Additive Material Repairs
The Changing Nature of Sustainment

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Additive Material Repair Technologies

Manufacture
- 3D Net Shape
  - EBW Electron Beam Welding
  - LAD Laser Additive Deposition
  - SPD (CS) Supersonic Particle Deposition (Cold Spray)

Repair & Modification
- Repairing & Enhancing Existing Material
  - LAD
  - SPD

Protective Processing
- Coating
  - LAD
  - SPD
  - Thermal Spray
Supersonic Particle Deposition (SPD) (Cold Spray)

- SPD is a technology in which metallic powder is accelerated to supersonic speeds in an inert gas.

- The particles gain kinetic energy, and plastically deform on impact with a surface in order to bond directly onto the surface.

- Subsequent overlapping passes build a specified 3-dimensional deposition structure which can be machined to a final shape and surface finish.
Laser Additive Deposition (LAD)

- LAD uses a high power laser beam to create a melt pool in the substrate. Particles are injected into the melt pool via an inert carrier gas.

- The particles melt in the substrate melt pool, and fuse with the substrate during local resolidification.

- Subsequent overlapping passes build a specified 3-dimensional deposition structure which can be machined to a final shape and surface finish.
Additive Material Repair Capabilities

Fixed SPD System

Portable SPD System
Additive Material Repair Capabilities

LAD Powder System

LAD Wire System
The Path to Our Approved Designs

- Identification of the substrate material
- Selection of deposition material
  - Material study
- Deposit onto Test Coupons
  - Various controlled deposition characteristics
The Path to Our Approved Designs

- Destructive and Non Destructive Inspection & Test Program
  - Approved Certification Basis Description (CBD)
  - Military and Industry Standards
  - Corrosion resistance
  - Tensile strength capability
  - Compression & bearing strength
  - Shear strength
  - Fatigue tolerance
  - Residual stress characteristics
  - Impact resistance
  - Hydrogen embrittlement characteristics

- MIL-STD 3021 Materials Deposition, Cold Spray
- MIL-STD 3049 Materials Deposition, Direct Deposition of Metal for Remanufacture, Restoration and Recoating
Scorecard for Additive Material Repairs

- +50 Approved Repairs
- +10,000 Operational Repair Hours
- +$8m of Recovered Equipment

- F/A-18 Hornet, AP-3C Orion, C-130J Hercules
- Seahawk, Tiger

- DASA Part 21J Design Approvals
- DASA Part 145 Repair Applications

- OEMs recognising Cold Spray
- US Army & US Navy applying Cold Spray
Successful Additive Material Repairs
In Flight Refueling Probe (Al Alloy 2024)

Corroded Surfaces

After Blending Surfaces

With SPD Application

After Machining

RUAG Australia Proprietary Information
Fuel Pipe (Ti6Al4V)
Idler Hinge Assembly (Ti6Al4V)

Corroded Idler Hinge Assembly

Repaired Idler Hinge Assembly
Primary Servo
Nose Wheel Hub
Oil Reservoir

- Cost of recovery: <15% of purchase price
- Return to service: 8 weeks
Successful Additive Material Repairs

29 Successful Repairs
No Failures

Main Module
Sump Faces & Flight Control Pads
4 Repairs, 1334 AFHRs

Tail Rotor Gear Boxes (TRGB)
Mounting Faces
6 Repairs, 1060 AFHRs

Input Modules
Webs & Mounting Faces
6 Repairs, 684 AFHRs

Accessory Modules
Mounting Faces
8 Repairs, 300 AFHRs

Intermediate Gearbox (IGB)
Mounting Faces
5 Repairs, 704 AFHRs
Successful Additive Material Repairs
Successful Additive Material Repairs
Successful Additive Material Repairs

Corrosion damage expanding from the bare metal surface under the paint

During SPD Application

After Final Machining

Installed as a Serviceable Component
May 2008

Removed for Corrosion
April 2009

Service Time
11 Months
188 AFHRs

Re-installed
November 2012

Operational Repair Time
4 Years
892 AFHRs

Report from HMAS Toowoomba: “no corrosion”
Successful Additive Material Repairs

- Protected against erosion
- Sealed against corrosion
- Adhesion proven
- Aerodynamically proven
- Aesthetically acceptable
Additive Material Repairs on Site
Additive Material Repairs on Site
Successful Additive Material Repairs

- Single and multi track depositions
- Laser power
- Track paths
- Traversal rate
- Dwell times
- Shielding gas flow rate
- Powder flow rate
- Layer offsets
- Layer rotation
- Spiral depositions
Successful Additive Material Repairs
Fit for Service

Common criteria
- The deposition material prevents further damage to the substrate material.
- The deposition material protects the substrate material against the operational environment.
- No detrimental effects are permitted.

Non structural restoration
- The substrate material achieves all design load requirements.

Structural restoration?
- The substrate material is unable to achieve all design load requirements.
- The deposition material restores the part’s load carrying capability by achieving a credit against the design load requirements.
- How much credit?
Fit for Service : Sufficient Criteria?

- Corrosion resistance
- Tensile strength capability
- Compression & bearing strength
- Shear strength
- Fatigue tolerance
- Residual stress characteristics
- Impact resistance
- Hydrogen embrittlement characteristics
RUAG Australia is the industry partner of choice for the application of Additive Material Repair Technologies to damaged equipment.

- Aerospace
- Maritime
- Land
- Road
- Rail