



Fleet Readiness Center Southwest

Production Cold Spray Repairs for NAVAIR

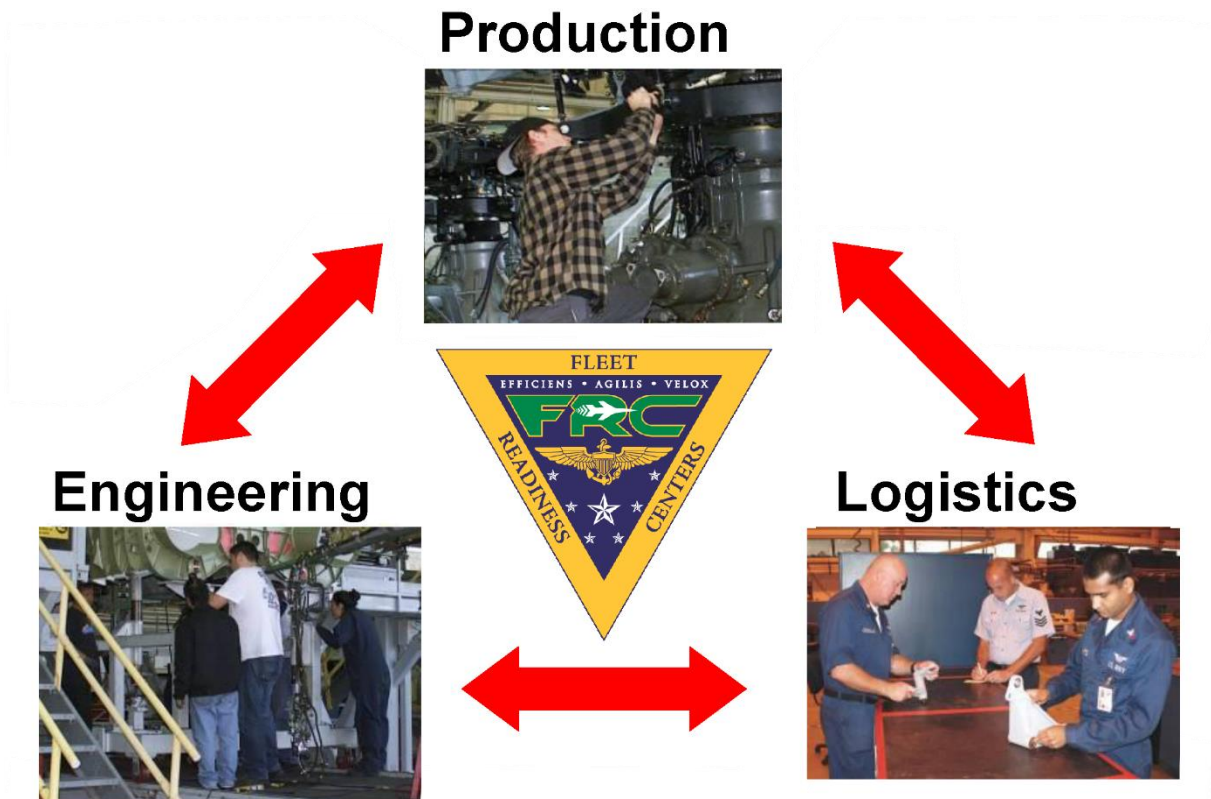
Presenter: Matthew Minnick, Materials Engineer, Code 43460

Cold Spray Action Team (CSAT) Event

Date: June 19, 2018



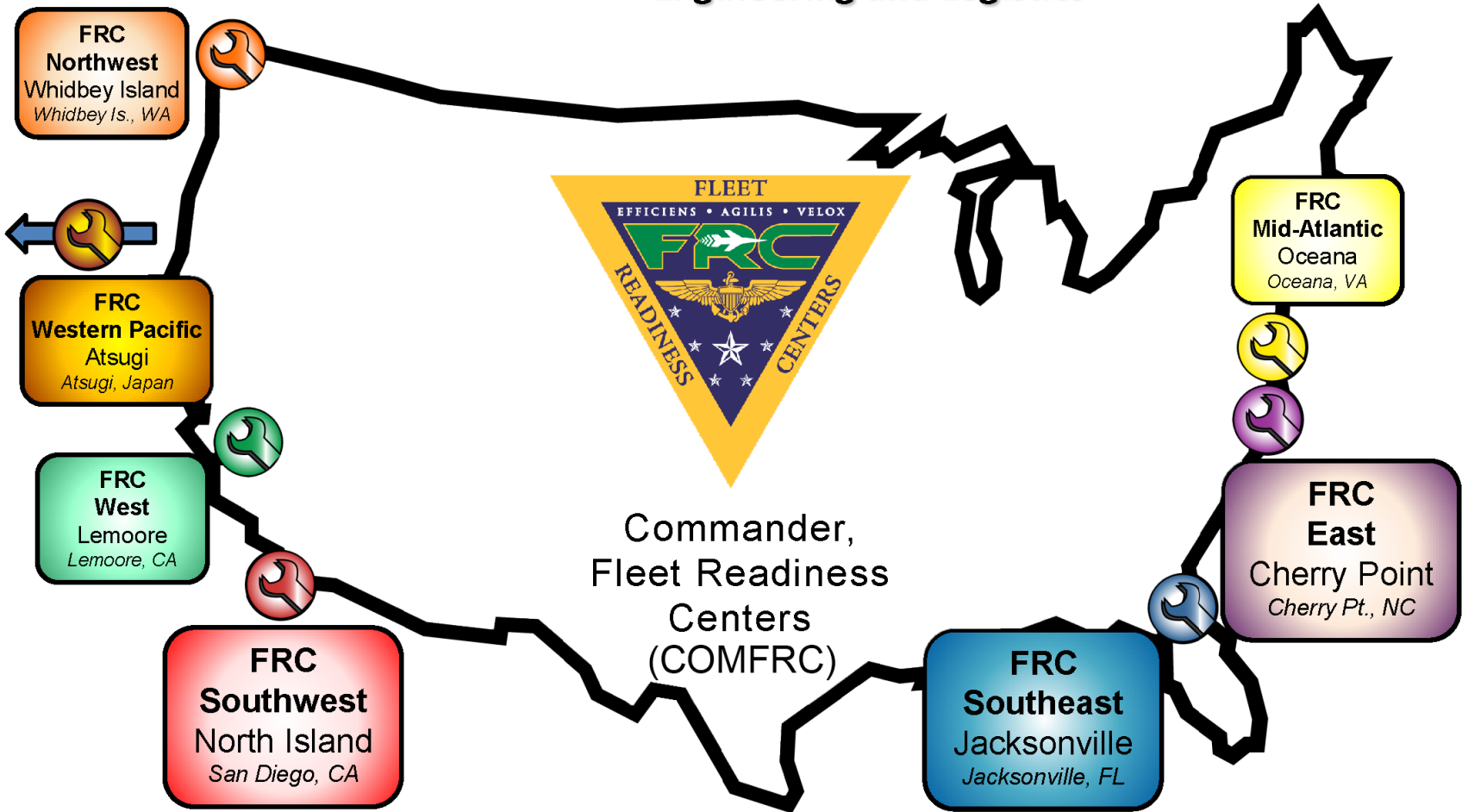
- Maintain, repair, and overhaul Naval aircraft and their components
- Commonly referred to as “depots”



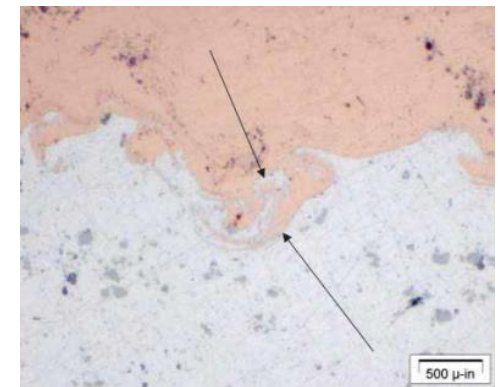
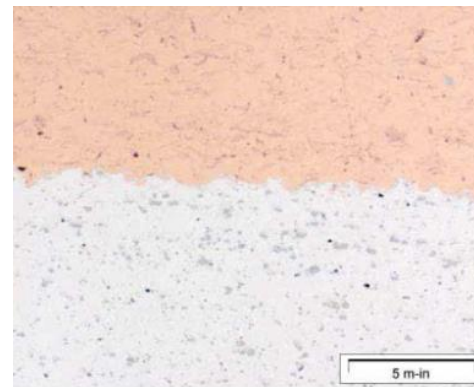
Where are the FRCs?



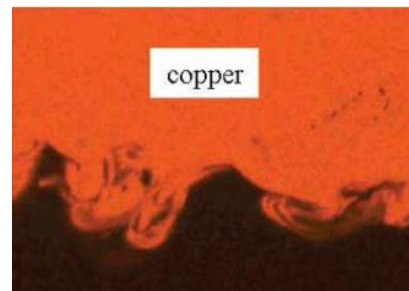
- Navy and Marine Corps aircraft and systems
- Components and Engines
- Manufacturing
- Engineering and Logistics



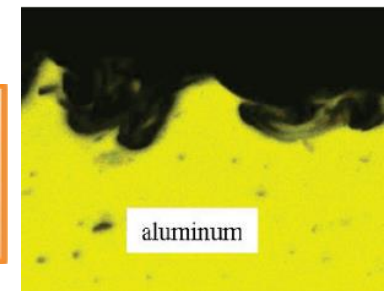
- Metal spray process
- Restores critical dimensions
- Impacts metal particles onto substrate
 - Metallurgical bond



Also known as Gas Dynamic Spraying, Kinetic Metallization (KM), Supersonic Particle Deposition (SPD), High Velocity Powder Deposition, and Kinetic Spraying



EDS X-ray Mapping showing mechanical mixing between coating material and substrate



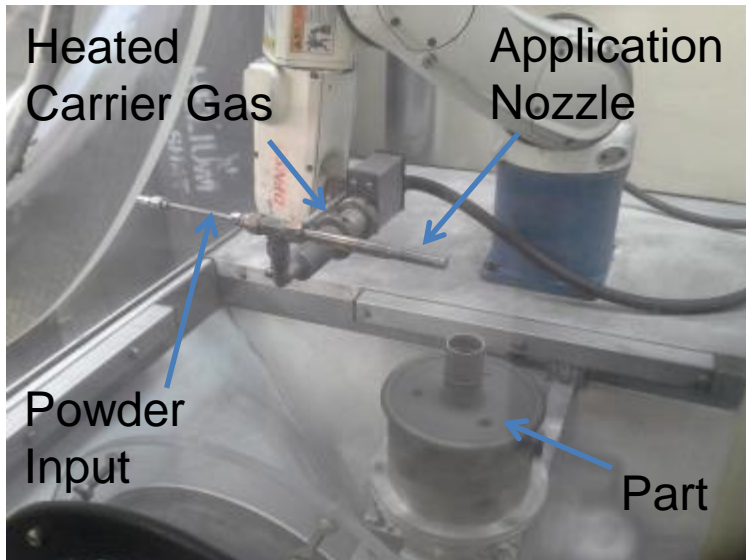
Courtesy Army Research Laboratory

How Does Cold Spray Work?

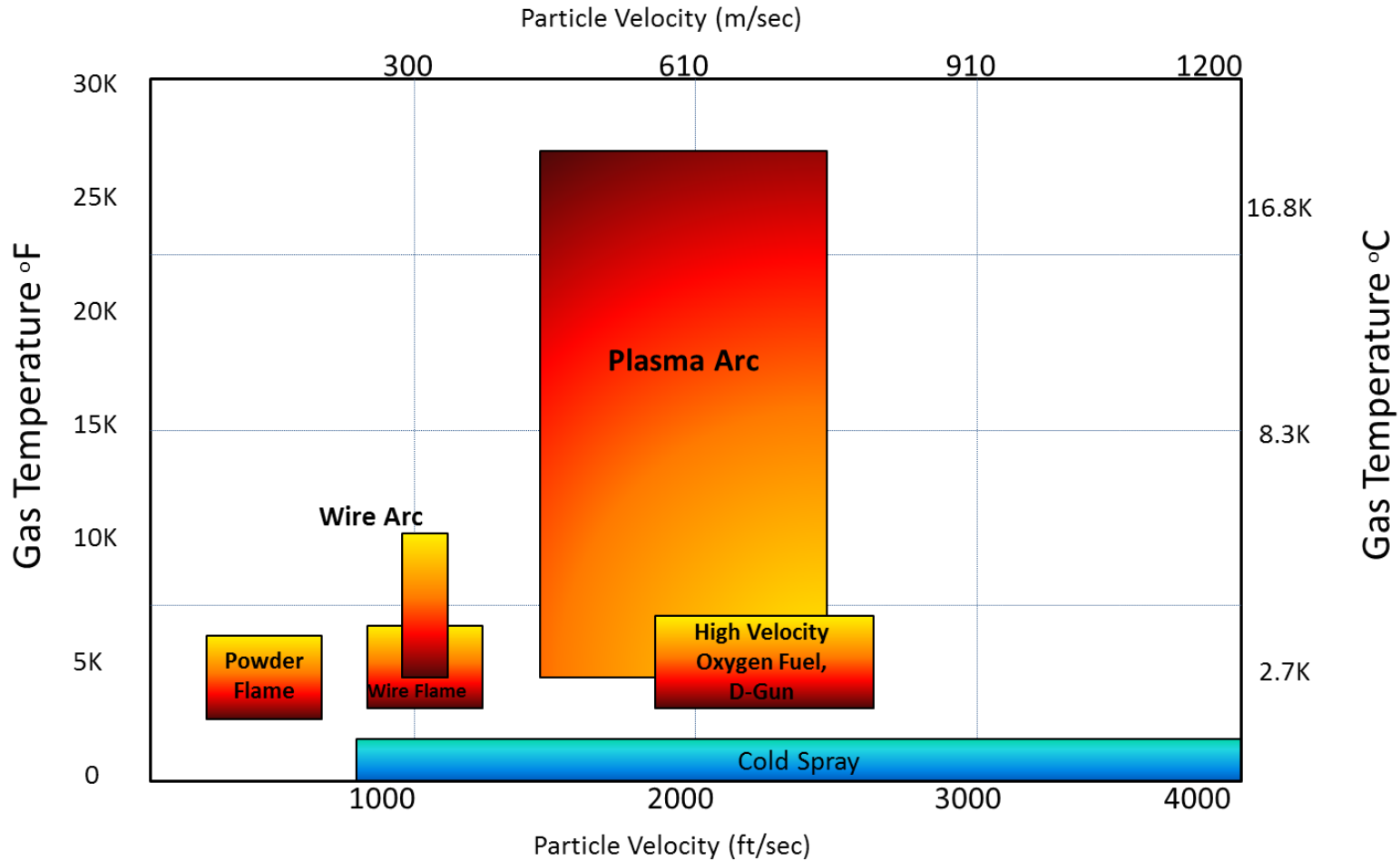
Prepared Surface

Built-up Material on Surface

Finished Surface



- **Heated carrier gas (Helium or Nitrogen)**
- **Powder injected at nozzle**
- **Emerges at sonic or supersonic speeds**
- **Kinetic energy stored in powder particles deforms and bonds them to surface**



- **Solid-state process (does not melt particles)**
 - **Low-porosity, high-quality coating**



Criteria for Candidate Repair Parts



- Approved repairs restore dimensions, not strength
- Damage (e.g., corrosion, wear, abrasion) of subject parts lends itself well to repair using the cold spray process
- Replacement part is **expensive** and/or **low in supply**
- Limited spares and **long lead-time** causing bottlenecks in the supply system
- Existing repairs have a **long turn-around-time (TAT)**



Repair Approval Approach



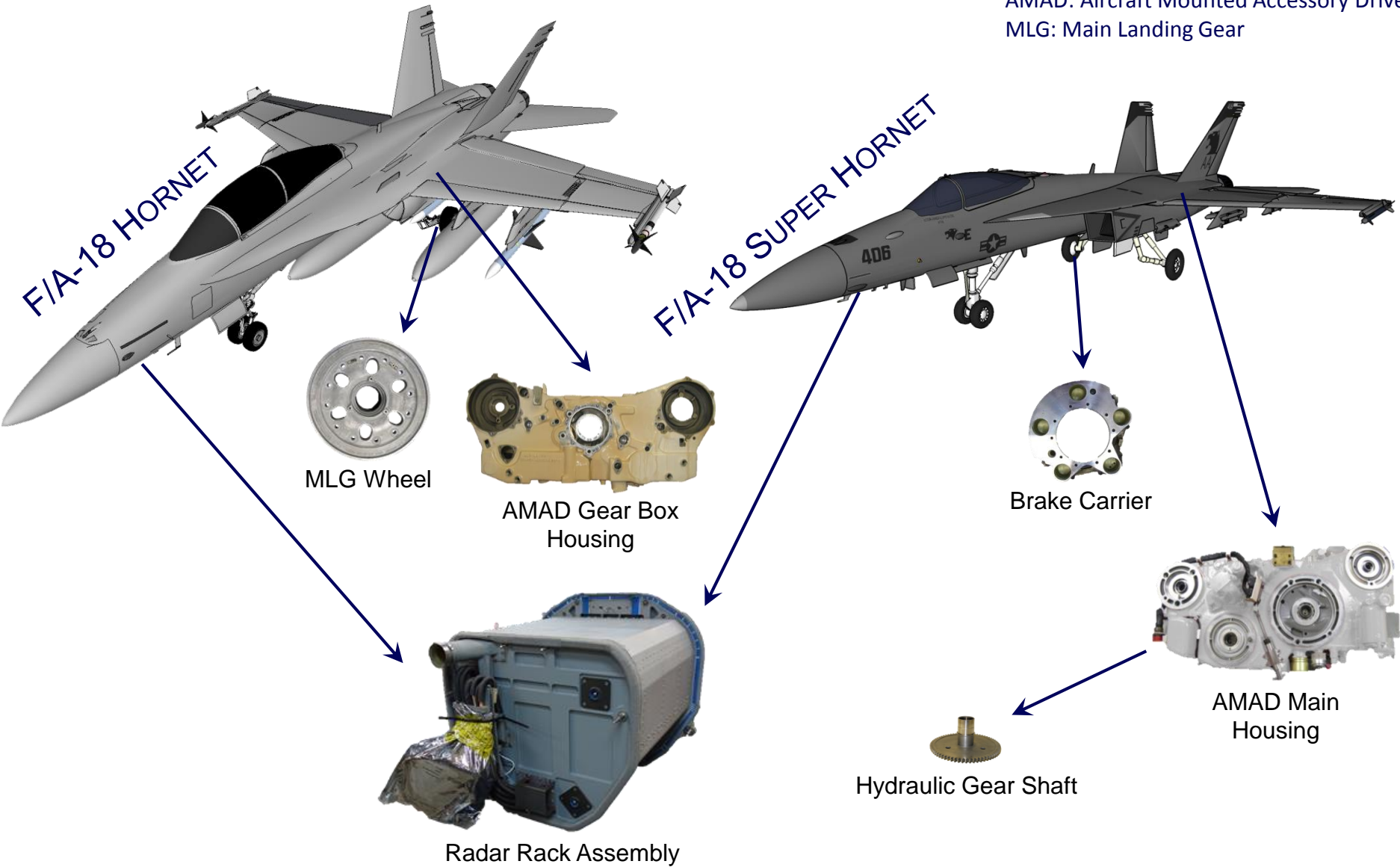
- **Blanket repair approval for already authorized parts**
 - Not for specific quantity or per each unit
 - Local engineering documents provide repair guidance
- **No special requirements for using repaired parts**
 - Maintainers unaware if part repaired with cold spray
- **Quality Control/Assurance inherent in cold spray process**
 - Spray parameters are programmed into the cold spray unit
 - Poor quality manifest during application or finish machining
 - Some parts require acceptance testing



FRC SW has seven approved
F/A-18 cold spray repairs

FRCSW Production Repaired Parts

AMAD: Aircraft Mounted Accessory Drive
MLG: Main Landing Gear





NAVAIR Production Repair Parts



AMAD: Aircraft Mounted
Accessory Drive
PTS: Powered Take-off Shaft

Site	Nomenclature	Quantity Recovered as of January 10, 2018
FRCSW	F/A-18E/F/G AMAD Main Housing (Hydraulic Pad)	14
FRCSW	F/A-18E/F/G AMAD Hydraulic Gear Shaft	47
FRCSW	F/A-18E/F Brake Carrier	83
FRCSW	F/A-18A/B/C/D AMAD Gearbox Housing (PTS Axis)	12
FRCSW	F/A-18A/B/C/D/E/F APG-73 Radar Rack Assembly	21
FRCSW	F/A-18A/B/C/D Outboard Wheel Bolt Spot Face	0
FRCSW	F/A-18E/F/G AMAD Main Housing (Internal Gear Damage)	6
FRCE	H-1 Combining Gear Box	12
Total:		195



NAVAIR Production Repair Parts



AMAD: Aircraft Mounted
Accessory Drive
PTS: Powered Take-off Shaft

Site	Nomenclature	Quantity Recovered as of January 10, 2018
FRCSW	F/A-18E/F/G AMAD Main Housing (Hydraulic Pad)	14
FRCSW	F/A-18E/F/G AMAD Hydraulic Gear Shaft	47
FRCSW	F/A-18E/F Brake Carrier	85
FRCSW	F/A-18A/B/C/D AMAD Gear Box Housing (PTS Axis)	12
FRCSW	F/A-18A/B/C/D/F-35 APG-73 Radar Rack Assembly	21
FRCSW	F/A-18A/B/C/D Outboard Wheel Bolt Spot Face	0
FRCSW	F/A-18E/F/G AMAD Main Housing (Internal Gear Damage)	6
FRCE	H-1 Combining Gear Box	12

\$17.3 million

in costs avoided*

Total: 195

* Prices used in calculations were from IHS Haystack® Gold. They do not include the cost of contracting to buy a new item.



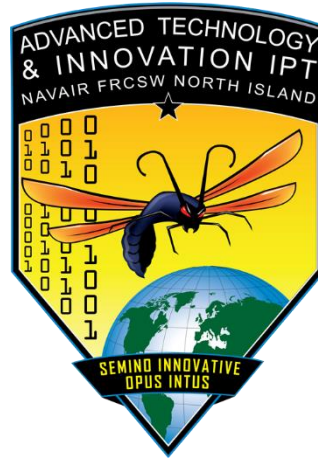
Total Return on Investment for Approved Repairs



$$\begin{array}{rcc} \$17.3 \text{ Million} & - & \$4 \text{ Million}^* & = & \mathbf{\$13.3 \text{ Million}} \\ \text{Costs Avoided} & & \text{Technology Investment} & & \end{array}$$

* Estimated S&T funding from 219, NPRE, SBIR, and AERMIP from 2006-2016. Cost is for investment on parts approved for repair discussed in this brief, and does not include repairs in development. Cost also includes purchase of systems.

Thanks to Our Funding Sponsors



AMAD: Aircraft Mounted Accessory Drive

Platform: F/A-18E/F and EA-18G

Repair: Fretting damage to sealing surface

Repair Type: Dimensional restoration

Previous Repair: None

Repair Authorized: FRCSW North Island

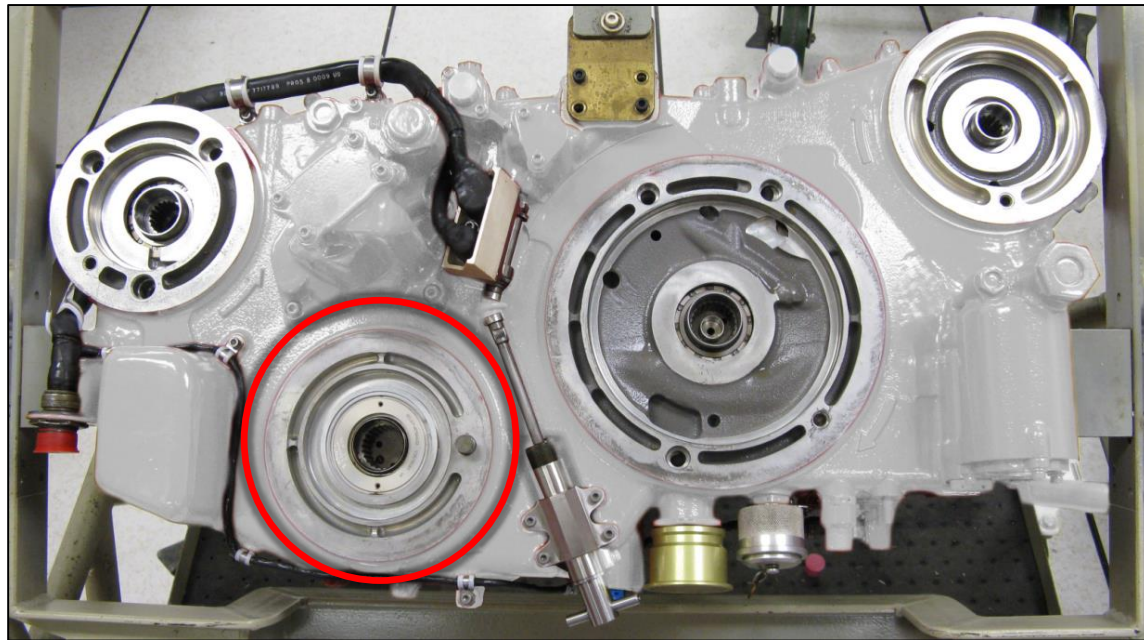
System: Inovati KM-PCS

Powder: 7075 Aluminum with Nickel

Part Material: Aluminum A357 casting



Fretting Damage



After Repair



AMAD Housing Hydraulic Pad Repair



AMAD: Aircraft Mounted Accessory Drive

Repaired AMAD Hydraulic Pads repaired and returned to service

AMAD Repaired	Date Sold by AMAD Shop	Material Sprayed	Date Installed	Hours on Hydraulic Pad as of March 1, 2018
1	1/13/2011	6061	5/1/2011	2,579
2	7/9/2011	6061	4/12/2013	1,187
3	8/16/2011	4047	8/30/2011	1,177
4	7/22/2011	4047	9/5/2011	1,748
5	11/28/2011	7075 w/ Ni	1/1/2012	311
6	10/16/2012	7075 w/ Ni	11/5/2012	1,040
7	10/18/2012	7075 w/ Ni	12/18/2013	317
8	6/26/2014	7075 w/ Ni	3/18/2015	919
9	8/29/2016	7075 w/ Ni	12/10/2016	546
10	5/31/2017	4047	10/26/2017	141
11	8/5/2017	7075 w/ Ni		
12	12/7/2017	7075 w/ Ni		
13		7075 w/ Ni		
14		7075 w/ Ni		
			Total	9,965



AMAD Housing Hydraulic Pad Repair



AMAD: Aircraft Mounted Accessory Drive

Repaired AMAD Hydraulic Pads repaired and returned to service

AMAD Repaired	Date Sold by AMAD Shop	Material Sprayed	Date Installed	Hours on Hydraulic Pad as of March 1, 2018
1	1/13/2011	6061	5/1/2011	2,579
2	7/9/2011	6061	4/12/2013	1,187
3	8/16/2011	4047	8/30/2011	1,177
4	7/22/2011	4047	9/5/2011	1,748
5	11/28/2011	7075 w/ Ni	1/1/2012	311
6	10/16/2012	7075 w/ Ni	11/5/2012	1,040
7	10/18/2012	7075 w/ Ni	12/18/2013	317
8	6/26/2014	7075 w/ Ni	3/18/2015	919
9	8/29/2016	7075 w/ Ni	12/10/2016	546
10	5/31/2017	4047	10/26/2017	141
11	8/5/2017	7075 w/ Ni		
12	12/7/2017	7075 w/ Ni		
13		7075 w/ Ni		
14		7075 w/ Ni		
			Total	9,965

←
Performed post-service inspection

AMAD: Aircraft Mounted Accessory Drive

Repaired AMAD Hydraulic Pads repaired and returned to service

AMAD Repaired	Date Sold by AMAD Shop	Material Sprayed	Date Installed	Hours on Hydraulic Pad as of September 1, 2017
4	7/22/2011	4047	9/5/2011	1,748

May 2011



Cold Spray Repaired

November 2016



Inspection at 1,748 Flight Hours

Platform: F/A-18E/F and EA-18G

Repair: Wear damage to sealing surface

Repair Type: Dimensional restoration

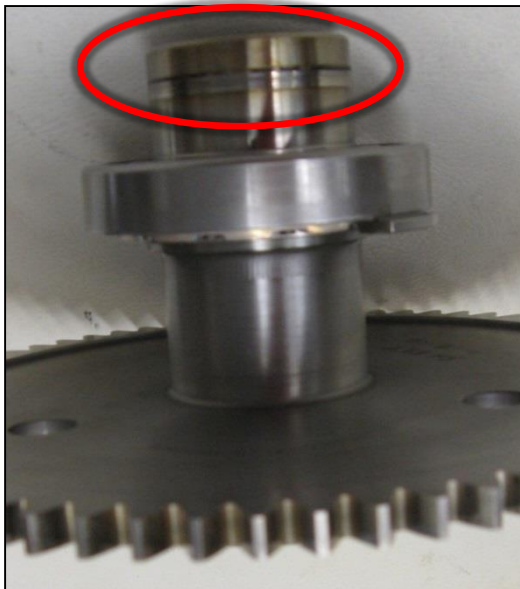
Previous Repair: None

Repair Authorized: FRCSW North Island

System: Inovati KM-PCS

Powder: Tungsten Carbide Cobalt

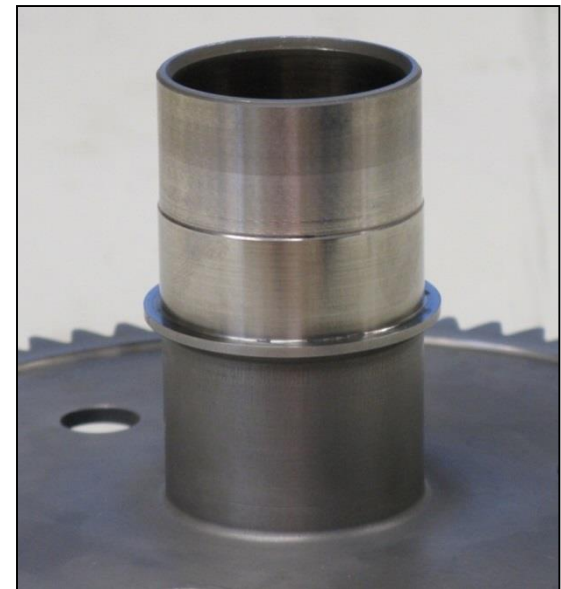
Part Material: AMS 6265 steel



Damaged Seal Surface



After Cold Spray



Restored Seal Surface

Platform: F/A-18E/F and EA-18G

Repair: Corrosion damage

Repair Type: Dimensional restoration

Previous Repair: Plasma spray

Repair Authorized: FRCSW North Island

System: Inovati KM-PCS

Powder: Aluminum with Chrome

Part Material: Aluminum 2014-T61



Corrosion Damage



After Repair

AMAD: Aircraft Mounted Accessory Drive
PTS: Powered Take-off Shaft

Platform: F/A-18A/B/C/D

Repair: Fretting damage

Repair Type: Dimensional restoration

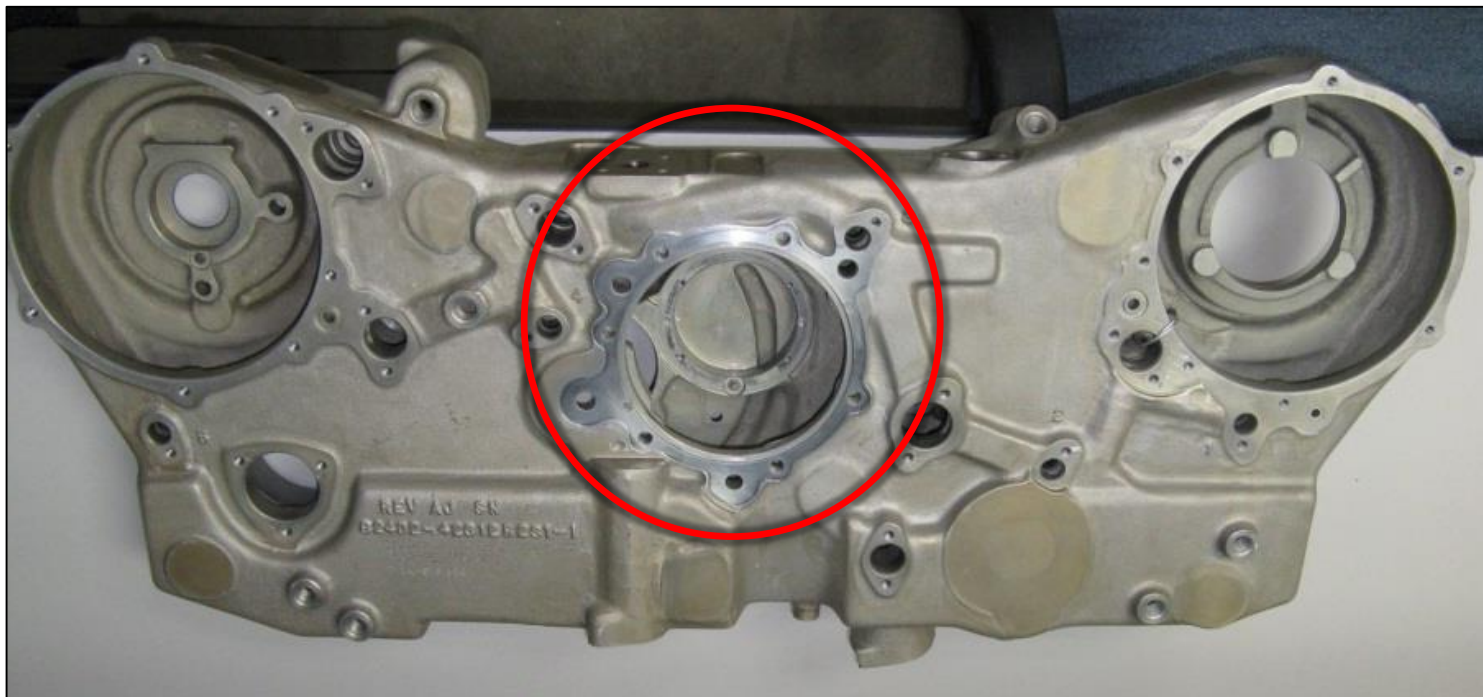
Previous Repair: Plasma spray

Repair Authorized: FRCSW North Island

System: Inovati KM-PCS

Powder: 7075 Aluminum with Nickel

Part Material: Aluminum A356 casting



After Repair

Platform: F/A-18A/B/C/D/E/F

Repair: Corrosion damage

Repair Type: Dimensional restoration

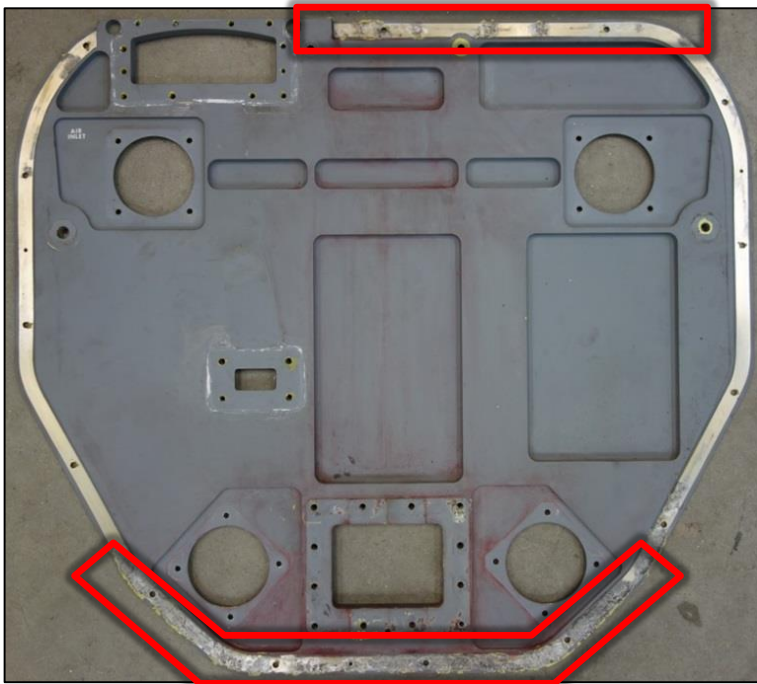
Previous Repair: None

Repair Authorized: FRCSW North Island

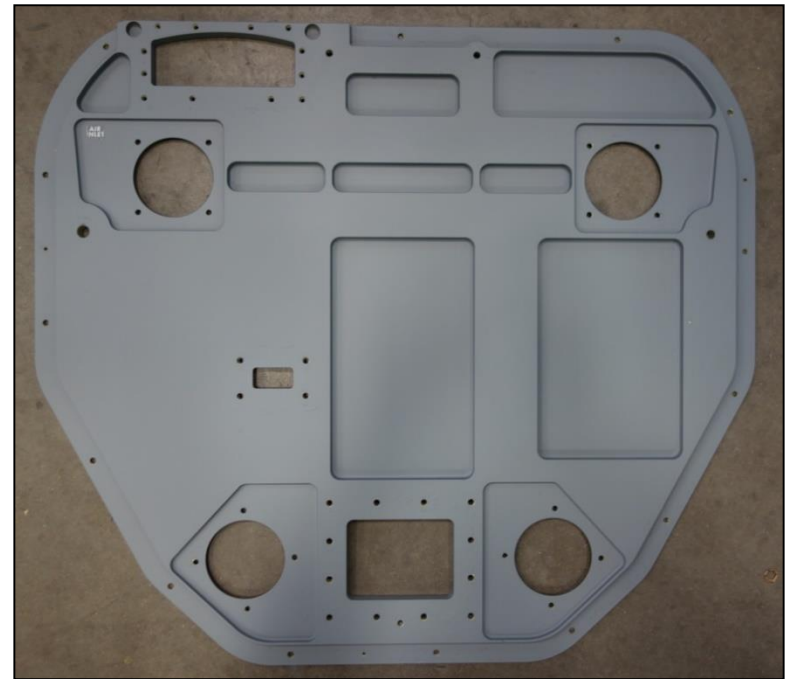
System: Inovati KM-PCS

Powder: Aluminum with Chrome

Part Material: Aluminum 7075-T7351



Corrosion Damage



After Repair

Platform: F/A-18A/B/C/D

Repair: Mechanical/corrosion damage

Repair Type: Dimensional restoration

Previous Repair: Machine away corrosion

Repair Authorized: FRCSW North Island

System: Inovati KM-PCS

Powder: Aluminum with Chrome

Part Material: Aluminum 2014



Before Repair

AMAD: Aircraft Mounted Accessory Drive

Platform: F/A-18E/F and EA-18G

Repair: Mechanical damage

Repair Type: Dimensional restoration

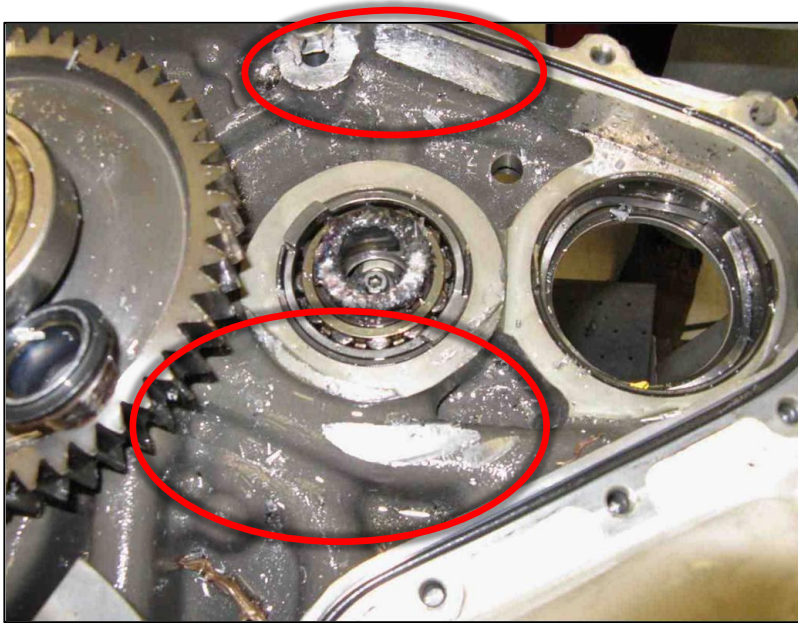
Previous Repair: None

Repair Authorized: FRCSW North Island

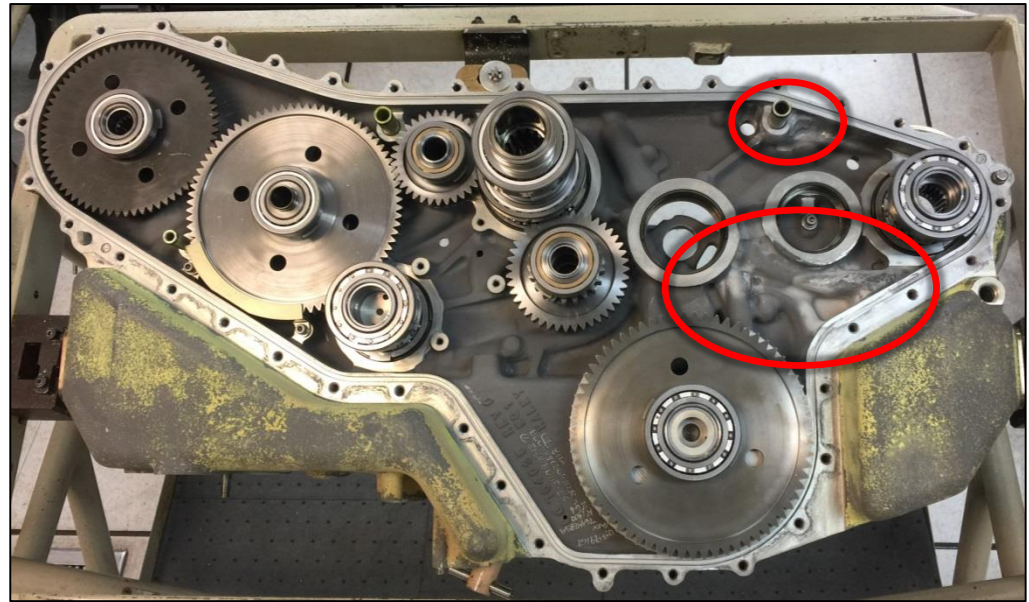
System: Inovati KM-PCS

Powder: Aluminum with Chrome

Part Material: Aluminum A357 casting



Mechanical Damage



After Repair



What's Next?



Where We're Going



- **Pursuing class-based approval for non-structural repairs**
 - **Classes such as shafts, sealing surfaces, and surfaces mounted in compression**
 - **Current approval is on part-by-part basis**
 - **Cold spray as a regular repair process like plasma spray or chrome plating**
- **Investigating restoring dimensions to structures within approved blend limits**
 - **Dimensions lost to corrosion and mechanical damage**
 - **Not claim strength credit for dimensions restored**
- **Field-deployable artisans and on-aircraft repair**