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Laser Depainting Using Handheld Lasers

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Handheld Laser Ablation Overview

- Motivation
- Established Facilities
- Quality Control
- Qualification and Production Trials
- Safety and Culture
- Summary and Next Steps

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Committed to Environment Leadership

At Boeing, we're committed to environmental leadership — an important pillar of our broader sustainability strategy to help make the world a better place for future generations.

Products	Operations	Collaboration	Governance
Providing innovative products and services to improve environmental performance.	Sustainable operations to improve the environmental performance of our factories, work sites and supply chain.	Collaborating with partners globally to advance innovative environmental solutions.	Comprehensive review and assessment of the most significant environmental challenges and risks.

Lasers can play a key role in our environmental leadership strategy

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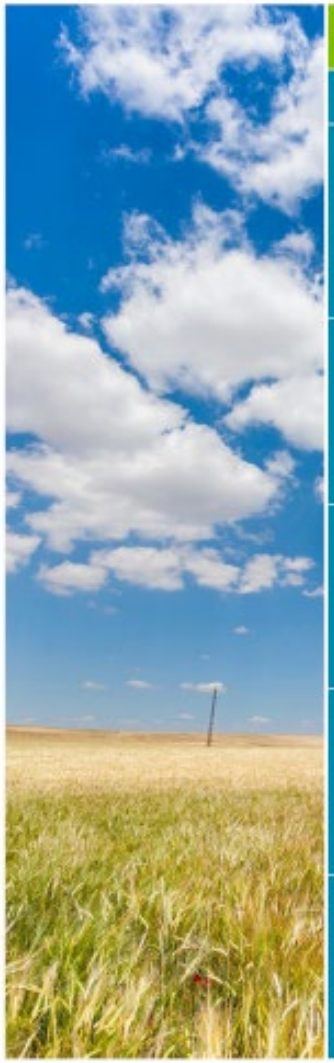
Committed to Environment Leadership



Progress Toward 2025 Goals in 2019 (from 2017)	
2025 Reduction Goals	**Progress Details**
Reduce greenhouse gas emissions by 25%	Reduced 2.8%
Reduce water consumption by 20%	Reduced 7%
Reduce solid waste to landfill by 20%	Reduced by 15%
Reduce energy consumption by 10%	Increased 0.3%
Reduce hazardous waste by 5%	Increased 2.7%

Lasers ablation reduces or eliminates solvent cleaning and associated VOCs

Lasers ablation replaces cleaning and chemical stripping, reducing water consumption

Laser ablation reducing Personal Protective Equipment (PPE), reduces waste to landfill (rags, sandpaper, grit, etc)

Laser ablation reduces hazardous waste (solvent rags, chromated grit and sandpaper, chemical stripper and paint removed goo)

Lasers can play a key role in our environmental leadership strategy

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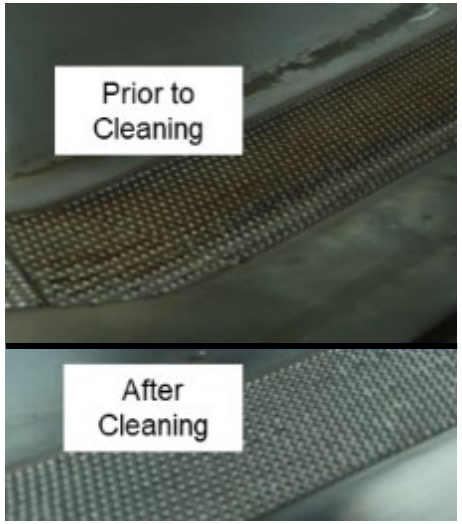
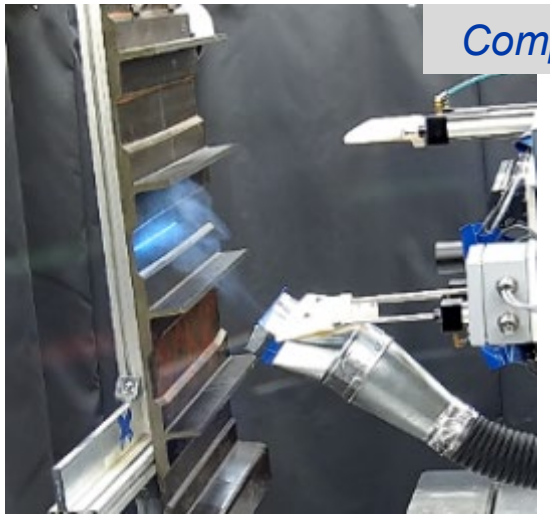
Laser Ablation Versatility

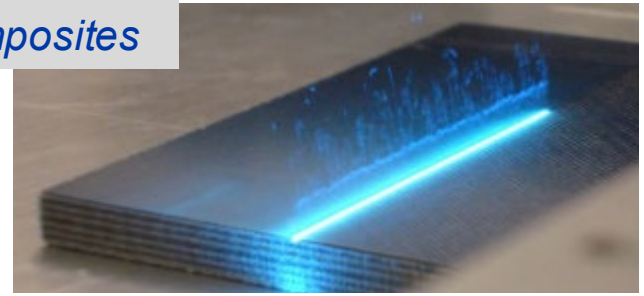
Tool Cleaning

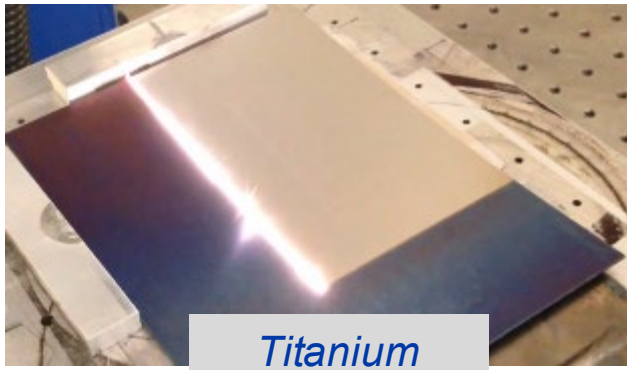




Surface Preparation

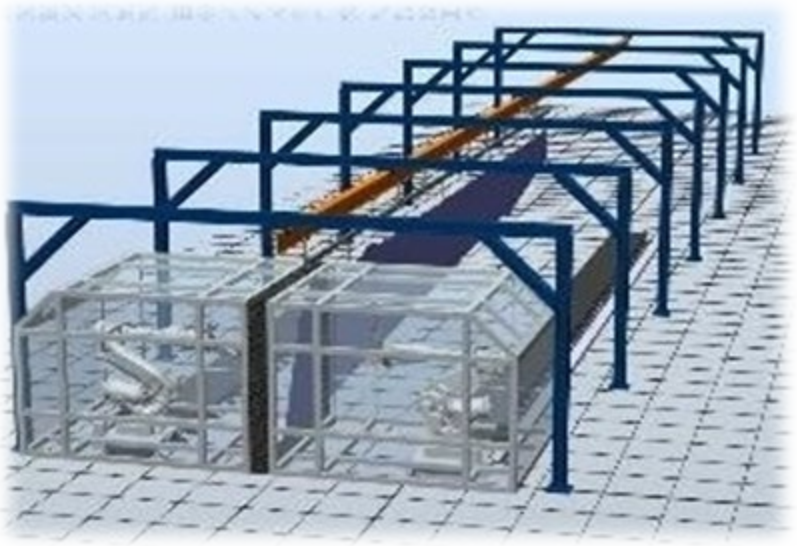
Composites





Titanium

OEM Depaint



Aftermarket Depaint

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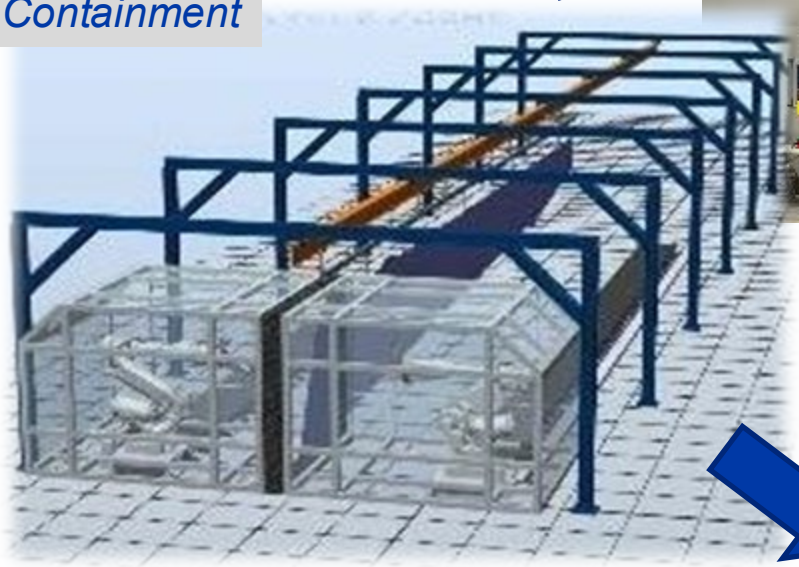
Established Facilities

- Factory Space
  - Green space is limited
  - Right sized systems
  - Localized containment reduces footprint
- Looking Forward
  - Localized containment for complex geometries
  - Localized containment for handhelds
  - Multi-functional, multi-purpose facilities
    - Integrated paint/depaint

Full Enclosure

Localized Containment



Handhelds

Space is limited

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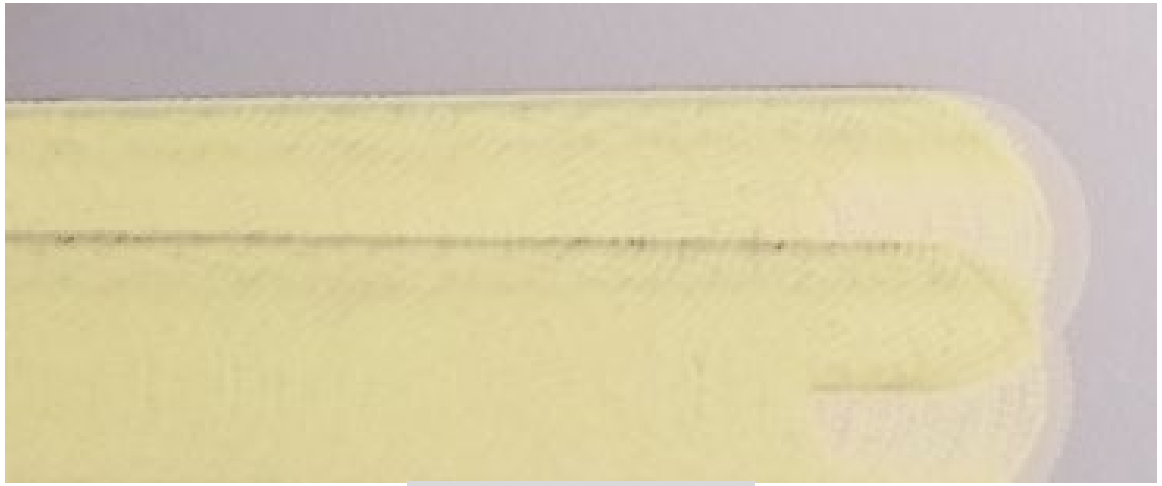
Quality Control

- Sanding – difficult to stop at a desired interface
- Lasers – more precision, more control

Sanded Surface



Ablated Surface

Lasers and closed-loop feedback improves quality and protects substrates

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Quality Control

- Closed-Loop Feedback
  - Automated systems
  - In-process vs post process
  - Key technology for handheld but only based on color

- Looking Forward
  - Alternative closed-loop options

Lasers and closed-loop feedback improves quality and protects substrates

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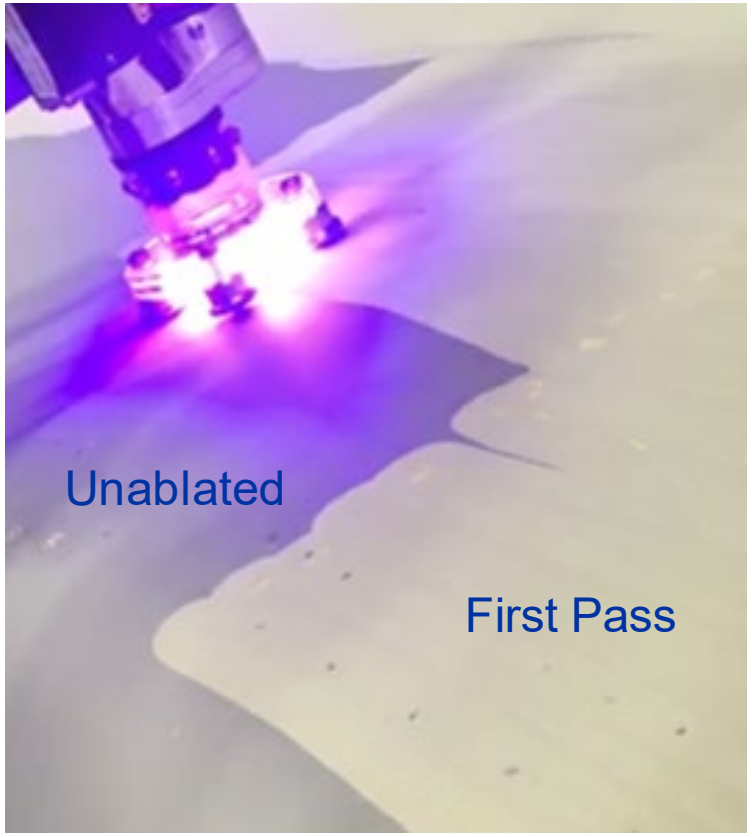
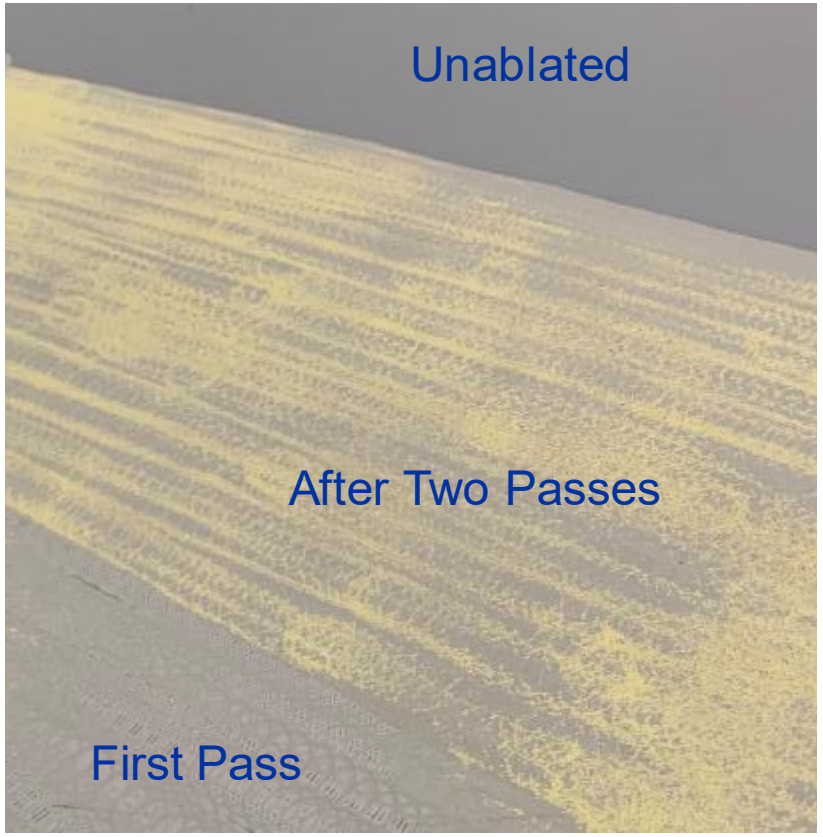
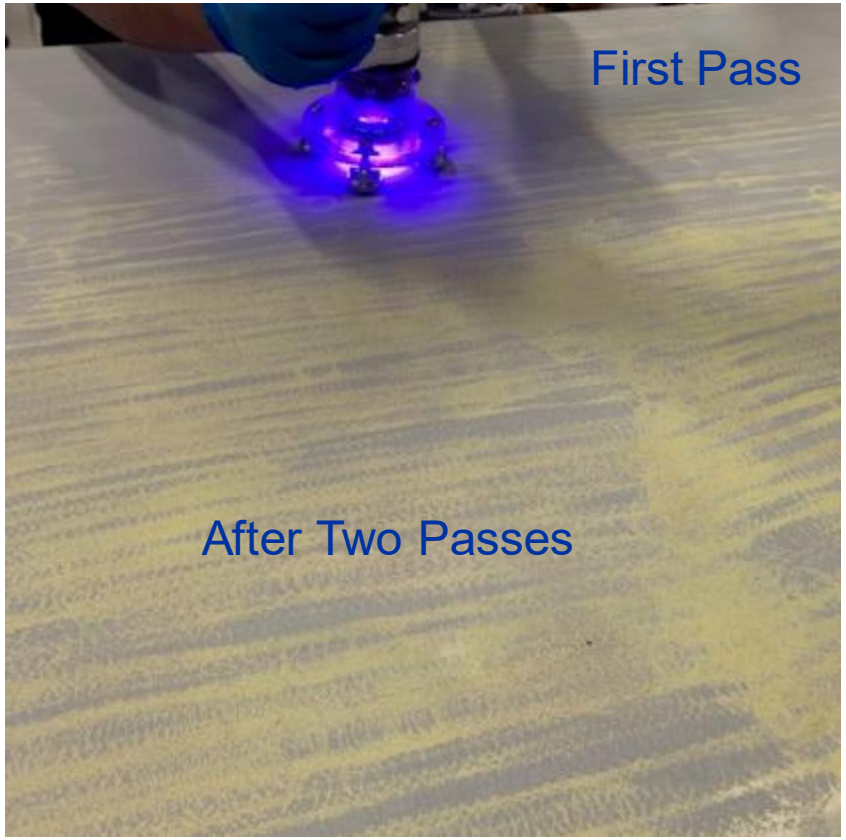
Qualification and Production trials

- 4 Production trials complete
- Transitioning to low rate production







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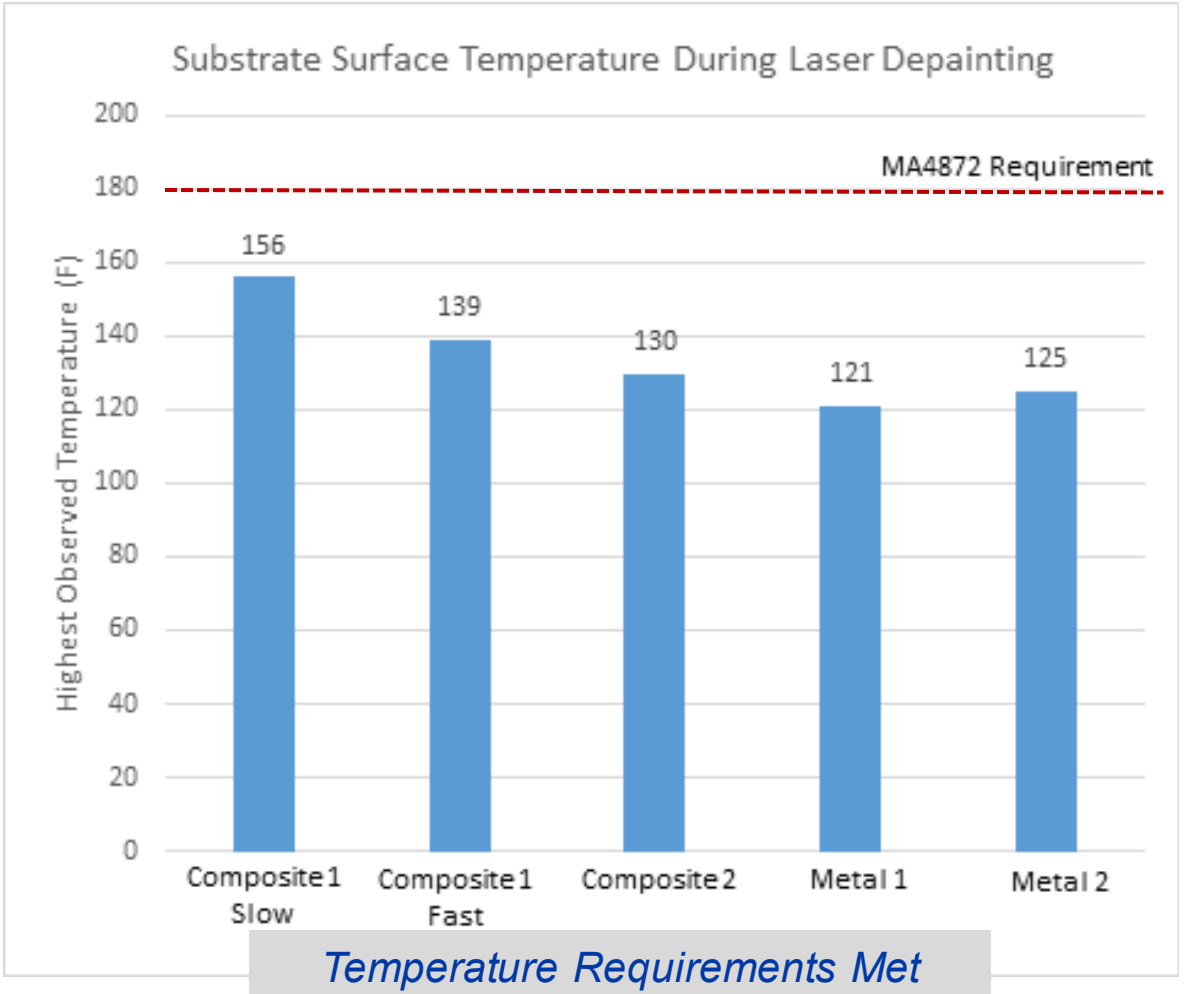
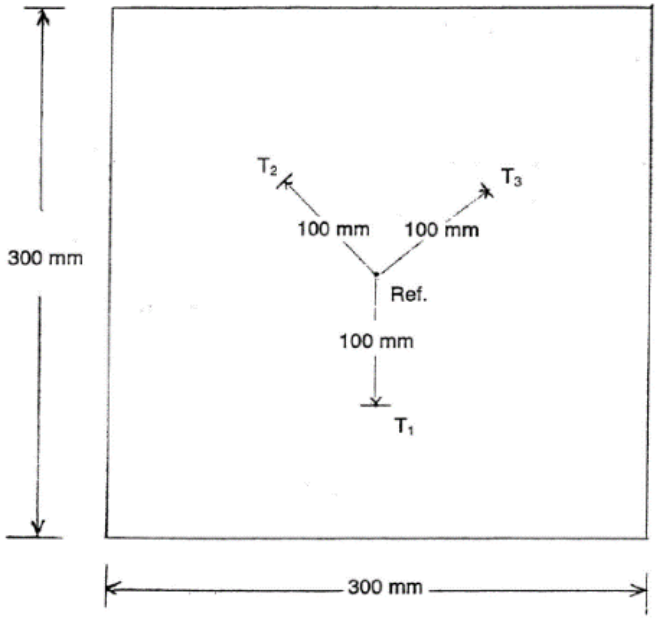
Qualification and Production trials

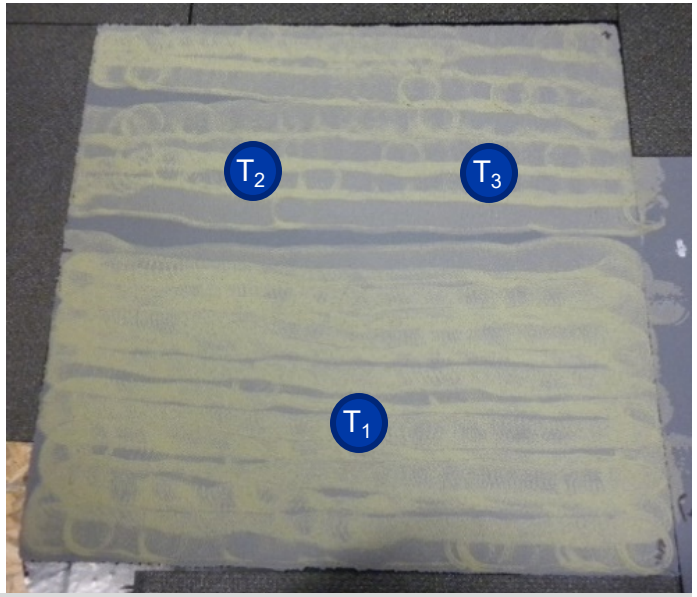
- Requirement: MA4872 Section 4.2, during depainting composite substrate temperature must not exceed 180 F
- All panels below 180F, and substrate cools down within seconds



Temperature Requirements Met



SAE MA4872A



Panel with thermocouples imbedded

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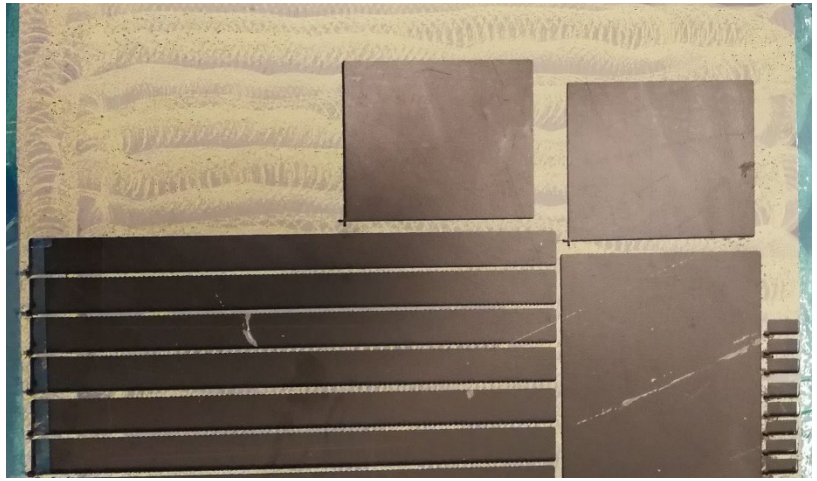
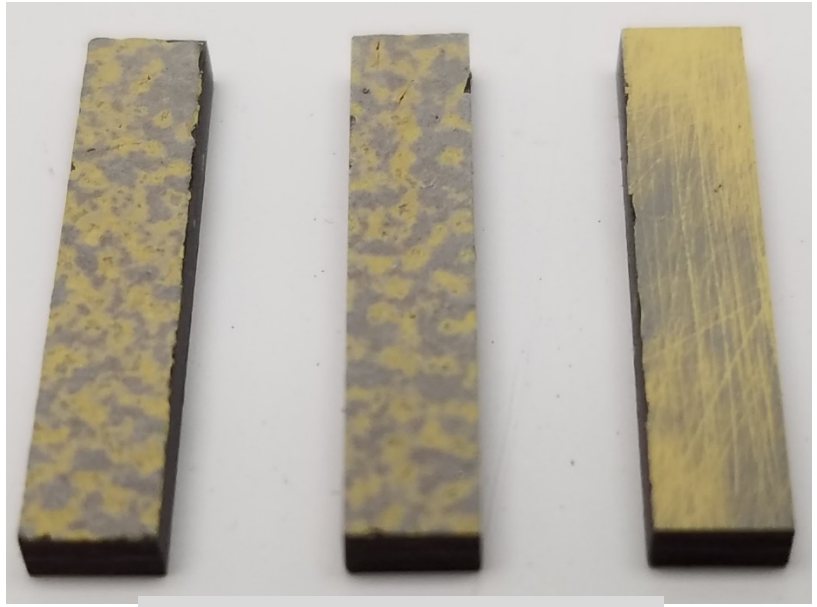
Qualification and Production trials

Test	Substrate 1	Substrate 2	Substrate 3
Un-notched Compression	*Pass*	*Pass*	*Pass*
Open Hole Compression	*Pass*	*Pass*	*Pass*
Laminate Tensile	*Pass*	*Pass*	*Pass*
Short Beam Shear	*Pass*	*Pass*	*Pass*
SEM	*Pass*	*Pass*	*Pass*

*Includes 3 rounds of paint/depaint for all testing



Ablated panel with cutouts



Structural coupons

Passing all required structural testing

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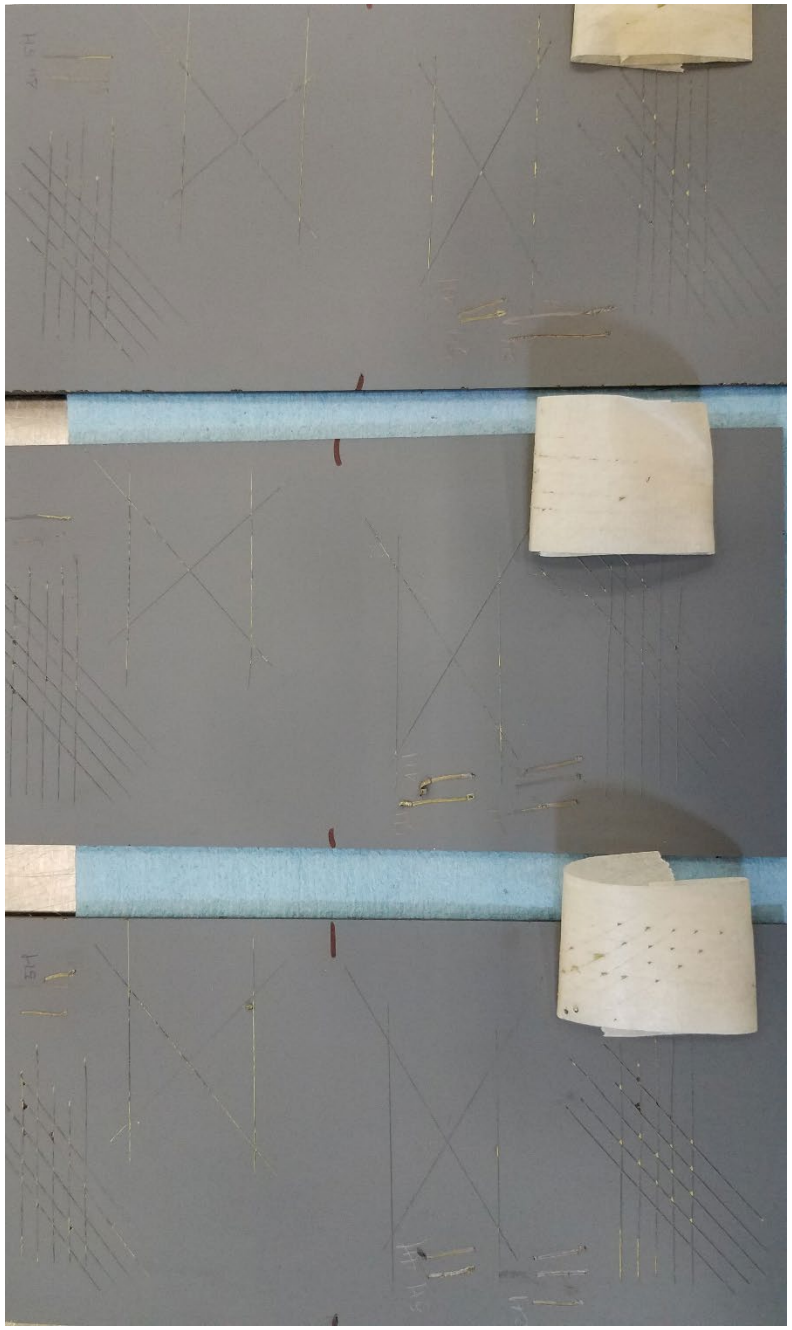
Qualification and Production trials

Test	Scribe Adhesion	Pencil Hardness	Patti Adhesion
Dry Adhesion Scribe	*Pass*	*Pass*	*Pass*
Water Ambient	*Pass*	*Pass*	
Water 120F	*Pass*	*Pass*	
Hydraulic Fluid 150F	*Pass*	*Pass*	
Oil 250F	*Pass*	*Pass*	

Passing paint requirements post ablation



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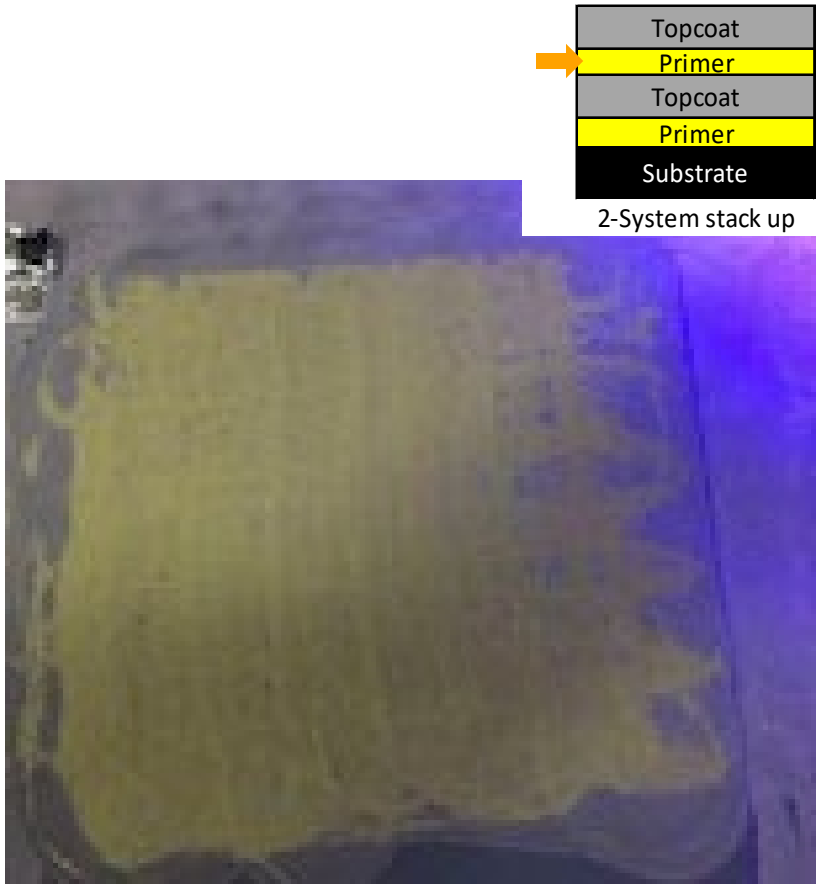
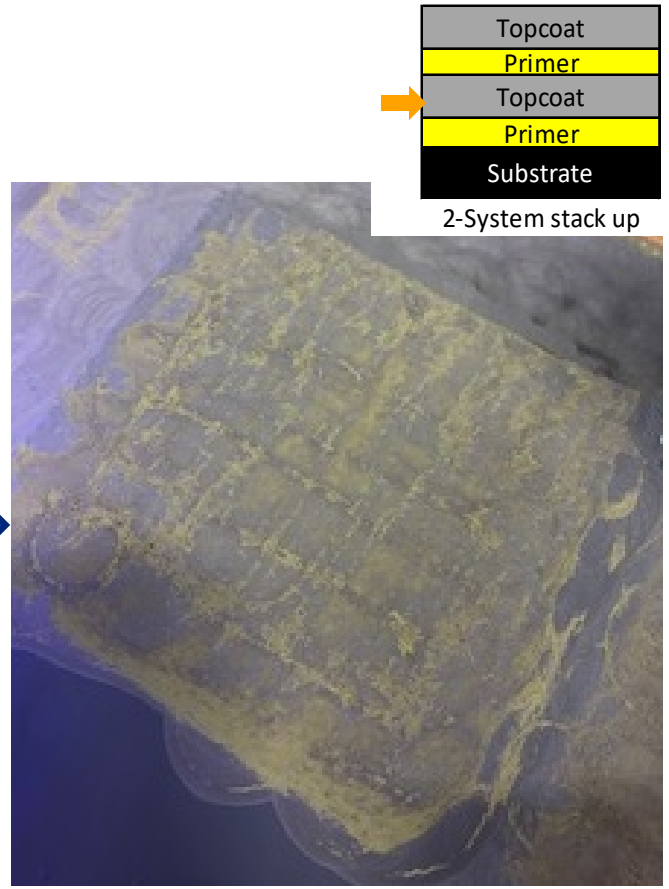
Qualification and Production trials

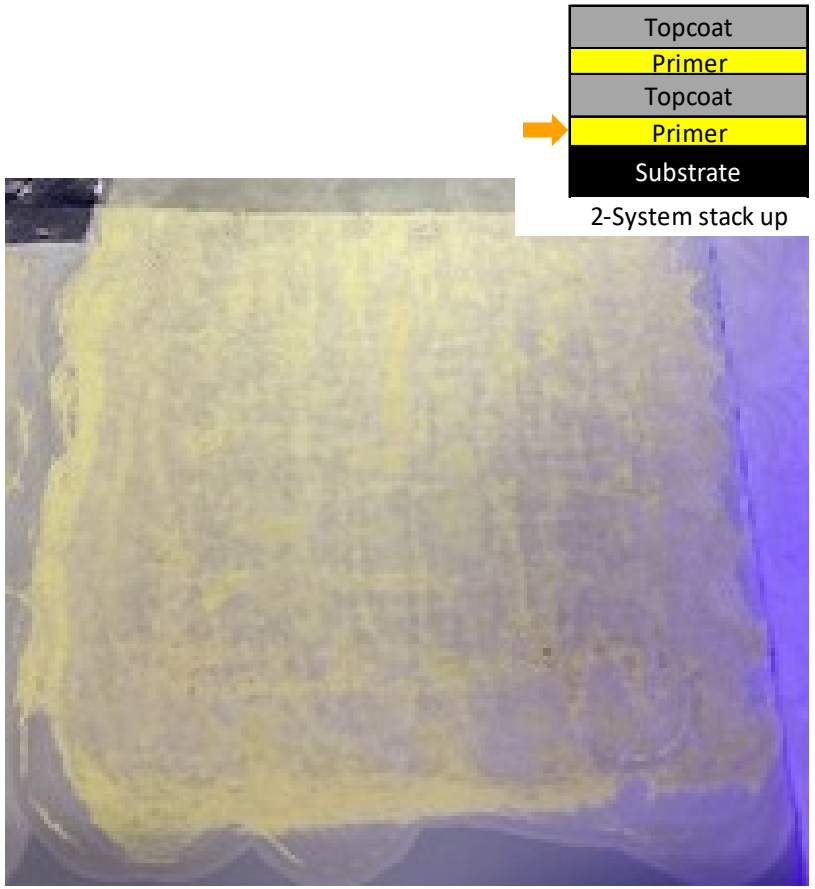
- Selectively strip to base primer layer



1st layer topcoat removal



1st layer primer removal



2nd layer topcoat removal

Removal through multiple primer layers successful

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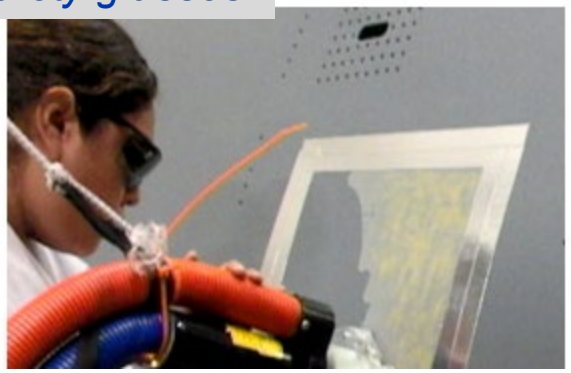
Workplace Safety

- Protect Employees
  - Reduce ergonomic impact
  - Reduce required PPE
  - Reduces potential worker exposure to hazards

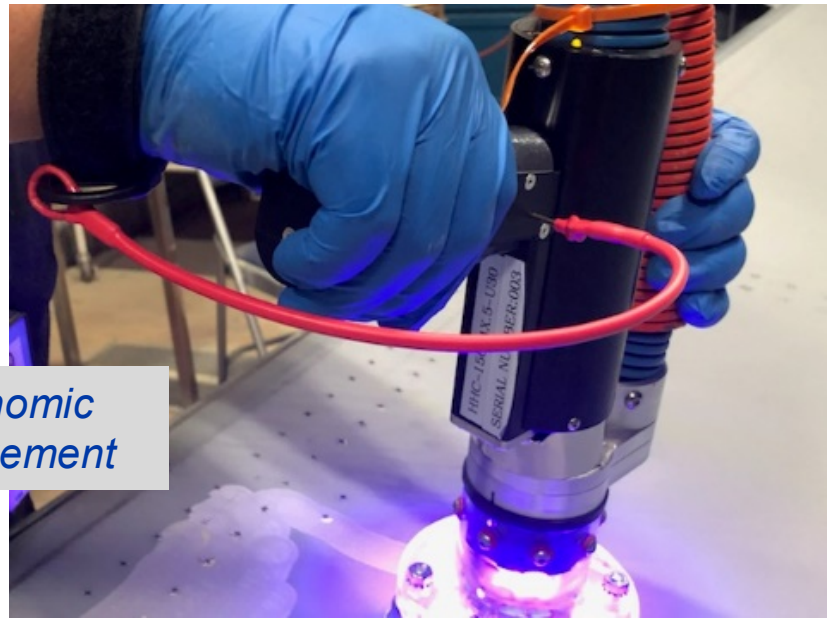
Close proximity of workers not ideal

Laser safety glasses



- Looking Forward
  - Localized containment to enable implementation across factory and depot
  - Socializing laser safety in the factory
  - Reducing size

Ergonomic Improvement



New technologies bring new safety considerations

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Workplace Safety

- Air Sampling: The OSHA Permissible Exposure Limit (PEL) for Chromium VI calculated as an 8-hour time weighted average (TWA) is 5 micrograms per cubic meter of air (5 µg/m³)
- Air sampling results were lower than the OSHA PEL and Action Level on the day monitored

Sample Number	Sample Location	8 Hr TWA Results (µg/m³)	OSHA PEL / AL	Times Over PEL Limit	Sample Time (min)	Exceeded PEL?	Adequately Protected?
09272018A3	Personal sample– Laser Booth (Shop Code 201, E-14) in Large Parts Wash Area	<0.028	5 / 2.5	N/A	36	No	Yes
09272018A5	Area Sample: 3 ft. from filtration system outside Large Parts Wash Area, Column C-12	<0.023	5 / 2.5	N/A	37	No	Yes
09272018A4	Blank	<0.025	N/A	N/A	N/A	N/A	N/A

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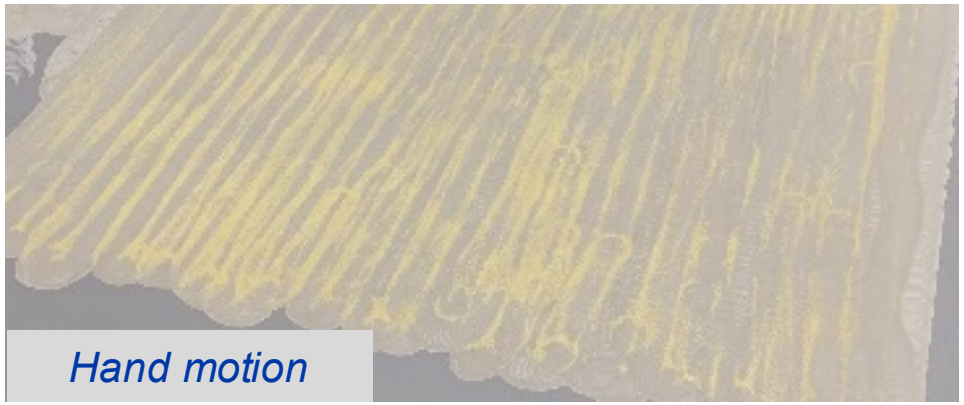
Scale



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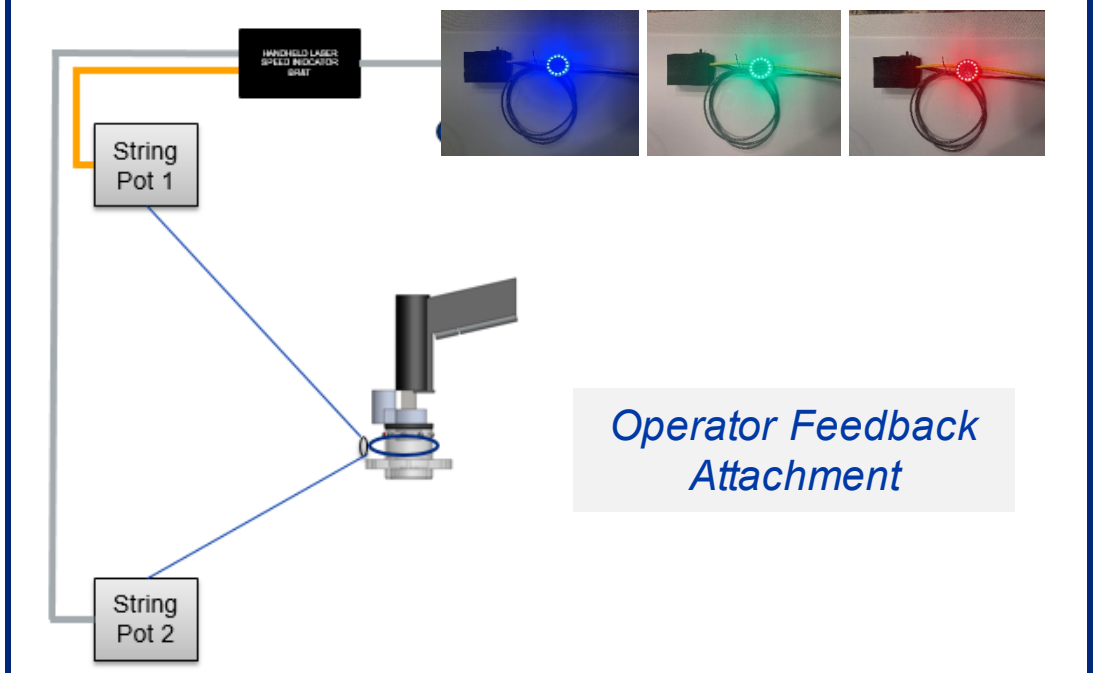
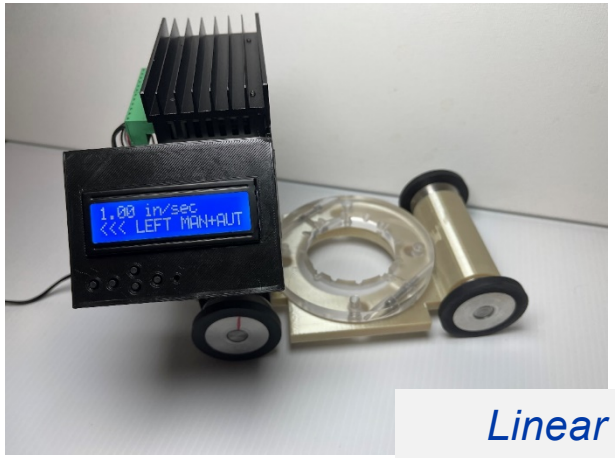
Culture and Transition to Production

Move away from hand sanding

Adopt handheld laser



Operator Feedback Attachment



Linear motion

Benefits can only be obtained if advancements are implemented

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Summary and Next Steps

- Handheld laser approved for use on composite flight hardware
- Four production trials completed
- Currently TRL 8
- Working on operator assist tools to further improve rate and quality
  - Indicator system
  - Linear motion cart
  - Automation

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Acknowledgements

BGS San Antonio Site

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Thank you!

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