

AVT-339 Research Workshop on Robotics and laser/plasma – paint interaction in paint removal

Low Temperature Atmospheric Plasma Coating Removal with Integrated Robotic Control

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Australian Government

Department of Defence
Science and Technology

20 – 22 October 2020

The Australian Defence Context

- Relatively small defence force dependant on advanced military platforms that are required to defend a large area
- Navy (vessels & aircraft) patrols $\approx 1/3$ of the earth's ocean
- Requires the same diversity of platforms to achieve capability, with fewer of each platform



By File:Australia (orthographic projection).svg: Ssolbergj / derivative work Roke - File:Australia (orthographic projection).svg, CC BY-SA 3.0 <https://commons.wikimedia.org/w/index.php?curid=9397159>

Maintenance Challenges

- No economy of scale – tools must be multi-functional
- WHS is very restrictive, management of work health and safety risks are expensive
- Platforms now come with OEM maintenance packages
- Business cases can be challenging to find for singular tasks



Creator: CPL Nicci Freeman
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Coating Removal in the Royal Australian Air Force

- Fatigue/Cracking Inspections
- Non Destructive Inspection
- Corrosion Inspections
- Coating System Repair

1. Hand Sanding



Dust Generation

Solid Waste \$\$\$

High Labour \$\$\$

2. Media Blasting



Dust Generation

Solid Waste \$\$\$

Substrate Damage

3. Chemical Stripping



Liquid Waste \$\$\$

High Labour \$\$\$

Substrate Damage (Composite)

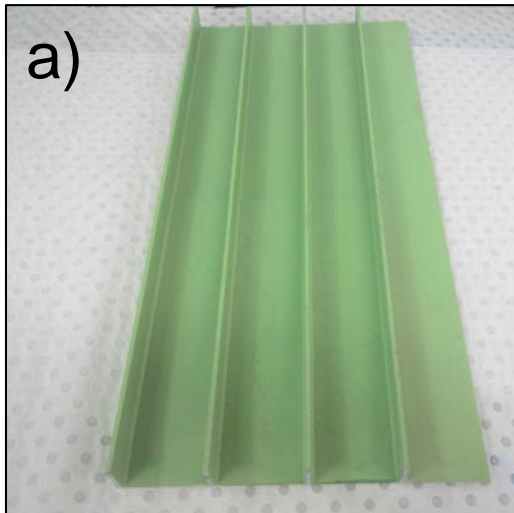


What does RAAF need from a solution?

- 1) **Consistency/Precision** – high power is required for fast removal rates, which is challenging to control as a human operator
- 2) **Ease of Use** – robotics and automation are desirable, however programming skills can't be relied on at a workshop level.
- 3) **Safety** – with Cr^{6+} exposure under international review, a solution must be able to be isolated/contained from the user.
- 4) **Versatility** – With relatively low numbers of a large number of platforms, a technique needs to be able to adapt to a range of shapes, materials and coatings.

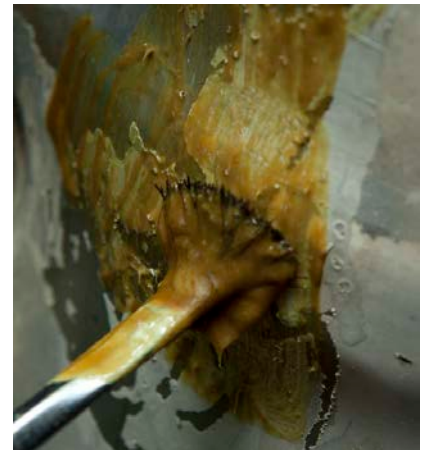
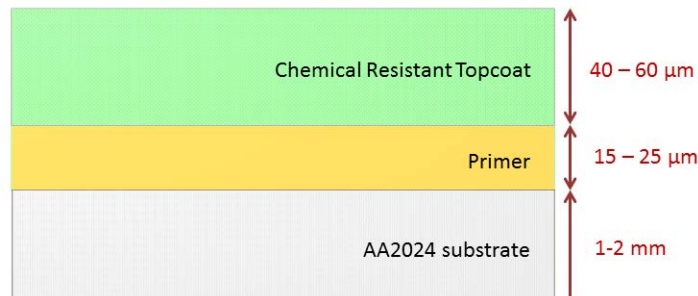
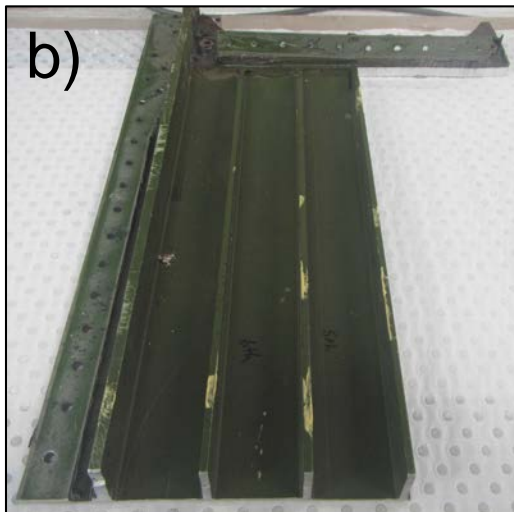


Case Study – Outer Wing Panel from AP-3C Orion



- Wing panels from an AP-3C Orion maritime patrol aircraft (currently being phased out for P-8A Poseidon)
- Coated in a chemical resistant paint (internals)
- Stripping Method: Soak overnight in thinned Bonderite S-ST Aero, abrade with Scotchbrite scrubbers, followed by a nitric acid wash and rinse with H₂O

Enormously time consuming, using very hazardous chemicals (methylene chloride, chromates) and generating a lot of chemical waste.

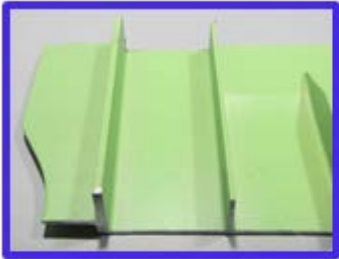


Cpl. Ruben J. Tan - This Image was released by the United States Marine Corps with the ID [120605-M-YE163-007](#)

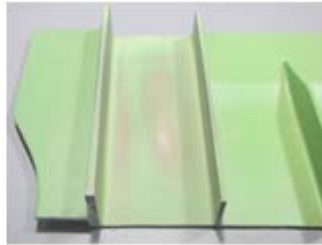


Coating removal with Bonderite S-ST Aero

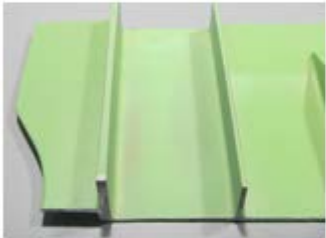
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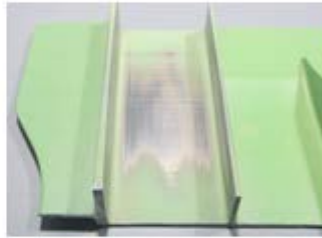
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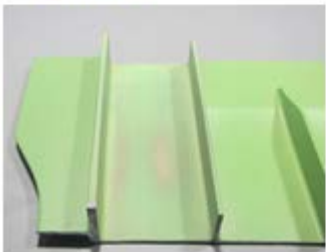
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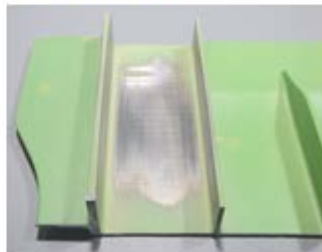
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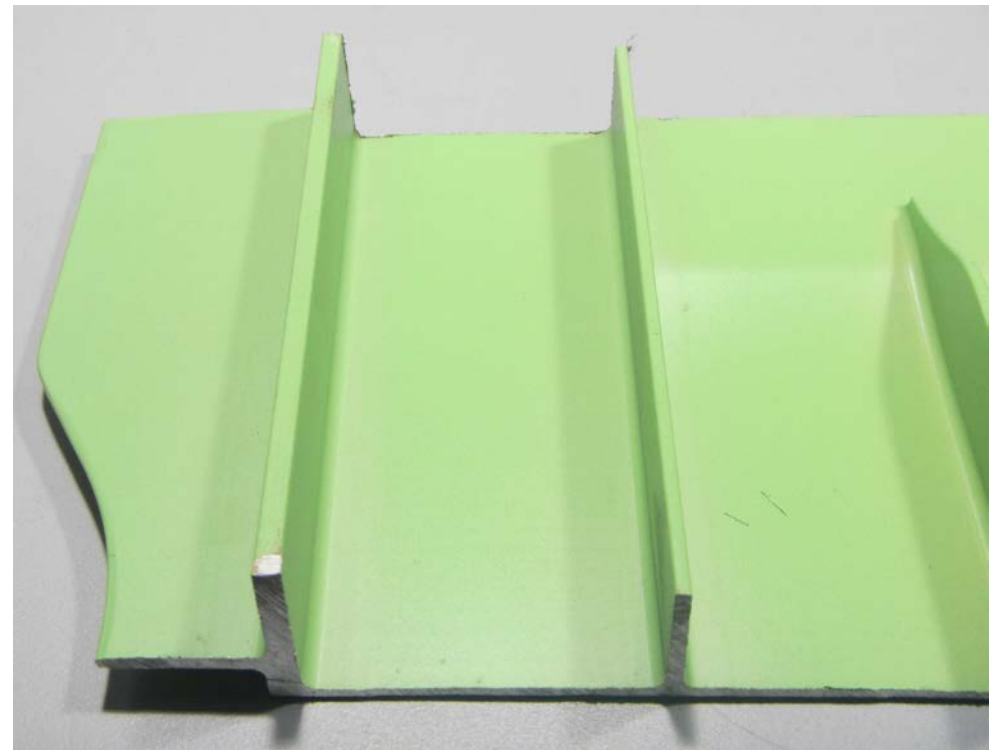
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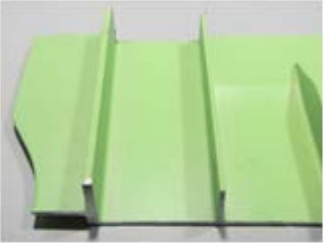


Applications -

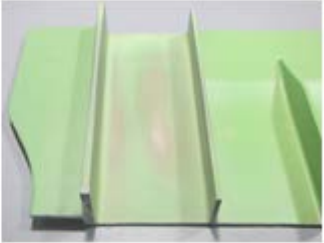


Coating removal with Bonderite S-ST Aero

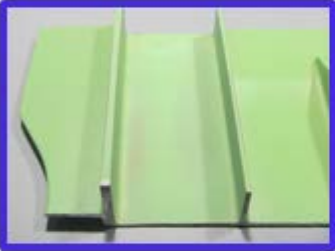
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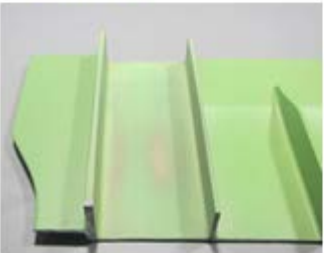
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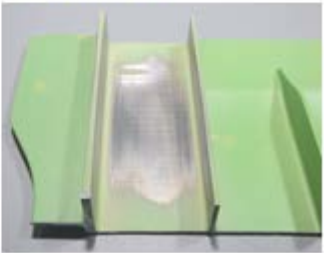
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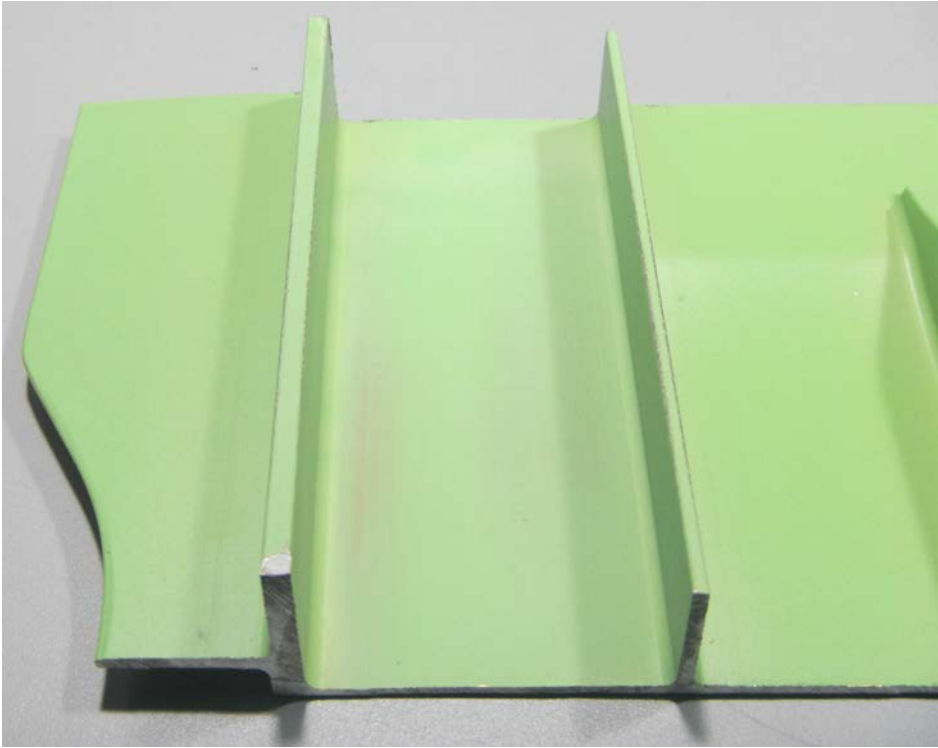
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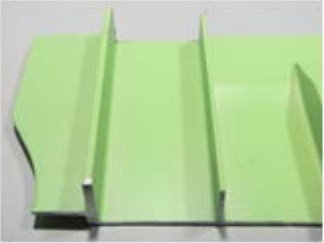


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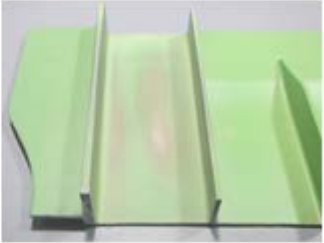


Coating removal with Bonderite S-ST Aero

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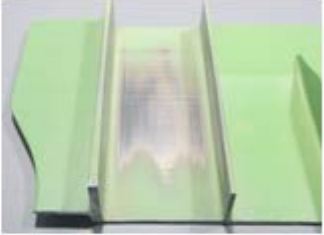
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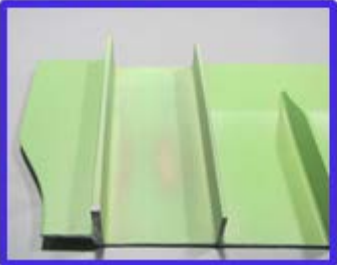
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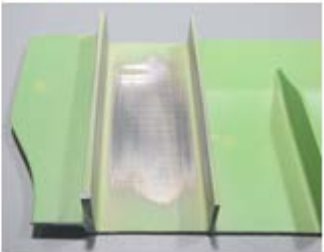
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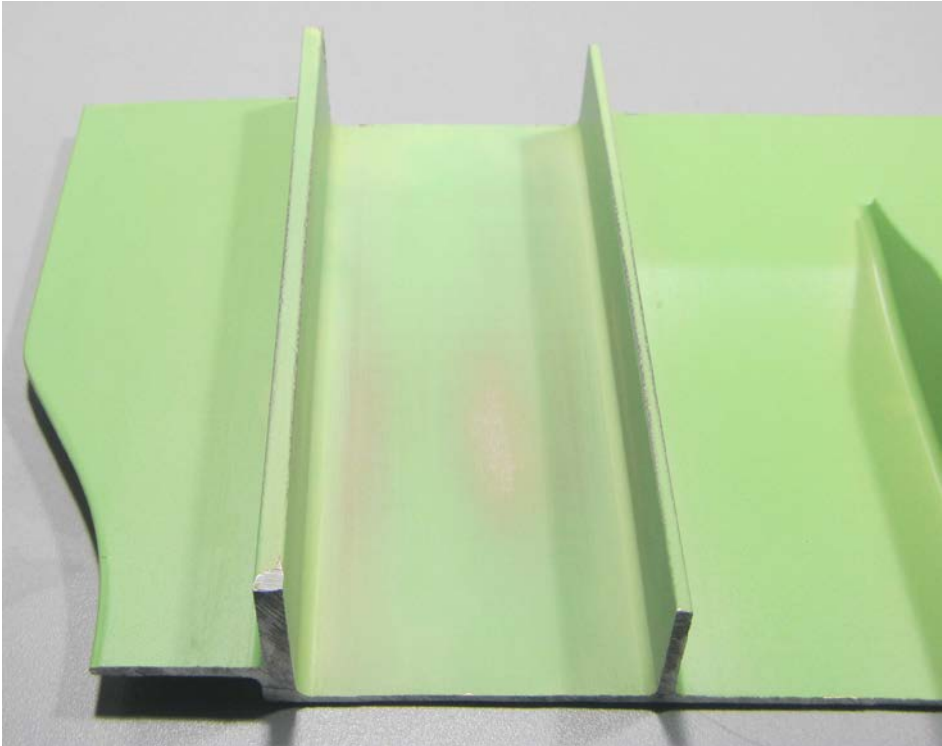
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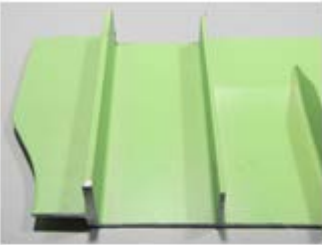


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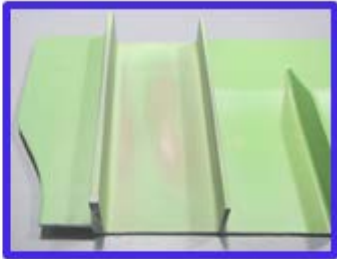


Coating removal with Bonderite S-ST Aero

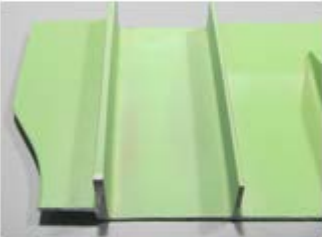
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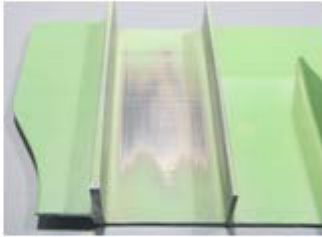
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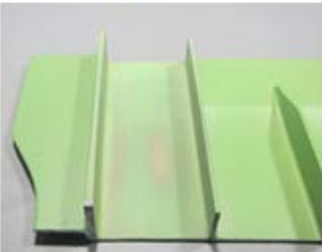
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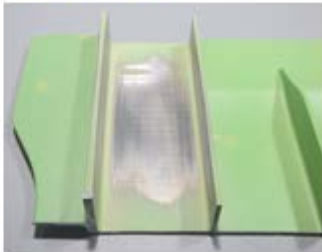
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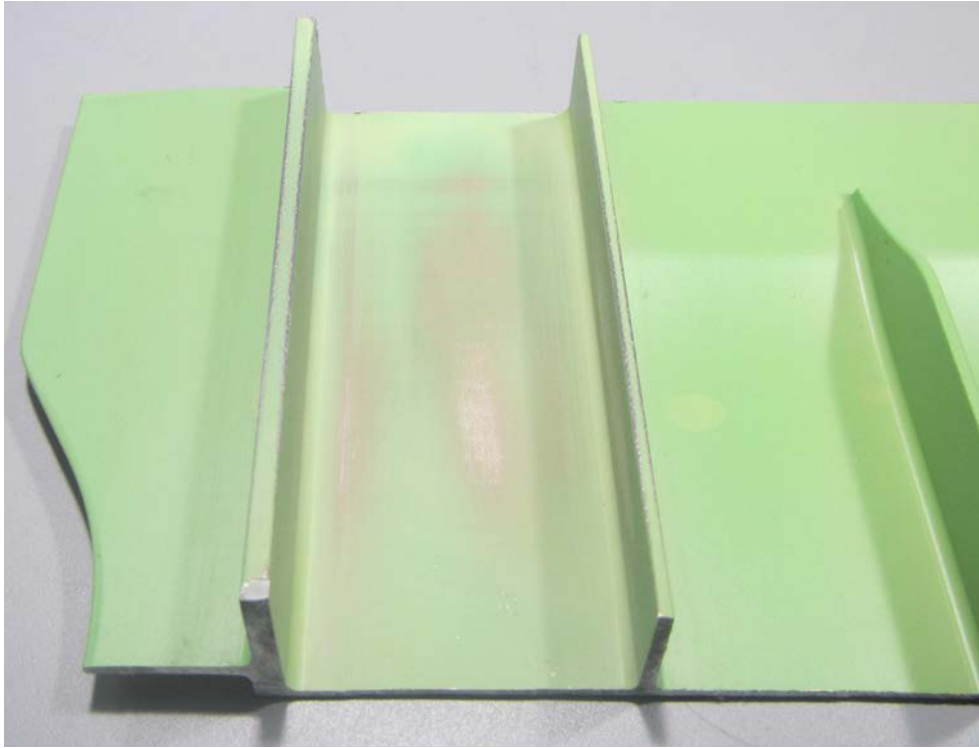
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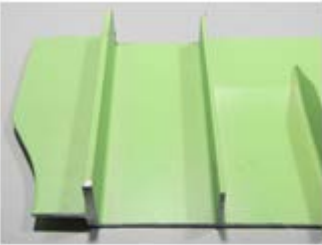


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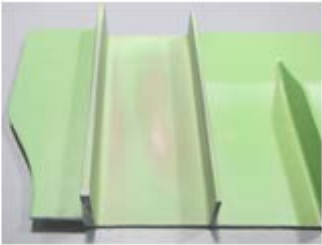


Coating removal with Bonderite S-ST Aero

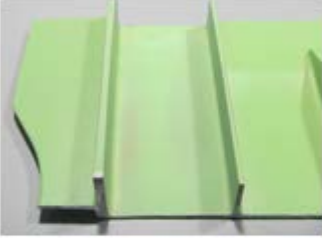
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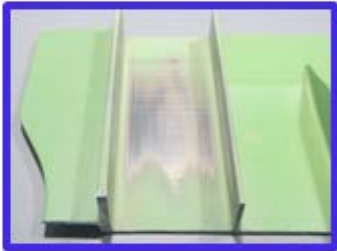
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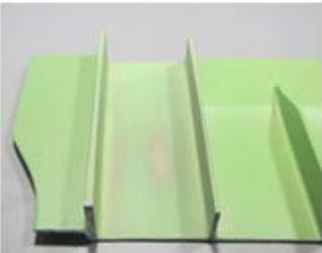
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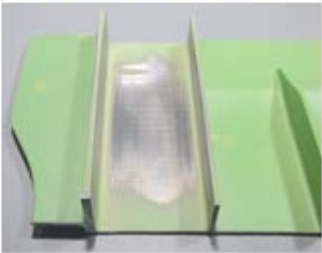
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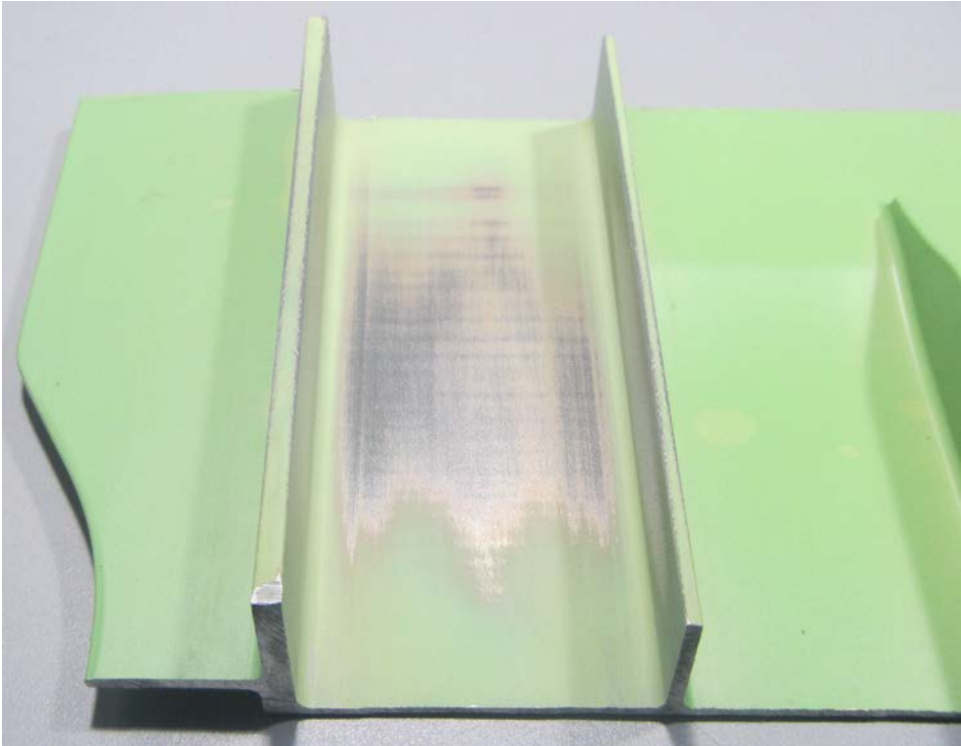
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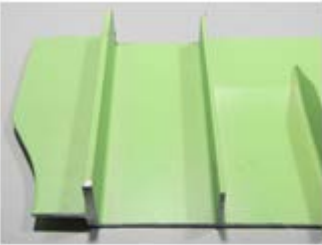


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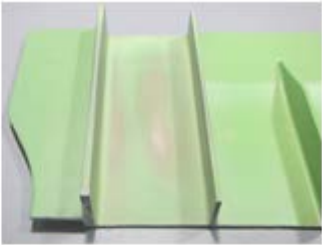


Coating removal with Bonderite S-ST Aero

0 hours



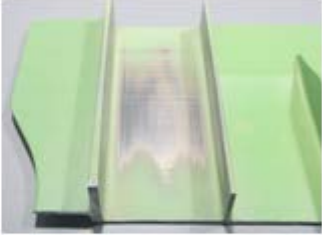
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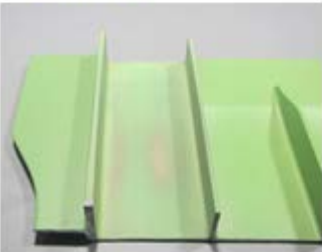
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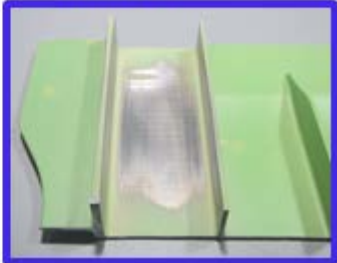
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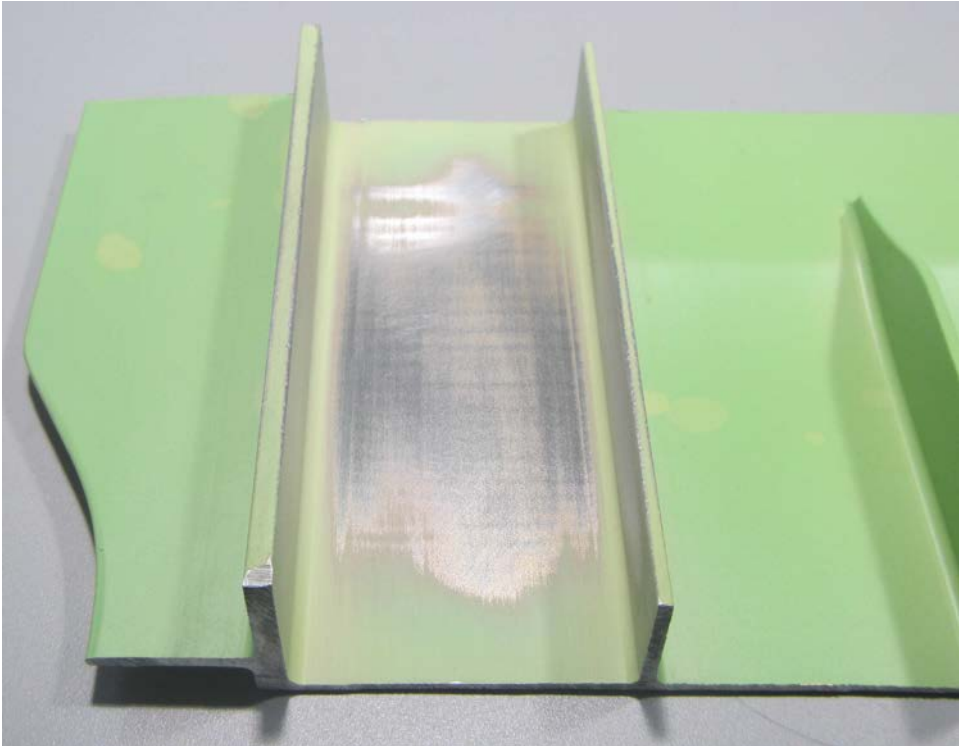
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Applications - ●●●●●



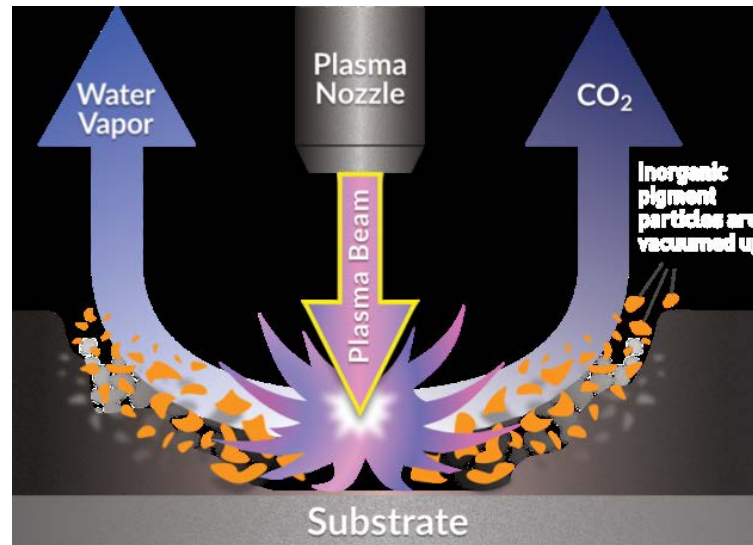
Low Temperature Atmospheric Plasma

- Commercialised but not yet widely adopted technology
- Currently a small-scale instrument
- Deployed as a tool in US Navy yards
- Available but un-trialed in Australia Defence Forces



www.apspasma.com

Defence Science & Technology Group has purchased a PlasmaBlast 7000 Atmospheric Plasma system for evaluation as a non-destructive coatings removal tool



www.apspasma.com



Robotically Integrated Plasma with Low Environmental Yield – R.I.P.L.E.Y.



- Integrated with electronically compliant Universal Robot
- Self contained for dust extraction
- Portable for use in workshops/hangars
- Programmable for repeatability – low barrier to operation

Example: Removal of a Navy Polysiloxane Topcoat



Example: Removal of a Navy Polysiloxane Topcoat

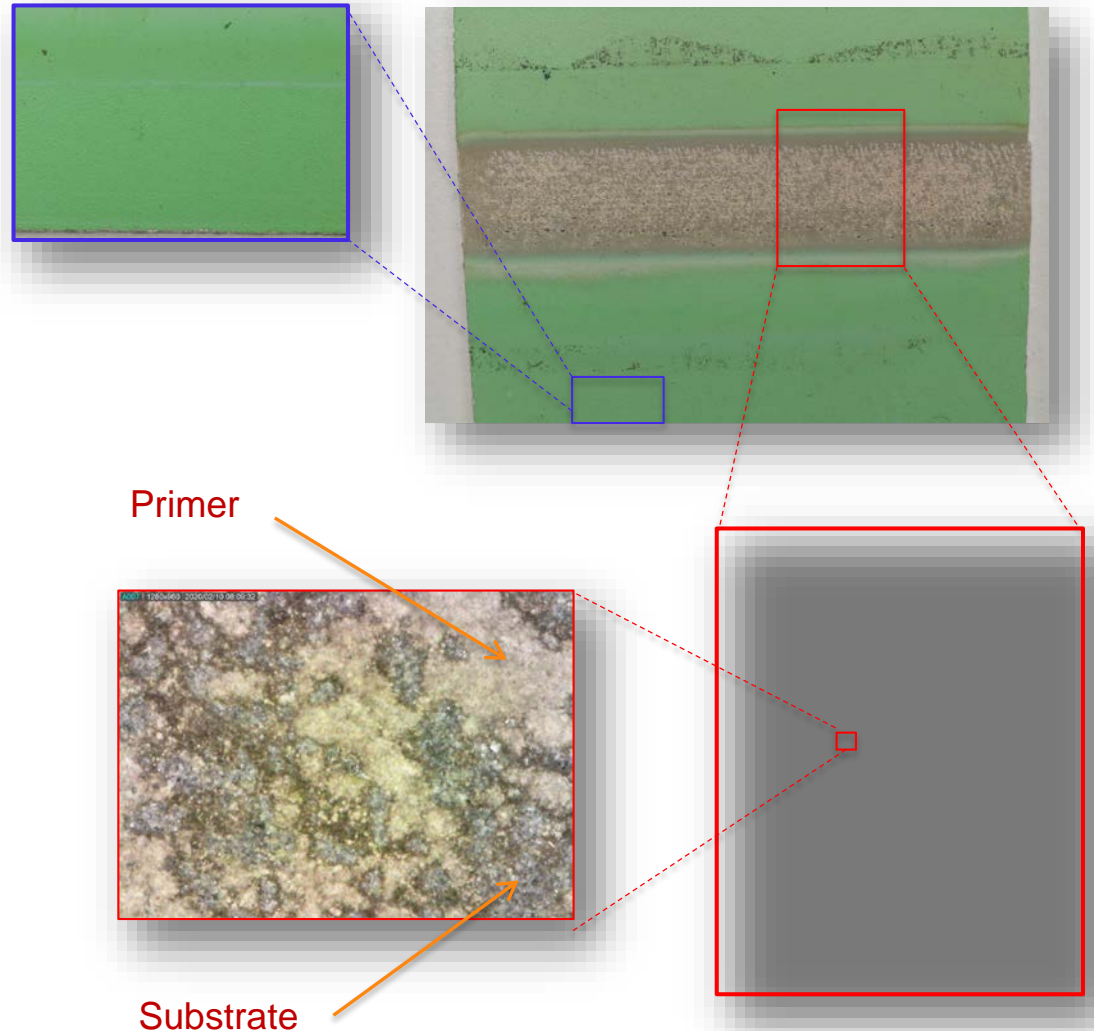


Atmospheric Plasma Wing Section Stripping

Plasma Parameters

Offset: 3 mm from surface
Raster Speed: 200 mm.s⁻¹
Scan Interval: 0.5 mm
No. Scans: 20

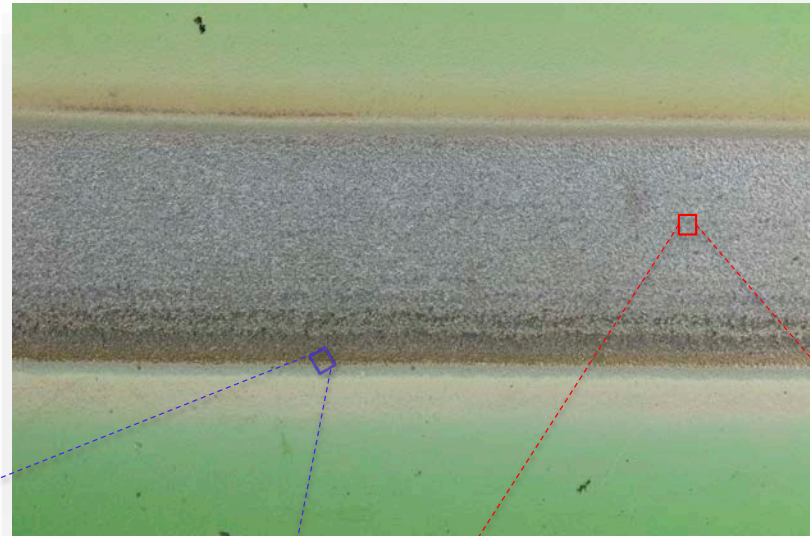
Under these conditions, visual inspection shows coating removal. Closer viewing reveals that a layer of yellow primer is still present, with bare AA2024 visible in small areas



Atmospheric Plasma Wing Section Stripping

Plasma Parameters

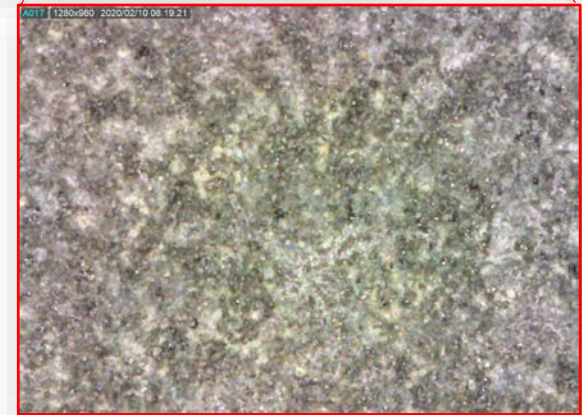
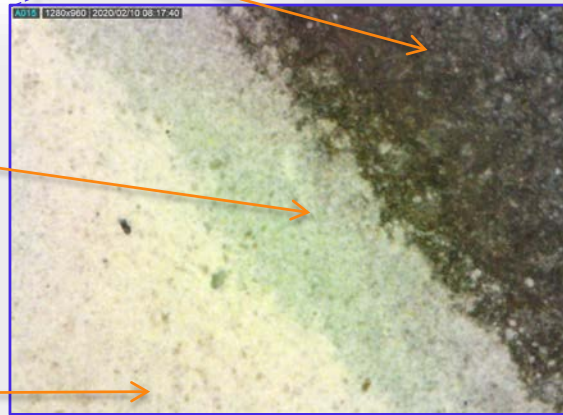
Offset: 3 mm from surface
Raster Speed: 50 mm.s⁻¹
Scan Interval: 0.5 mm
No. Scans: 20



Substrate

Coating Edge

Coating Debris



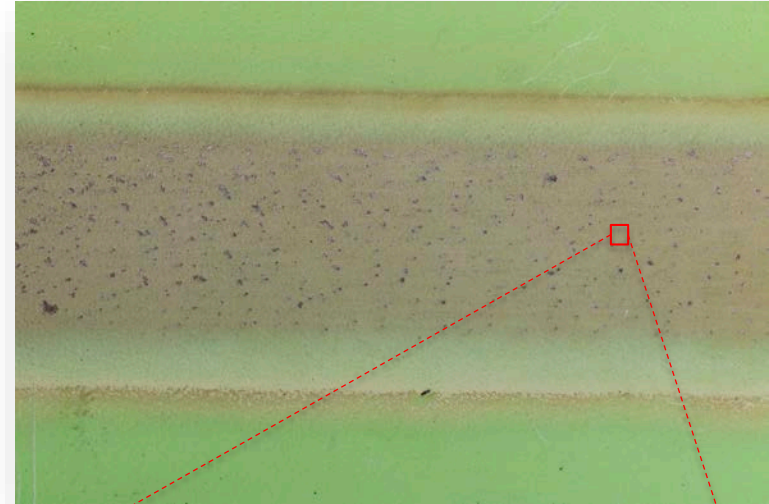
Atmospheric Plasma Wing Section Stripping

Plasma Parameters

Offset: 3 mm from surface
Raster Speed: 500 mm.s⁻¹
Scan Interval: 0.5 mm
No. Scans: 20

At faster raster speeds
it may be possible to
remove only the top
coat, leaving only
primer behind

Arc strikes punching
through were observed
on the primer layer



Arc Strikes



Coating/Primer

Conclusions

- The PlasmaBlast 7000 successfully removed the chemically resistant paint scheme on the wing panel of the AP-3C Orion
- Relative selectivity is attainable on flat surfaces by tuning the raster speed (50 mm.s^{-1} to 500 mm.s^{-1}) of the pen tip at a set tip offset (3 mm)
- The initial passes are most efficient, with the underlying layers more difficult to ablate
- The comparative efficiency on small working areas of Atmospheric Plasma compared to chemical stripping was found to be in the range of minutes vs hours
- Arcing damage was observed on some panels, however the extent of substrate damage is yet to be characterised
- The R.I.P.L.E.Y. system addresses some of the critical issues associated with coating removal operations in RAAF

Future Work

- Substrate Damage
 - Thermal damage, material property changes (eg. temper)
- Substrate Suitability
 - The ability to safely remove coatings from metals, plastics & composites
- Operability
 - Can the pen be operated by hand? Does it alter the performance and observed damage to substrate material?
- Safety Concerns
 - Can the system be used to effectively control the exposure of workers to hazardous materials generated during coating removal operations?
- Broader Applications within ADF
 - Navy applications (eg tank weld inspections) will be explored for the potential to mitigate laborious and hazardous tasks

Questions?

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