Director
US Army Research Laboratory Center for Cold Spray
Aberdeen Proving Ground, MD

THANKS!