

AF Life Cycle Management Center



COLD SPRAY & THE AIR FORCE CSAT: 14 JUN 17

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Providing the Warfighter's Edge

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Topics



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- **USAF Investment in Cold Spray**
- **Airworthiness Bulletin – AWB-1015**
- **Quick Update on AF CS RIF Project**
 - **Applying AWB-1015 Requirements**



USAF Investment in Cold Spray



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Ellsworth AFB

- Investment to Date: \$775K
- Operational: June 2017





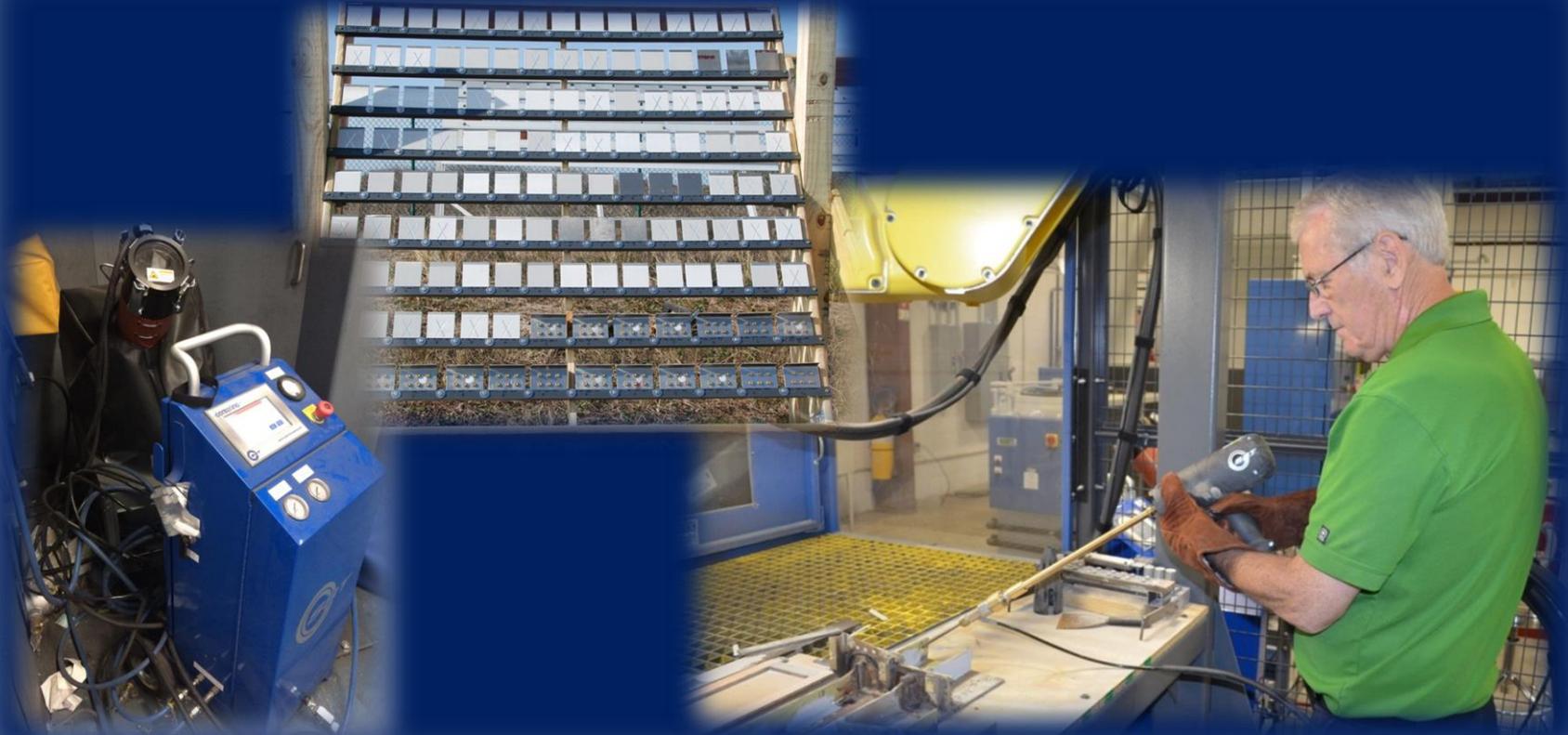
USAF Investment in Cold Spray



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Warner Robins AFB

- Investment to date: \$270K
- Operational: February 2017





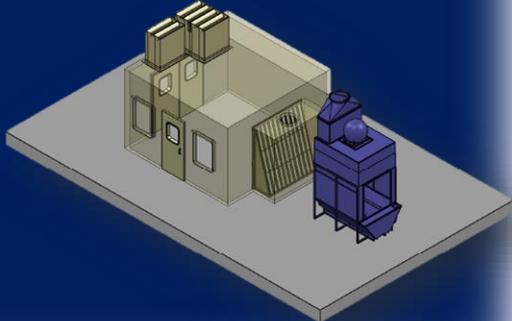
USAF Investment in Cold Spray



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AFLCMC Cold Spray Innovation Center (Dayton, OH)

- Investment to date: \$1.2M
- Operational: March 2017





Airworthiness Bulletin (AWB-1015)



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- **AWB-1015: “Airworthiness Process for Deploying New or Substitute Materials, Processes, and Product Forms”**
 - **Purpose**
 - **Ensure safety of material, process, and product form changes**
 - **Promote enterprise approach to qualifying new materials/processes/product forms across multiple weapon systems (WS)**
 - **Scope**
 - **Changes assessed by a WS Chief Engineer (CE) as having an impact to airworthiness of that weapon system**
 - **Organization**
 - **Coordinated by Air Force Life Cycle Management - Product Support Engineering Division (AFLCMC/EZP)**
 - **Engage SMEs in evaluation of proposed material/technology solutions**
 - **Change Evaluation Team (CET) approach**
 - **Membership: AFRL, AF SL's, WS engineers and industry (as req'd)**

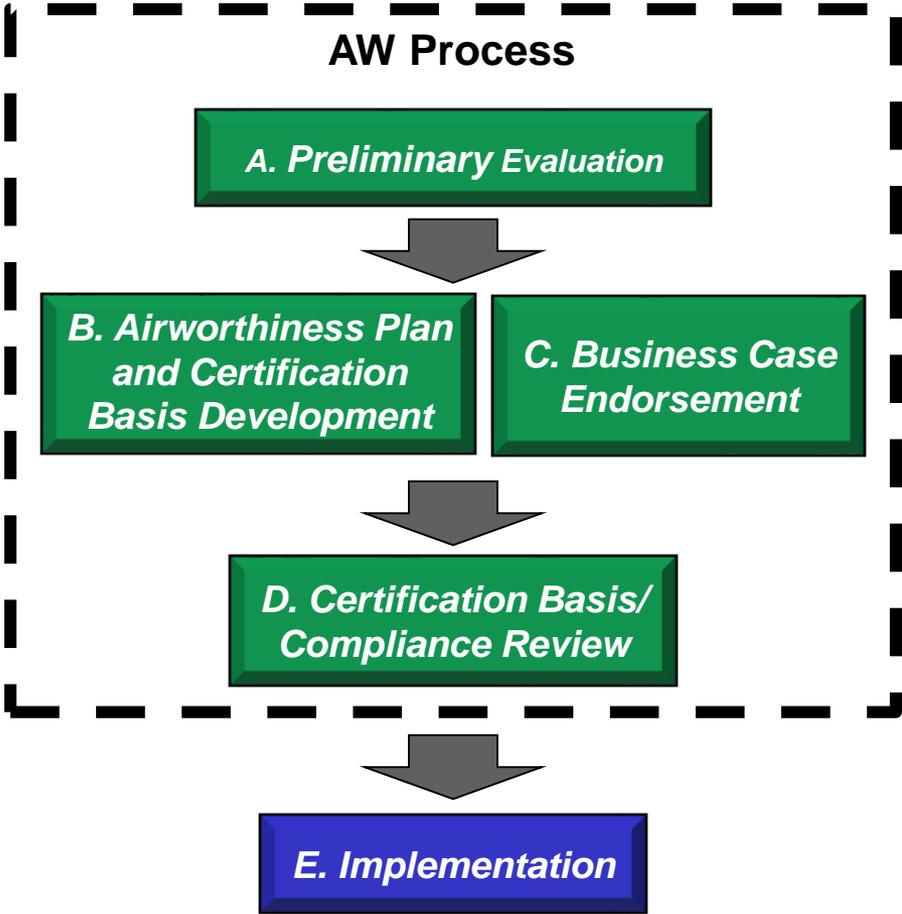


AWB-1015 Process



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- Applies to all new/substitute materials, processes and products on currently certified platforms
 - Reduces duplication
 - Ensures technology is mature and ready for implementation
 - Ensures airworthiness requirements are addressed
 - Faster implementation of technology across the enterprise
- Review artifacts, develop baseline requirements and initial qualification plan for safely deploying new/substitute materials, processes or product forms



Signed by USAF TAA on 15 Jul 15



Technology Maturity Evaluation



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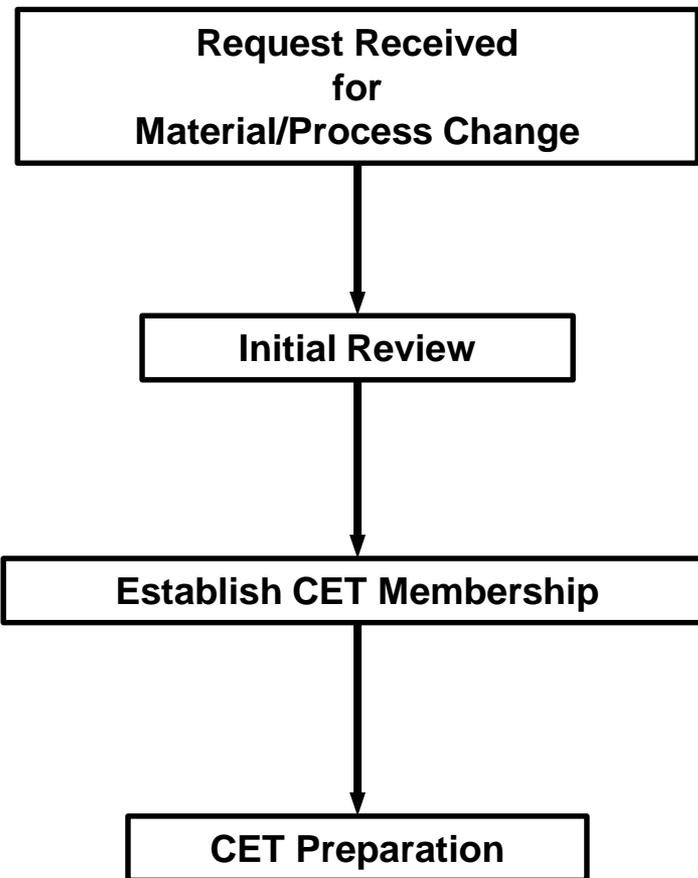
- “Five Factors” of maturity
 - Stability
 - Producibility
 - Characterized Mechanical & Physical Properties
 - Predictability of Performance
 - Supportability
- Structures Bulletin EZ-SB-13-001 as applicable

Technology maturity \neq Full qualification



Change Evaluation Team Process

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- Product Support Engineering (EZP) is clearing house
- EZP pre-screens submission for completeness
- EZP preliminary review with AFLCMC/SL and AFRL/RX
 - Determines single vs possible multi-platform applications
 - Identifies scope of CET participation
- EZP solicits SPO's for CET participants
- AFLCMC/SL and AFRL/RX appoint CET reps
- EZP establishes SharePoint data site
- Submitter populates data onto SharePoint
- Tech Lead prepares briefing for CET
- EZP schedules first CET meeting



CET Process / Cadence



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- **Hosted by EZP**
- **Briefing by Tech Lead**
 - Test data
- **CET preliminary screening**
 - Does it meet 5 primary factors?
 - Determines single or multi-platform applicability
 - Recommends to proceed or terminate
- **Identify and document gaps in test & validation**
- **Develops optimal qualification plan & enterprise business case**
- **Reviews qualification testing results**

- **CET Provides recommendation to MDS Chief Engineers**
- **EZP and affected MDS archive information**

- **WS(s) prepare and submit Compliance Reports**
- **WS proceeds through Airworthiness process for approval**

Initial CET Meeting



CET Tasks



CET Deliverables



Weapon System Implementation



Objective



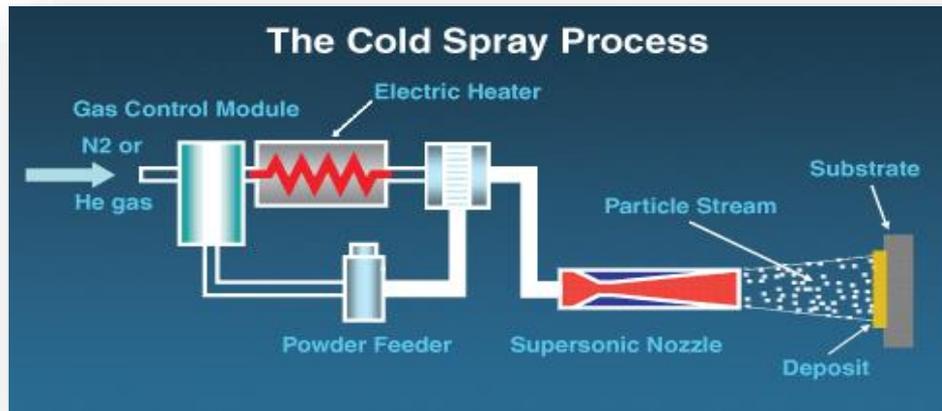
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Authorize cold spray repair on aircraft panels at Ellsworth AFB

- VRC Gen III System w/ Helium carrier gas
- Production parameters
- Approval using AWB-1015

5 primary factors of AWB-1015

- Stability
- Producibility
- Characterized Mechanical & Physical Properties
- Predictability of Performance
- Supportability





Panel Repair

Test Plan/Results



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#	Tests	Test Standard	System Pedigree	Production Parameters	Result	
MATERIAL TESTING	1	Ductility/Tensile Testing	ASTM E8/8M	Not required	Not required	NOT-REQ'D
	2	Bearing Load	ASTM E238			PASS (see test 16)
	3	Hardness	ASTM E384	Gen III, He	Y	PASS
	4	Bond Strength (Adhesion)	ASTM C 633	Gen III, He	Y	PASS
	5	Linear Indication	ASTM E3, MIL-STD-3021	Gen III, He	Y	FAIL
	6	Porosity, & Foreign Mater.	ASTM E2109	Gen III, He	Y	PASS
	6.1	Oxides	ASTM E2109	Gen III, He	Y	PASS
	7	Galvanic Corrosion	ASTM G71	Not required	Not required	NOT-REQ'D
FUNCTIONAL TESTING	8	Hardness	ASTM E384	Gen III, He	Y	PASS
	9	Bond Strength (Adhesion)	ASTM C 633	Gen III, He	Y	NOT-REQ'D
	10	Linear Indication	ASTM E3, MIL-STD-3021	Gen III, He	Y	MISSING
	11	Porosity & Foreign Materials	ASTM E2109	Gen III, He	Y	PASS
	12	Oxides	ASTM E2109	Gen III, He	Y	PASS
RELIABILITY TESTING	13	Wear Test	ASTM G 133	Gen III, He	Y	~2x FASTER WEAR
	14	Impact Test	Custom Charpy Test	Gen III, He	Y	PASS
	15	Salt Spray Corrosion	ASTM B117	Gen III, He	Y	PASS
	16	Bearing Load Test	Custom Bearing Load Test	Gen III, He	Y	PASS

Material testing coupons produced on non-production representative equipment & process parameters

- Machine configuration (Gen II vs. Gen III)
- Process parameters
- Carrier gas (Compressed air vs. He)

Functional testing complete; conflicting data on adhesion test results & on linear indications

Reliability testing complete; results under review

Panel Repair Test Plan/Results

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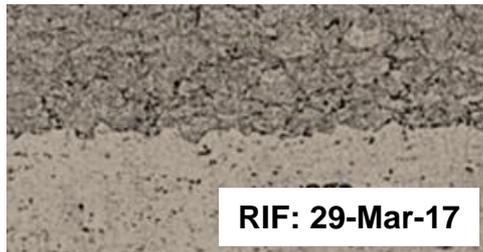
List of Condcuted Adhesion & Linear Indication Testing

Date	Test	# of Samples	Previously impact tested	Conducted by	Results
8-Mar-17	Linear Indication	5	Yes	AFRL	FAIL
15-Mar-17	Adhesion Testing	3	Yes	RIF	NO CRITERIA
29-Mar-17	Linear Indication	2	No	RIF	PASS
15-Apr-17	Linear Indication	2	No	AFRL	FAIL
16-May-17	Adhesion Testing	2	No	RIF	PASS

Samples sprayed with:
 - Gen III configuration
 - Helium carrier gas
 - VRC



AFRL: 8-Mar-18



RIF: 29-Mar-17



AFRL: 15-APR-17

- Impact tested
- Linear indication
- Adhesion (conducted by RIF): **Did not meet criteria**

- Not impacted tested
- No linear indication
- No adhesion testing

- Not impact tested
- Linear indication
- Adhesion (conducted by RIF): **Met criteria**

Conflicting test results from multiple test locations (RIF vs. AFRL)



Primary Gaps



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- 1. Material testing samples not from production representative equipment**
 - Needs: VRC Gen III, Helium carrier gas, production parameters
 - Applies to AWB-1015 factor: Stability
- 2. Linear indications at bond line**
 - AFRL vs RIF reports disagree
 - Applies to AWB-1015 factor: *Characterized Mechanical & Physical Properties*
- 3. Reduced adhesive strength of impact tested parts**
 - Impact tested parts show reduced adhesion strength. Investigate additional or redefined acceptance criteria post impact test
 - Applies to AWB-1015 factor: Characterized Mechanical & Physical Properties
- 4. Process repeatability not proven**
 - Test samples were not produced using the production equipment at Ellsworth AFB
 - No data available to demonstrate that the process is repeatable machine to machine
 - Applies to AWB-1015 factor: Predictability of Performance



Way Forward



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1. Produce new set of test specimens using cold spray facility at Ellsworth AFB (VRC, Gen III, He)
2. Re-do mechanical property tests
3. Define appropriate sample preparation & evaluation methodology for microscopy/linear indication
4. Identify post-impact adhesion strength requirement
5. Re-do impact testing and linear indication analysis
6. Validate booth setup verification process (ensures properties observed during testing are achieved in production)



Way Forward



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Working to resolve issues to ensure a stable, repeatable process during successful implementation of automated Cold Spray...





AIR FORCE LCMC