# Atmospheric Plasma Depainting

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**Atmospheric Plasma Solutions, Inc.**

# Report Documentation Page

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# Outline

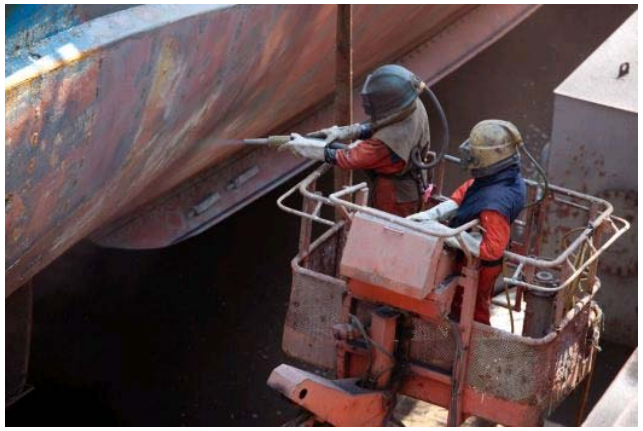
- Problem Statement
- Define Plasma
- Define Atmospheric Plasma
- Describe Atmospheric Plasma Coating Removal (APCR)
- Benefits of APCR
- Introduce the PlasmaFlux™ APCR system
- Aerospace Depainting Efforts
- Navy Ship Depainting Efforts

# Problem Statement

- Annual cost of corrosion for DoD ~ $22 Billion
- Virtually every weapon system across all segments of DoD require periodic maintenance of coating systems

**Plastic Media Blasting**

**High Pressure Water Jet**



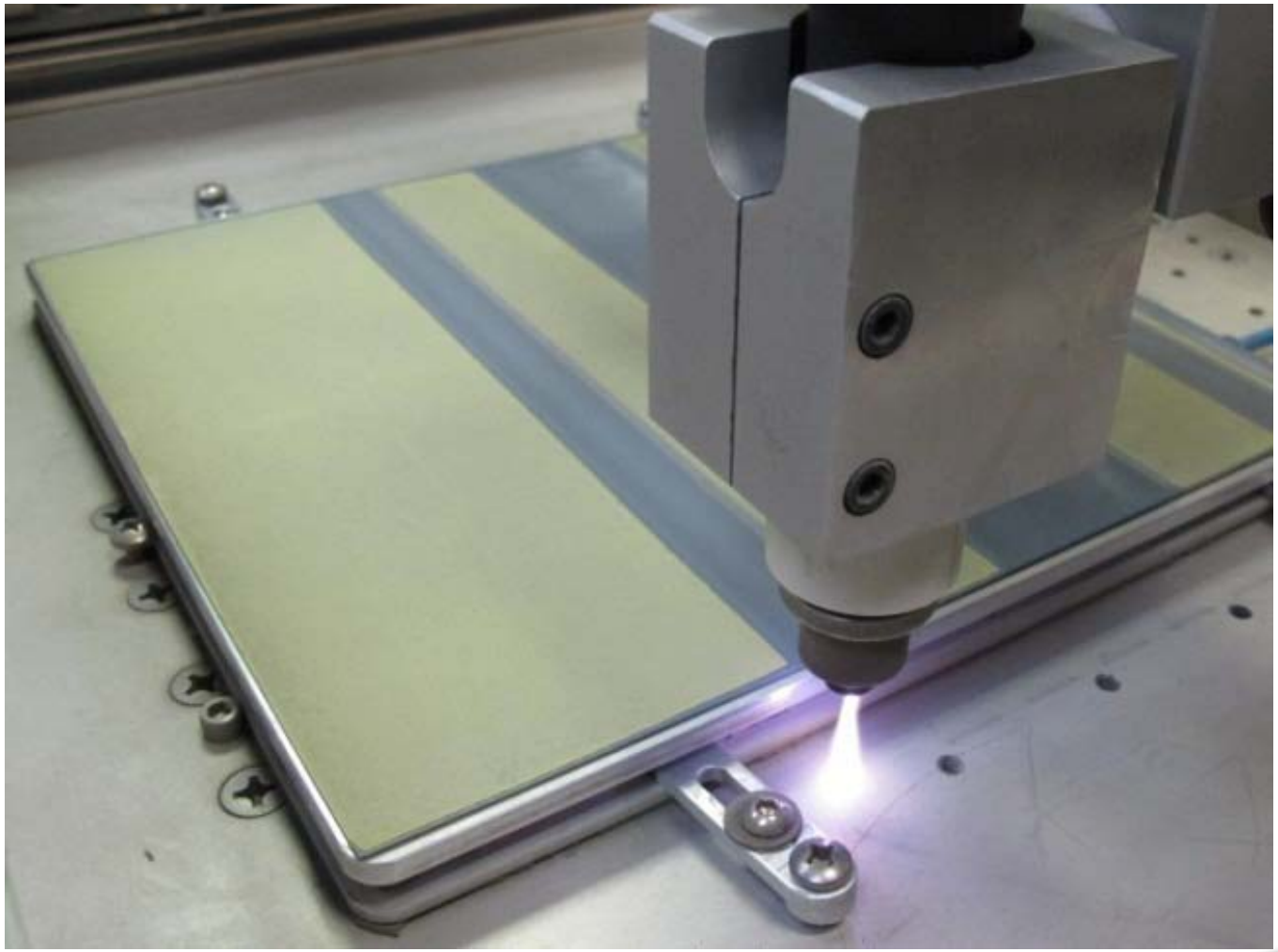
**Grit blasting**

# Problem Statement

- Conventional paint and coating removal techniques are based on a variety of mechanical or wet chemical techniques.
  - Media based (sand/grit, dry Ice, and plastic media blasting)
  - High pressure water
  - Liquid Solvent Chemical stripping

- Disadvantages
  - Labor intensive
  - High materials cost (procurement, storage, transport, disposal)
  - High environmental cost (solid / liquid waste disposal)
  - Potentially damaging to some substrate materials (composites)

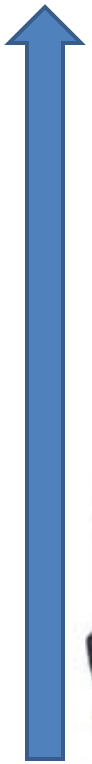
# Solution:  Atmospheric Plasma Coating Removal



# What is Plasma?

# Plasma: Fourth State of Matter

**Increasing Energy**



**Solid**

**Liquid**

**Gas**

**Plasma**

**State of Matter**

# What is Atmospheric Plasma?

# What is Atmospheric Plasma?

- **Plasma occurring at Atmospheric Pressure**
- **Plasma with Atmospheric Composition (Compressed air is only gas required)**

# Atmospheric Plasma Coating Removal (APCR)

Atmospheric Plasma

+

Paint / Sealant

=


Carbon Dioxide

Water Vapor

- APCR requires no media
- Atmospheric plasma produces highly reactive gas
  - Cold plasma ⇨ high chemical energy, low thermal energy
  - Vaporizes organic portion of coatings to $CO_2$ and $H_2O$
  - No damage to temperature sensitive substrates

# Features and Benefits of APCR Technology

| Feature | Benefit |
|---|---|
| No Media Required | Cost - Reduced procurement, storage, and disposal costs |
| | Safety - Reduced exposure to hazardous materials |
| | Environmental – Reduced environmental impact |
| Atmospheric Pressure Operation | Non-damaging removal, preserves surface profile |
| | Selective layer-by-layer removal |
| | Consumables: Compressed Air and Electricity |
| | Safety – No special safety equipment or procedures |
| | Cost – Eliminates need for “hot work” zones, faster maintenance cycle |
| Compact size, low weight | Controlled manually or by robotics |
| | Reaches areas that are inaccessible to other technologies |

# PlasmaFlux™ APCR Technology

## Power Supply


## Plasma Source

- The power supply produces a high frequency electric field to generate cold plasma
- Depot compatibility: Requires only compressed air and electrical power

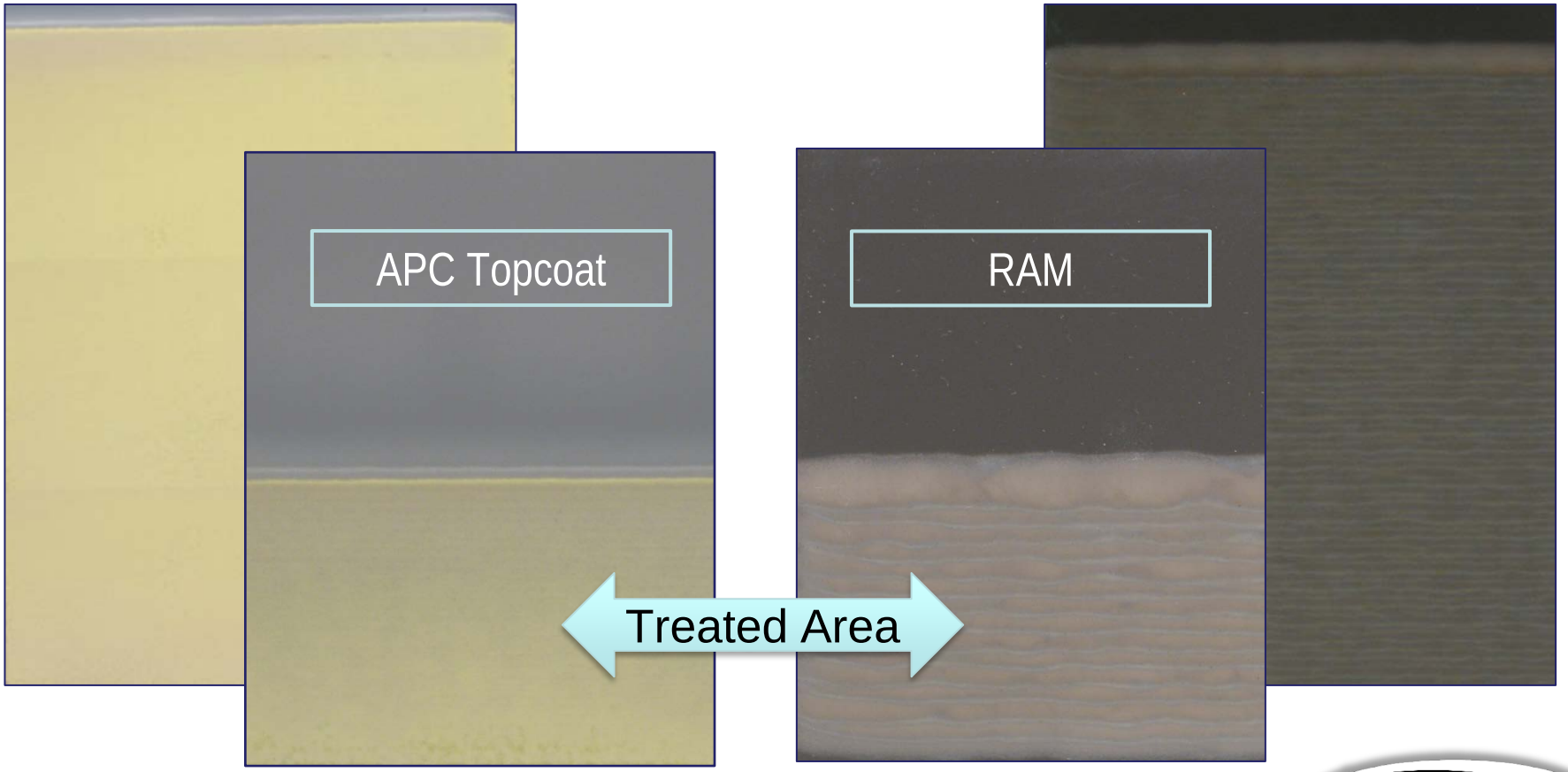
# Aerospace Depainting Efforts

- APC (Advanced Performance Coating), RAM (Radar Absorbing Material), and Sealant removal
- Aluminum, Titanium, Composite substrates
- Accessing confined spaces where other technologies struggle

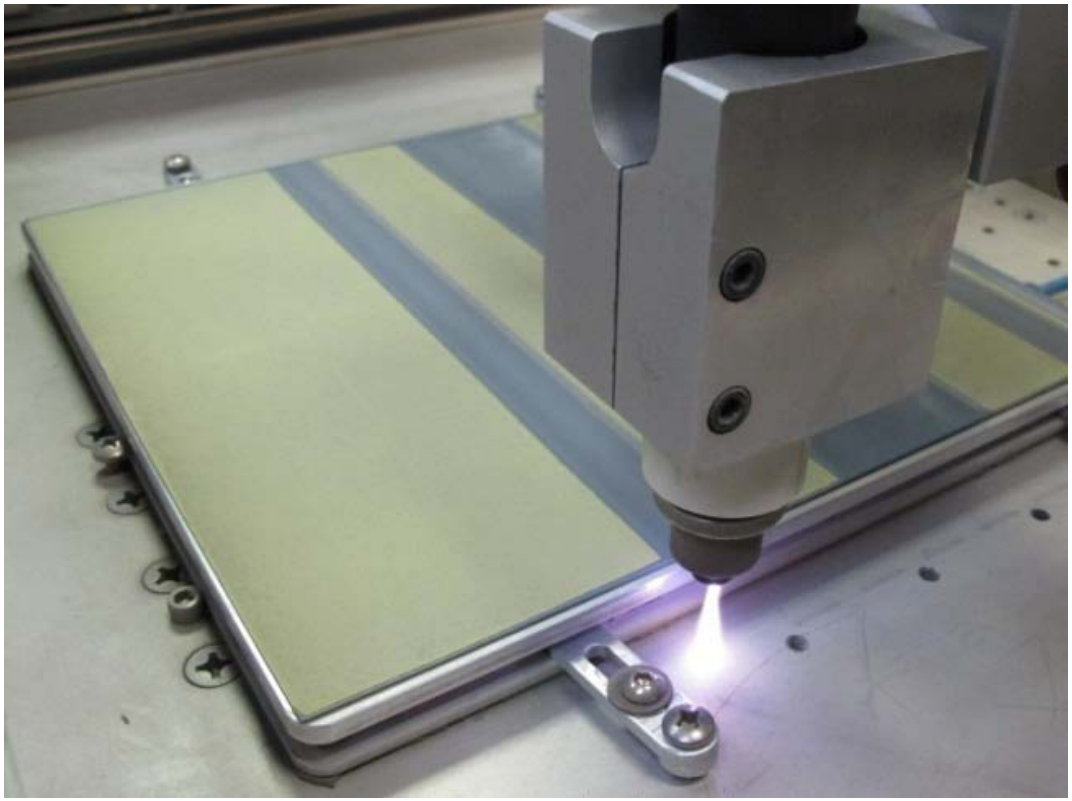
# Aerospace Depainting Efforts

APC on Aluminum
Removal to Primer

RAM on Carbon Fiber
Partial Topcoat Removal



# Aerospace Depainting Efforts



- Selective layer-by-layer removal has been demonstrated on contoured substrates using 3-axis automated systems

# Hand Held Removal of Polysulfide Sealant

**AC-240-B2 Sealant (2-5 mm thick) applied to lap joint with protruding rivets**

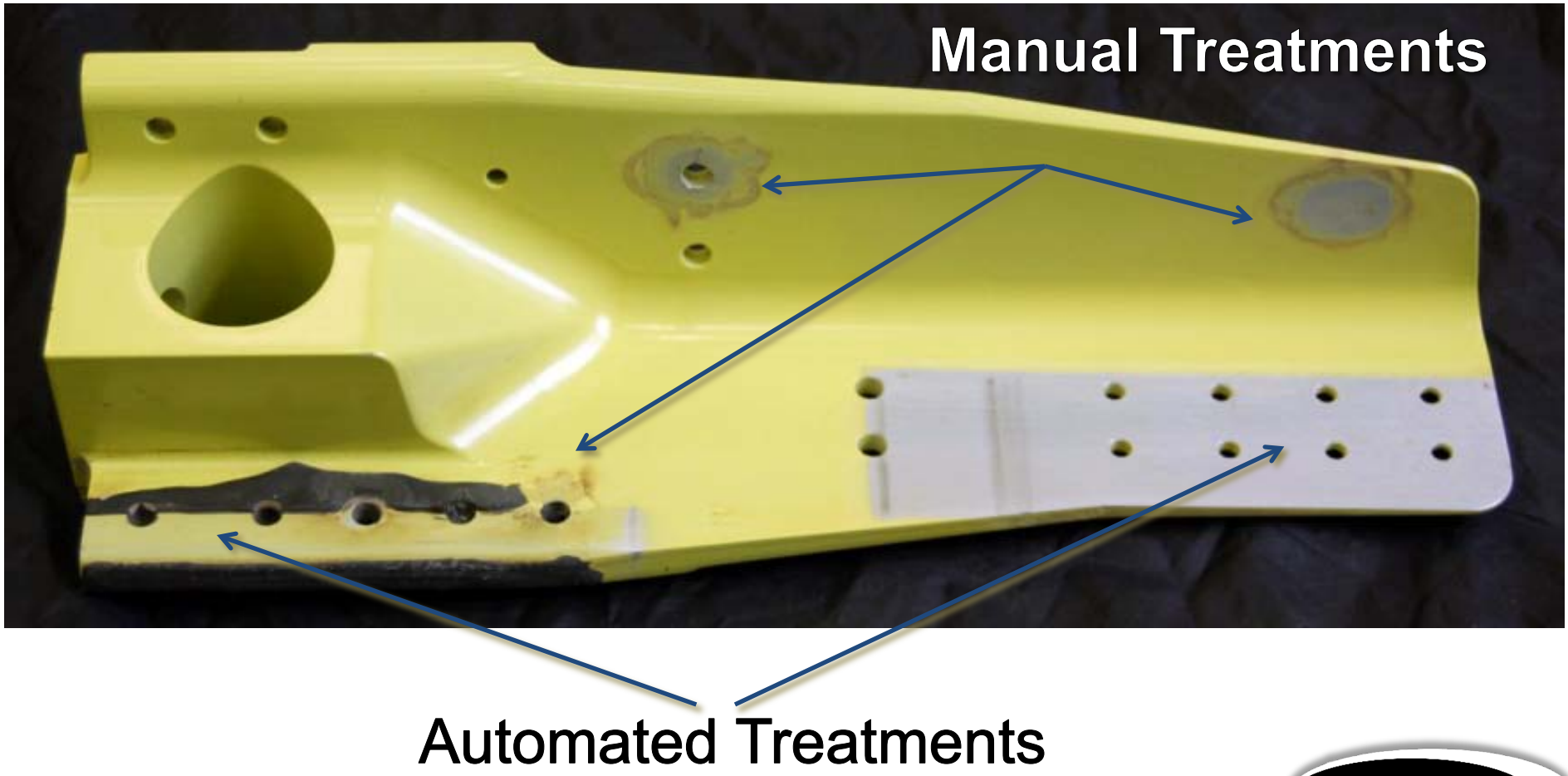
**~15 second handheld removal around rivet leaving bare metal and powdery residue**

# Primer Removal, Sealant Removal

## C-130 Aluminum Wing Corner Fitting

# Primer Removal, Sealant Removal

## C-130 Aluminum Wing Corner Fitting



# Aerospace Coating Removal Transition Programs

- AFRL (WPAFB)
  - Evaluation of high power atmospheric plasma process for aircraft coating removal
  - Evaluation of handheld APCR for Sealant removal
- NAVAIR (Cherry Point)
  - Evaluate AP for weld surface prep on Nickel Superalloys
- Ongoing projects with prime contractors
  - Evaluating APCR for surface treatment of aircraft fasteners and sealant removal
  - Evaluating removal of specialty LO coatings on composite substrates

# Naval Depainting Development Programs

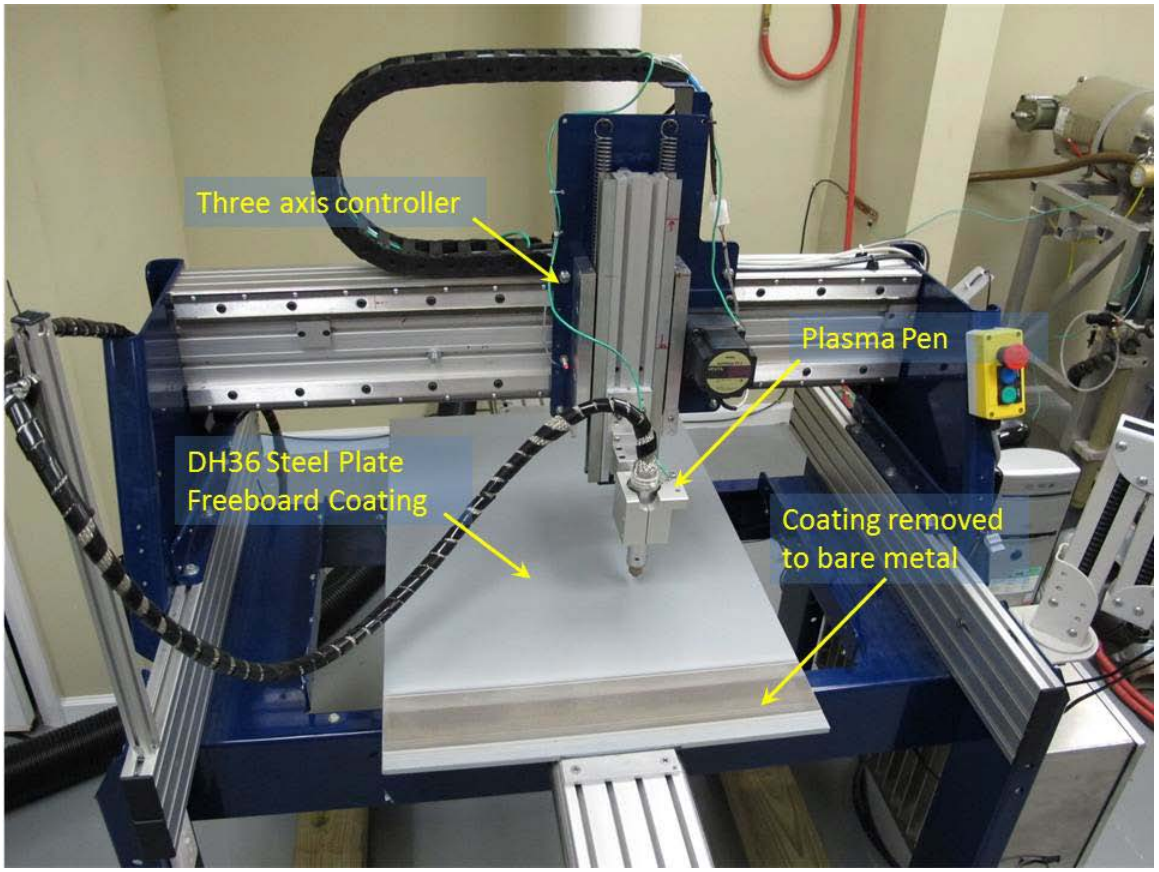
- Navy Phase I & II SBIR (N00014-10-C-0266)
  - Projects focused on engineering development challenges
    - Modular 20kW, Stackable Power supplies
    - Improved single and multi-pen designs
    - Ruggedization for Dry-dock environment
    - Operation using Dry-dock 480V 3-phase power

# Naval Depainting Development Programs

- SERDP WP-1762 (NCSU Lead, APS Co-performer)
  - Recoating performance of APCR depainted surfaces
  - Multi-pen removal process development using SBIR designed plasma system
  - Removal rate enhancement on Naval ship coatings
  - Plasma plume-surface interaction
  - Environment, Safety and Occupational Health characterization of the plasma depaint process

# Naval Coatings Removal

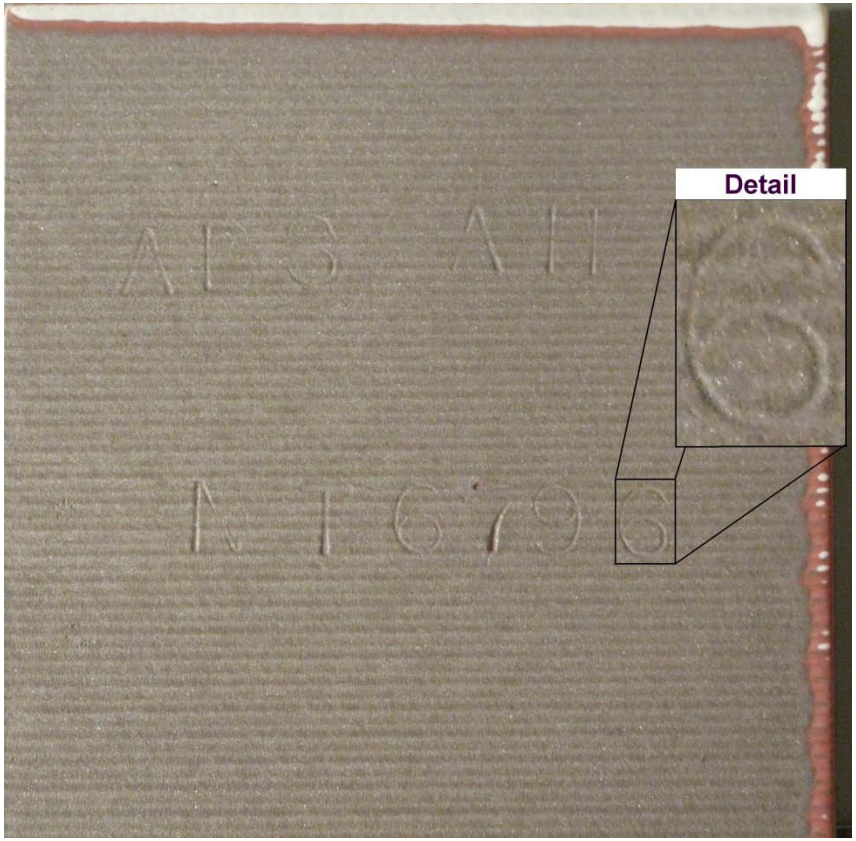
- Plasma pen integrates with COTS automated system for coating removal tests
- Sample coupons
  - 24” x 36”  3/8”  DH36 steel
  - (± 2.5 mil roughness)
- Coating stacks
  - Freeboard
  - Anti-Fouling
  - 20 mils thick (nominal)



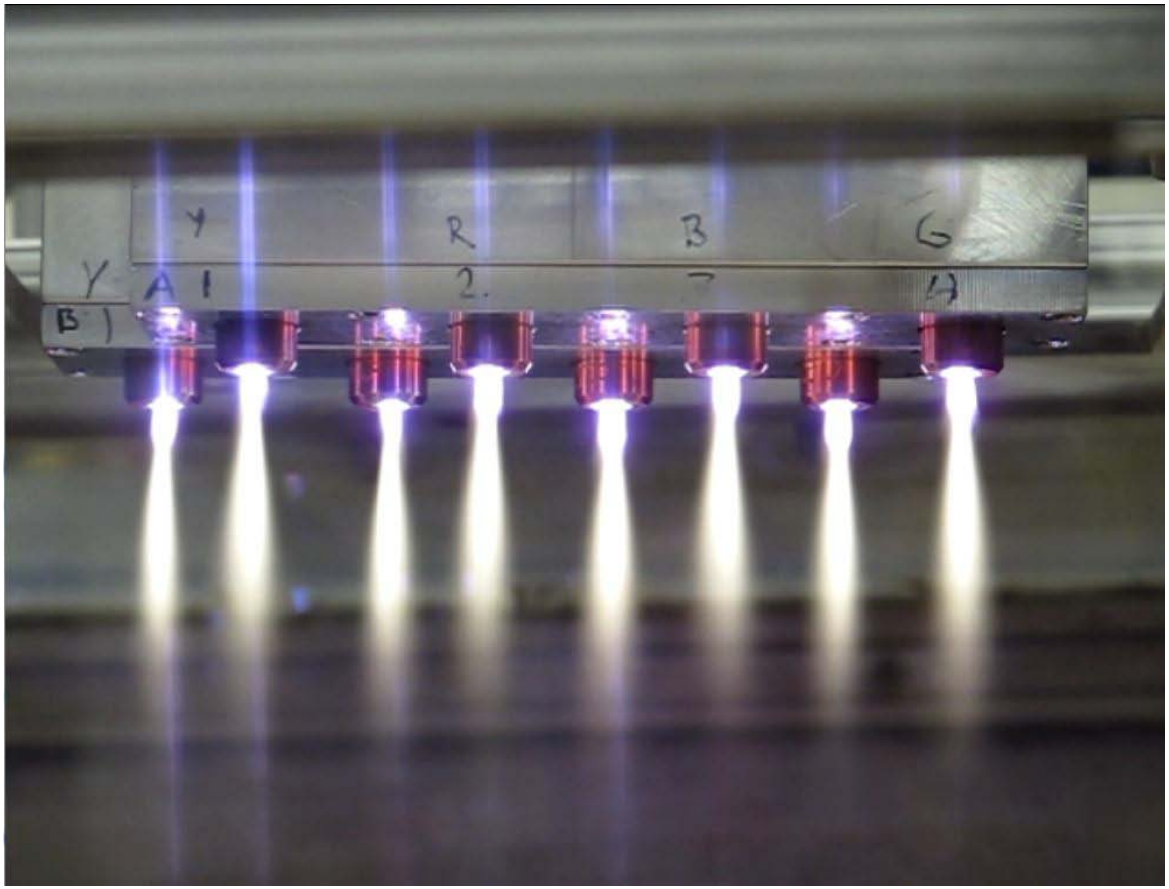

Three axis automated system

# Anti-Fouling Coating Removal

- APCR produces surface with “near white metal blast cleanliness”
- Underlying surface profile is unchanged
- Uniform removal demonstrated for freeboard and anti-fouling coatings
- Demonstrated excellent adhesion of re-applied coating with no secondary wiping or cleaning required to recoat



# APCR Multi-Pen Array




**Eight Pen Array**

# SERDP Program Findings

- Comparable efficacy of APCR to conventional Naval coating removal techniques
- Test panels were depainted by grit blasting and APCR to “near white metal” conditions and then repainted
- No significant performance difference of reapplied coatings was observed between APCR and grit blast surface preparation
  - No discernible difference in surface grain size, structure, or composition.
  - Pull-off adhesion tests of re-applied coating are comparable
  - No significant coating performance difference in salt fog and cathodic disbondment testing

# Solid Mass Reduction Study

**Determine what % of coating is converted to vapor**

- **Closed system employed during coating removal to capture solid waste**
- **Results indicate that up to 60% of coating mass was converted to gaseous byproducts**
- **EDS analysis of solid residue showed primarily inorganic content**

- **Freeboard Silicone Alkyd, PRF-24635 46% reduction**
- **Antifouling, 60% reduction**

# Technology Transition

- **Scale up plasma coating removal technology to increase production rates**
  - **Increased power levels (power source and plasma pen)**
  - **Multiple Plasma Pens**
  - **Wide Area Plasma Source**

- **Ruggedize power supply and pen for testing under depot conditions**
  - **Outdoor marine environment: Category III, Pollution Degree 4**
  - **Compliance standards taken into consideration in design**

# Technology Transition

- **Seeking Strategic Partnerships to further develop APCR technology for specific applications, demonstration and evaluation**

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# Thank You,  Questions?

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# Complete Integration of AP coating removal with High Performance Robotics