VRC Metal Systems
Rapid City, South Dakota, U.S.A.

✓ Leading the U.S. Market in Cold Spray Technology
✓ Founded in 2007 to commercialize research with the US Army Research Laboratory and SDSM&T
What is Cold Spray?

- Solid-state thermal spray process that uses inert gases flowing through a supersonic nozzle to deposit metal powders onto a substrate.
- Uses: Repair, Novel Coatings, & Additive Manufacturing
Advantages of High Pressure Cold Spray

- Can repair parts previously considered unrepairable
- Wide range of Metals & Alloys
- No thermal softening or distortion
- No thickness limitation
- Environmentally Friendly
- Capable of Structural Properties
- Dissimilar metal combinations & MMC’s
- Solid-State Metallurgical Bond on Impact

No HAZ
Examples of Aluminum Cold Spray

- Al 6061 Aluminum (Helium)
  48.3 ksi ± 3.1 ksi
  [333 Mpa ± 21.4 MPa]
  **3.2% Elongation**

- Al 6061 Aluminum (Nitrogen)
  29.8 ± 0.97 ksi
  [205 Mpa ± 6.7 MPa]
  **<1% Elongation**
High Pressure Cold Spray Deposits

90Cu–10Sn (Bronze)
- helium gas
- 56.1 ± 1.0 ksi (387 ± 6.9 MPa)

INCO 625+CrC
- nitrogen gas
- HRC 36
More High Pressure Cold Spray Deposits

NiCr+CrC
nitrogen gas
HRC 40

CP Ti
helium
78.5 ± 1.1 ksi
(541 ± 7.6 MPa)

17-7 SS
nitrogen gas
HRC 34

1018 + CrC
nitrogen gas
16.2 ± 1.0 ksi
(111 ± 7.0 MPa)
AF B1 Forward Equipment Bay (FEB) Panel

- B-1s have been in operation since the mid-1980s.
- Panel Cost: >$200,000
- Available Spares: NONE
- Lead Time: 18-24 months

- Repaired June 2012
- 6+ Years in service
- 2,363 Flight Hours

8 panels/aircraft, 4 panels/side Lt and Rt sides

Approved by the AFLCMC/EZ change evaluation team (CET) on 10/25/2017

Wear beneath bolt heads on FEB panels

Cold Spray repair of FEB fastener holes
Navy Valve Actuator

- **NEED:**
  - $70K cost to replace
  - No Repair Possible
  - Shortages affect SEA WORTHINESS

- **BENEFITS:**
  - Can restore a condemned part to full functionality
  - Immediate availability
  - APPROVED by NAVSEA

ARMY AH-64 Apache Static Mast Support

- Over 70 unserviceable parts
- Cold Spray repair candidates
- Pitting corrosion
- Approved Jan 2018

Approved by the AFLCMC/EZ change evaluation team (CET) on 10/25/2017
First Fielded Cold Spray Near-Net Shape AM Part

Additive Manufactured Cold Spray Part*

With multi-axis path planning, cold spray can be used to rapidly create near-net shape parts.

*Sprayed by ARL using a VRC Gen III Cold Spray System
Patriot Missile Pedestal Corrosion Repair

Pedestal

Fielded Sep 2017

Corrosion Pitting Attack
Periscope Repair / Chrome Replacement Coating

- Cold Spray Coating with Comparable Corrosion & Wear Performance to Chrome Plating

- Fully Dense (>99.5%)

100 um

Volume % Carbide
55% WC (coating)

Hardness
499 HVkrs

ASTM G65 Dry

Abrasion Resistance
Vol. Loss: -27.2 mm³

20 um

Volume % Carbide
77% WC (coating)

Hardness
827 HVkrs

ASTM G65 Dry

Abrasion Resistance
Vol. Loss: -2.1 mm³
# Military Parts Fielded

<table>
<thead>
<tr>
<th>Component</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bell AH-1 Elevator Horns</td>
<td>2</td>
</tr>
<tr>
<td>2. KC-135 IDG Housings</td>
<td>39</td>
</tr>
<tr>
<td>3. Submarine TD-63 Actuator</td>
<td>3</td>
</tr>
<tr>
<td>4. T-700 Front Frame</td>
<td>1</td>
</tr>
<tr>
<td>5. H-60 Sump</td>
<td>2</td>
</tr>
<tr>
<td>6. B-1 FEB Panel</td>
<td>2</td>
</tr>
<tr>
<td>7. UH-60 Main Gearbox Housing</td>
<td>1</td>
</tr>
<tr>
<td>8. T700 Shafts</td>
<td>40</td>
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<tr>
<td>9. Nimitz Class Carrier Main Pump Housing</td>
<td>1</td>
</tr>
<tr>
<td>10. F-18 AMAD</td>
<td>4</td>
</tr>
<tr>
<td>11. Class 688 Submarine Cone Assembly</td>
<td>1</td>
</tr>
<tr>
<td>12. H-53 Main Transmission</td>
<td>1</td>
</tr>
<tr>
<td>13. H-53 Nose Gearbox</td>
<td>1</td>
</tr>
<tr>
<td>14. Patriot Missile (Pedestal, Door, Filter Box)</td>
<td>6</td>
</tr>
<tr>
<td>15. AH-64 Static Mast Support</td>
<td>2</td>
</tr>
<tr>
<td>16. AH-64 Intermediate Gear Support</td>
<td>2</td>
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**Totals 108**
## Pending Military Components Awaiting Final Qualification

<table>
<thead>
<tr>
<th>Component</th>
<th>Qty</th>
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</thead>
<tbody>
<tr>
<td>1. UH-60 Sump</td>
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<tr>
<td>2. UH-60 Main Gearbox Housing</td>
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<tr>
<td>3. F-15 AMAD</td>
<td>10</td>
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<tr>
<td>4. F-16 ADG</td>
<td>4</td>
</tr>
<tr>
<td>5. B-1 Hydrotubes</td>
<td>TBD</td>
</tr>
<tr>
<td>6. AH-64 Static Mast Support</td>
<td>70</td>
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<tr>
<td>7. AH-64 Nose Gearbox</td>
<td>15</td>
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<tr>
<td>8. AH-64 Input Flange</td>
<td>200</td>
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<tr>
<td>9. LA Class Submarine Stern Tube</td>
<td>1</td>
</tr>
<tr>
<td>10. Stryker Armored Vehicle</td>
<td>TBD</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>371+</strong></td>
</tr>
</tbody>
</table>

Pending Military Components Awaiting Final Qualification
Our Equipment

- Smallest cold spray applicator
- Hand-held or Robotic Mounting
- High or Low Pressure Operation
- Completely Mobile Cart
- Extended Reach (>100ft) from Cart
- Many patented & patent-pending features
- Unique Rotating Drum Powder Feeder

VRC Gen III™ & Gen III Max™
Integrated Manufacturing Systems

VRC Viper™ Development System

VRC Turnkey Cold Spray Booth & Motion System

VRC Paladin™ Cold Spray Additive Manufacturing System
Recent Equipment Advancements

**VRC Raptor™ Cold Spray System**

*Developed under DoD funding - Available mid-2019*

- Field & Shipyard Portable
- Integrated skid-frame for rigging and lifting
- Pneumatic casters for shipyard shop floors
- Small, integrated footprint
- IP67 Ingress Protection
- Ruggedized - MIL-STD-810
- Simplified control interface
- 22 kW heater
- CE compliant for the European market

**Helium Recovery System**

- Up to 90% recovery and re-use possible
- Expands opportunities for structural repair with helium...
- Can be coupled with onsite N2 generation or air compression

*DISTRIBUTION A. Approved for public release: distribution unlimited.*
Why Cold Spray is Gaining Traction

- **Cost Savings**
  - Repair vs. Replace
  - Life Extension with Superior Surface Properties

- **Reduced Downtime**
  - Spray and Immediately Re-machine
  - Minimal Distortion

- **Sustainability**
  - Cold Spray is a GREEN technology

- **Cold Spray Market Opportunities**
  - Cold Spray is a very large, rapidly accelerating market
Cold Spray Repair Candidates

1. **High Value**
   - If there is no big savings, its hard to justify a big capital investment

2. **Minimal Total Material Loss**
   - The majority of the part is intact and in good condition

3. **The capability exists to re-machine part features**
   - Is the equipment or expertise available to grind or re-machine the part after cold spray?

4. **Unavailability of replacements**
   - When spares are not available even a cheap part can become critical

5. **When a coating spot repair is needed**
   - Many times a large part must be completely recoated if a repair is needed using other processes (e.g. plating, thermal spray, etc.)

6. **A part is not weldable, or is an exotic material**

7. **A thick material deposit is needed**
Questions...?

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Making Metals Work!

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