



Boeing Research & Technology

# Laser Depainting: The Path to Implementation

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# Aircraft Coating Characteristics



**Economic to Remove**



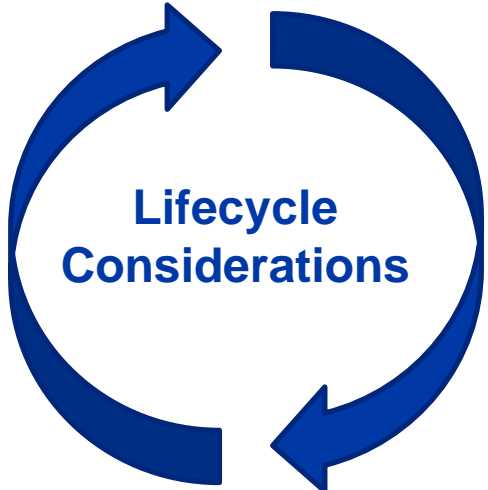
**Economic to Apply**



**Functional Performance**



**Durable & Repairable**



**Lifecycle Considerations**

**Appearance**



**Coating Removal is a Key Part of Coating Lifecycle**

# 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**

# Committed to Environment Leadership

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

Lasers ablation replacing chemical stripping, reduces water consumption

Laser ablation reducing Personal Protective Equipment (PPE), reduces waste to landfill

Laser ablation reduces and replaces amount of hazardous waste

**Lasers can play a key role in our environmental leadership strategy**

# Depainting Competitive Assessment

Approach	Hand Sanding	(EMMA) Easily Manipulated Mechanical Arm	Media Blasting	Chemical Stripping	Flashjet	Laser Ablation
Characteristic						
Adaptable to Variety of Substrates	Good	Good	Moderate	Poor	Good	Excellent
Multi-Coating Layer Sensitivity	Moderate	Moderate	Moderate	Poor	Good	Excellent
Paint Removal Rate	Very Slow	Moderate	High	Slow	Moderate	High
Pre/Post Processing	Moderate	Moderate	High	High	Low	Minimum
Media Intrusion Potential	Low	Low	High	High	Moderate	None
Quality Risk	High	Moderate	Moderate	Moderate	Very Low	Very Low
Total Waste Volume	Moderate	Moderate	Moderate*	High	Low	Very Low
Capital Cost	Low	Moderate	High	Low	High	Moderate to High
Recurring Cost	High	Moderate	High	High	Low	Low
Ergonomic Impact	High	Moderate	Low to Moderate	Moderate	Low	Low to Moderate

**Laser ablation reduces ergonomic impact, hazardous waste, & flow time and improves quality**

# Benefits of Laser Ablation

## MANUFACTURING AND REPAIR

- Automated process
- Reduce process labor time (abrasion as baseline)
- Reduce factory flow time
- Eliminate cleaning steps
- Eliminate hand touch-up

## QUALITY

- Robust, consistent process
- Precision removal of material
- Uniform treatment over irregular surfaces
- Reduce manual touch-ups in corners & edges

## ENVIRONMENT, HEALTH, AND SAFETY

- No repetitive stress injuries
- Reduce Volatile Organic Compounds (VOC's) & hazardous waste



Lasers, replacing paint sanders and chemicals in Boeing factories, are improving quality and accuracy while **reducing hazardous waste by 90%**.

# Laser Ablation Versatility

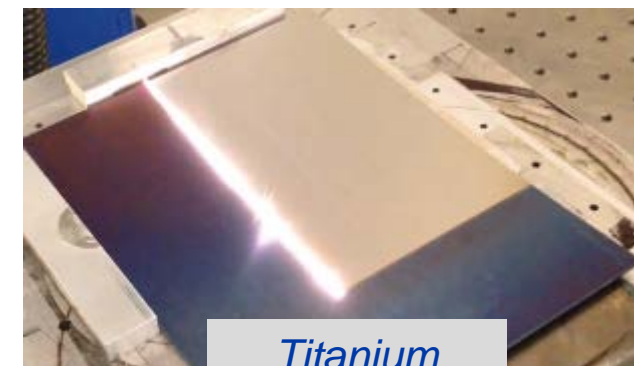
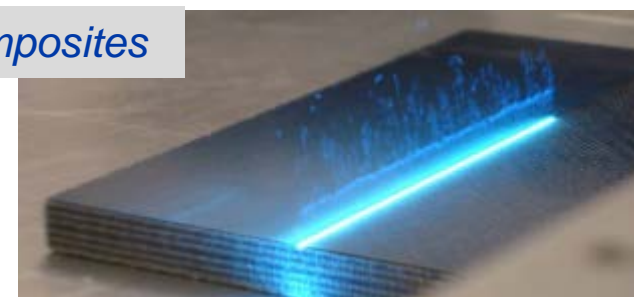


**Tool Cleaning**



**Surface Preparation**

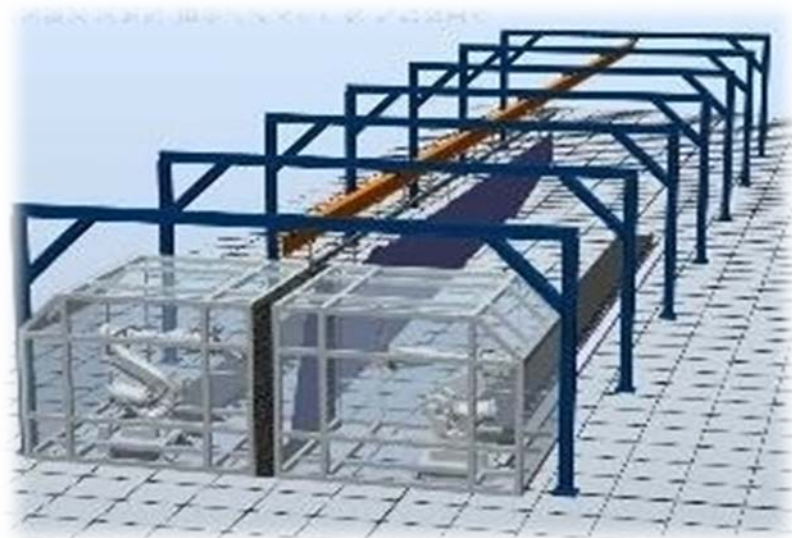
*Composites*



*Titanium*



**OEM Depaint**

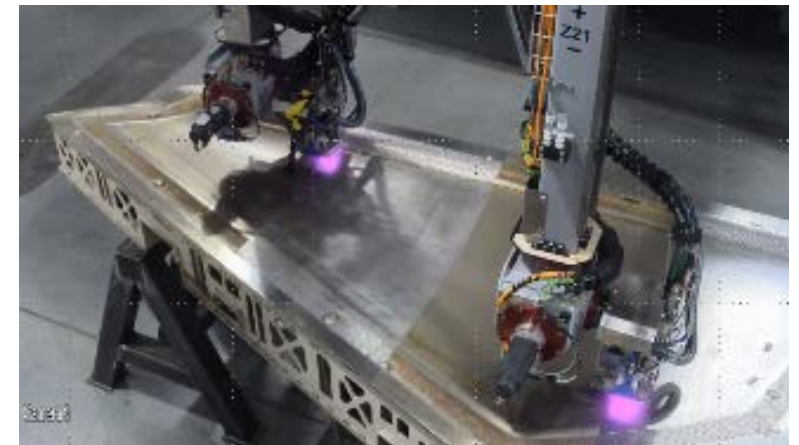
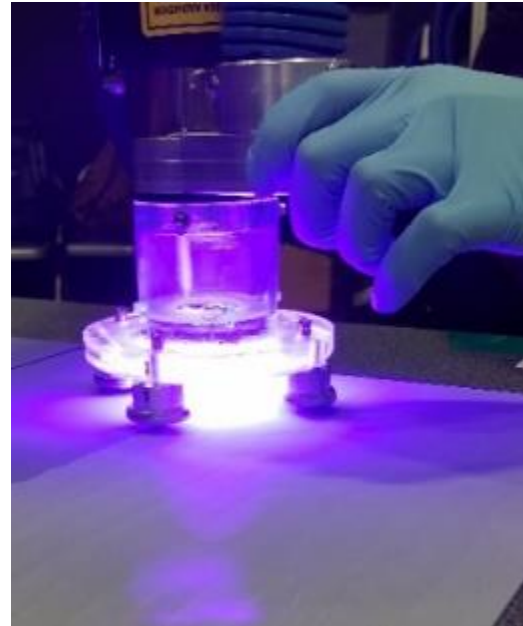


**Aftermarket Depaint**



# Identified Challenges of Implementation

- Scale
  - Movement of automation systems around complex geometries
  - Optimizing size and number of lasers
- Protection of Optics
- Worker Safety
- Substrate Integrity
- Quality Control
  - Closed-loop control of the laser
- Crowded, established facilities
  - Right-sized solutions
  - Localized containment
- Culture
  - Adoption of Technology



**Bridging the gap between development and implementation**



# Potential Solutions - Scale

## Technical Advancements

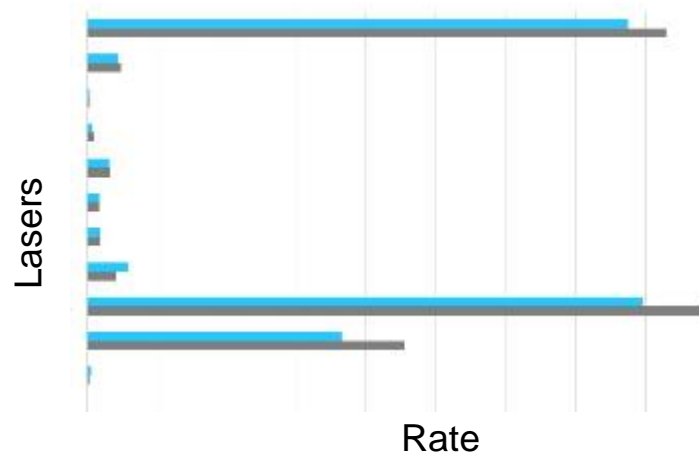
- Fiber lasers
- Higher power pulsed lasers
- Larger automation systems
- Working depth



*Scaled solutions  
Up to 50% reduction  
in flow time*

## • Looking Forward

- Improved optics
- Low cost beam delivery
- Flexibility and versatility
- Continued advancements in new laser developments



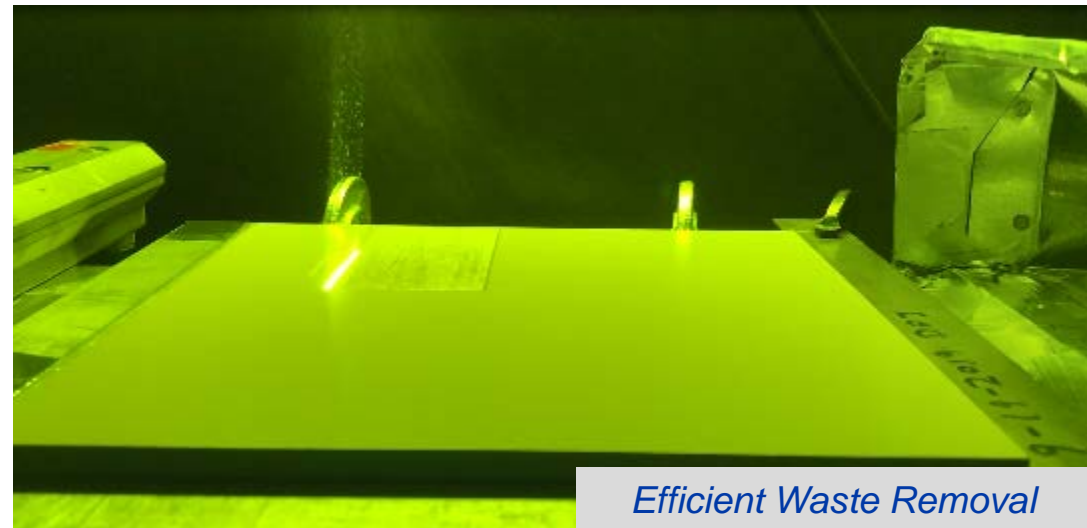
*Selecting wavelengths for  
fastest rates of removal*

*Image courtesy of Xyrec,*

**Significant advances over the last 5-10 years make laser ablation a viable processing method for large component or full aircraft depainting**

# Potential Solutions – Protection of Optics

- Contamination control
  - Positive pressure helps
  - Better optics enclosures
  - Regular cleaning schedules
  - Keep it simple
- Waste evacuation
  - Keeps area clean
  - Improves rate
  - Streamlined system
  - Reduces debris blocking the laser path



**Production environments have different levels of contamination to consider**

# Potential Solutions – Workplace Safety

- Protect Employees

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

- Looking Forward

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

**New technologies bring new safety considerations**

*Close proximity of workers not ideal*



*Class 1 Laser Enclosures*



*Socializing laser safety*



# Potential Solutions – 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*



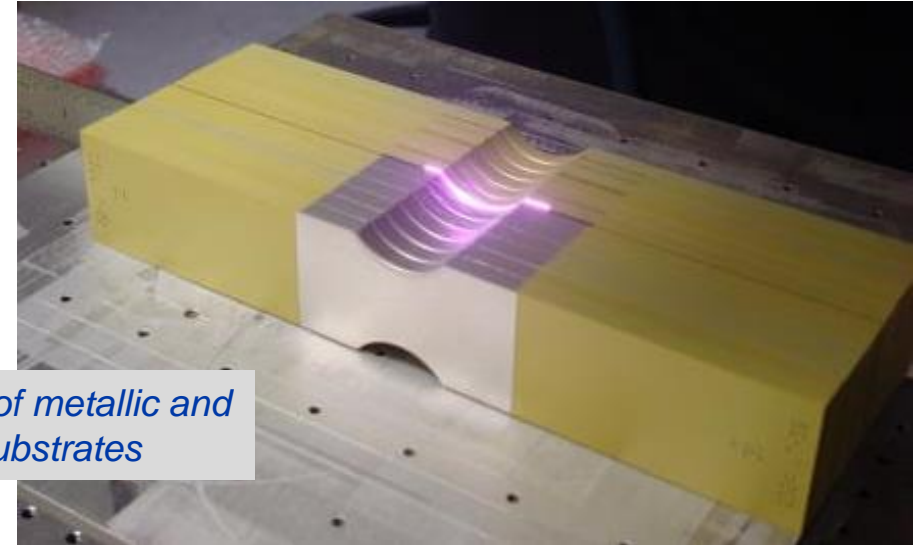
*Handhelds*



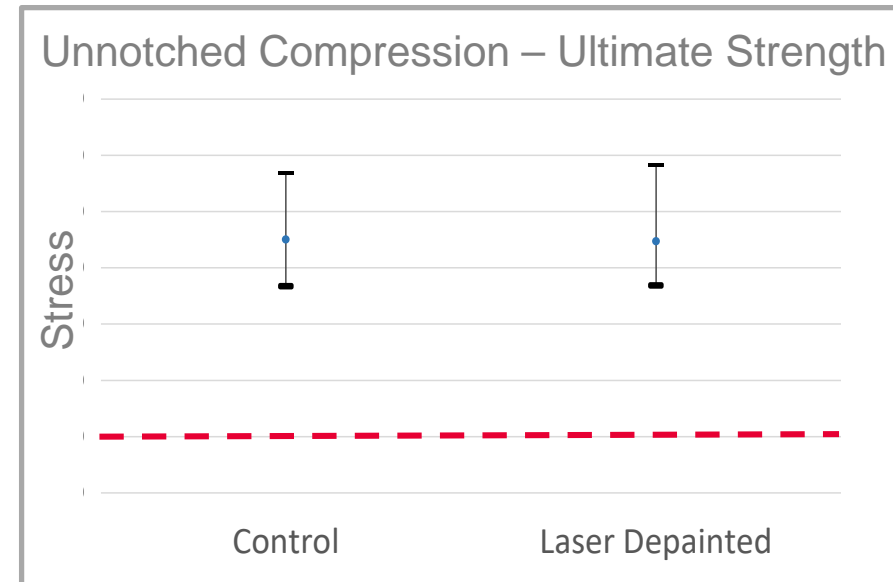
**Space is limited**

# Potential Solutions – Substrate Integrity

- No damage to substrates
  - Precise control of laser parameters
  - Test programs beyond SAE MA4872
- Looking Forward
  - New or updated industry standard(s)
  - Industry working group(s)
  - New and creative solutions to further protect the substrates



*Structural testing of metallic and composite substrates*

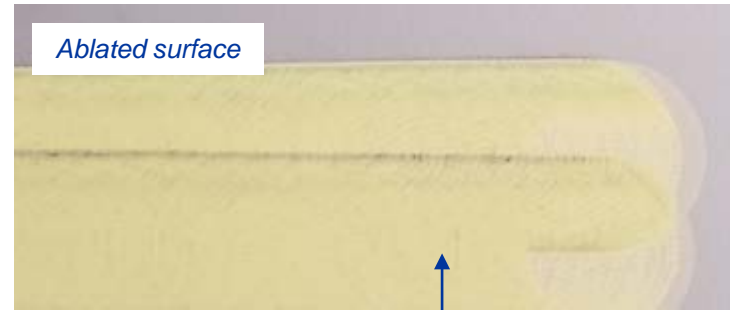


*Min. Requirement*

**Gap between industry standards and OEM requirements**

# Potential Solutions – Quality Control

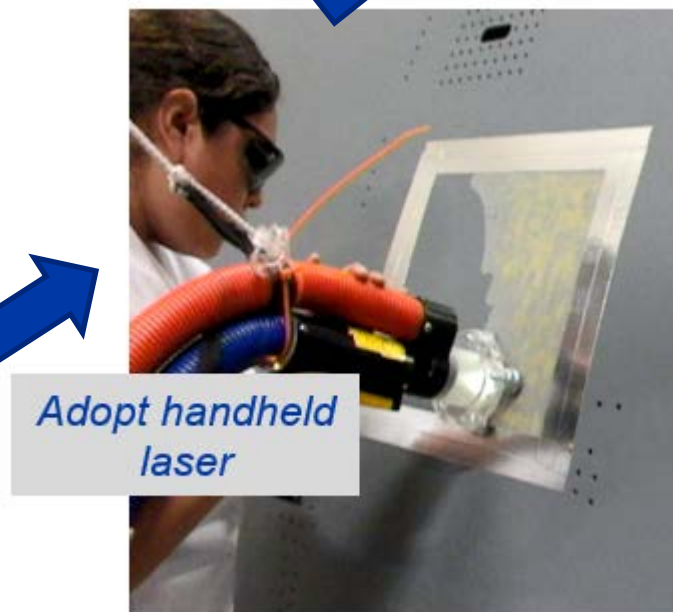
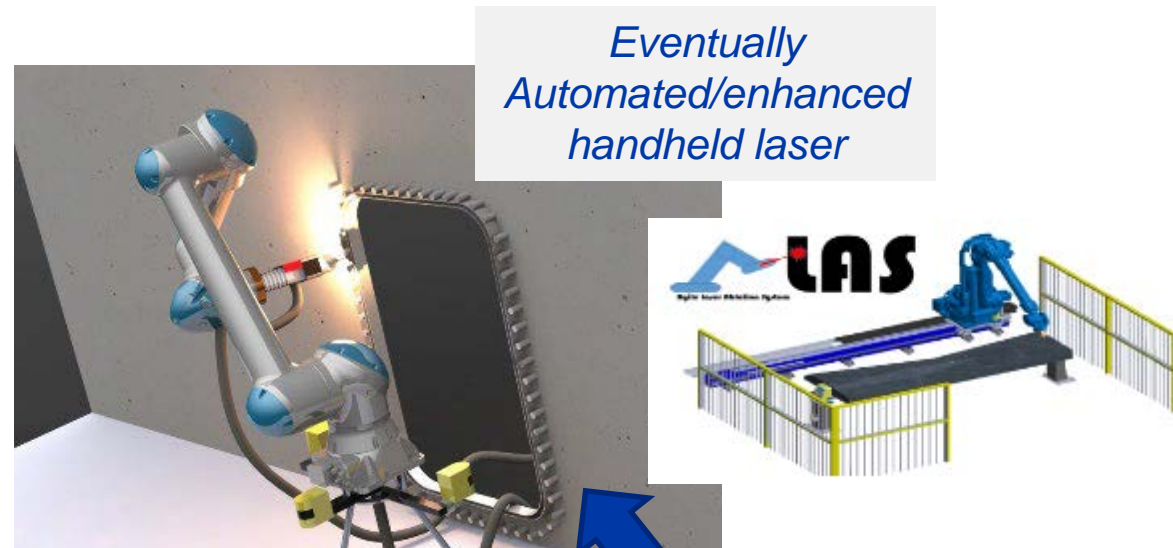
- Closed-Loop Feedback
  - Automated systems
  - In-process vs post process
  - Key technology for handheld but only based on color
- Looking Forward
  - Integrate with NDI
  - Closed-loop methods that recognize similar coating systems (e.g. light gray vs white or black over black).



**Lasers and closed-loop feedback improves quality and protects substrates**

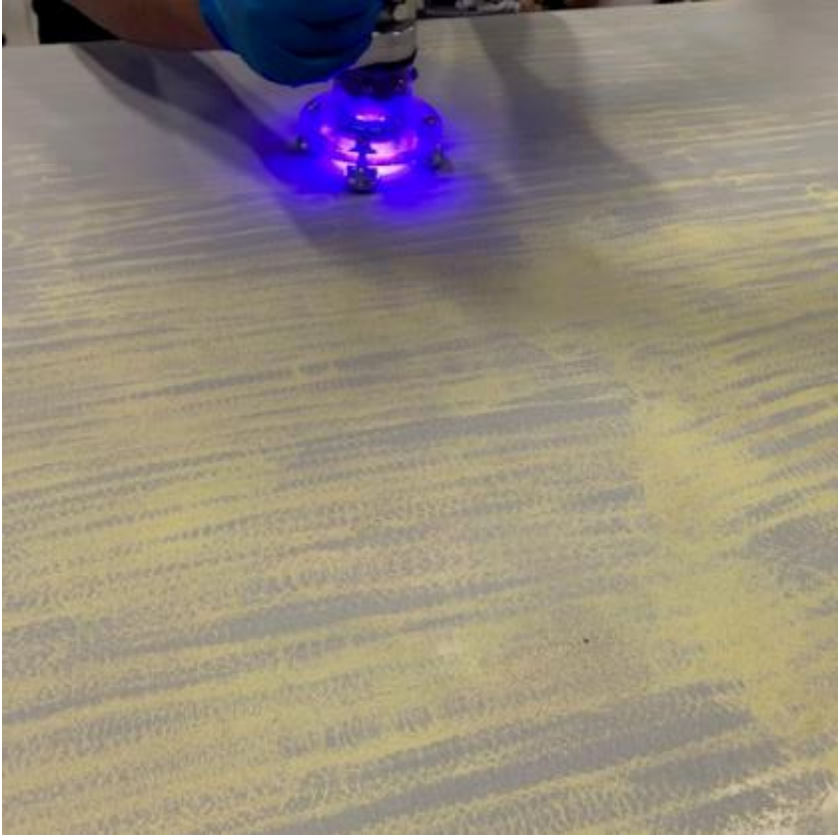
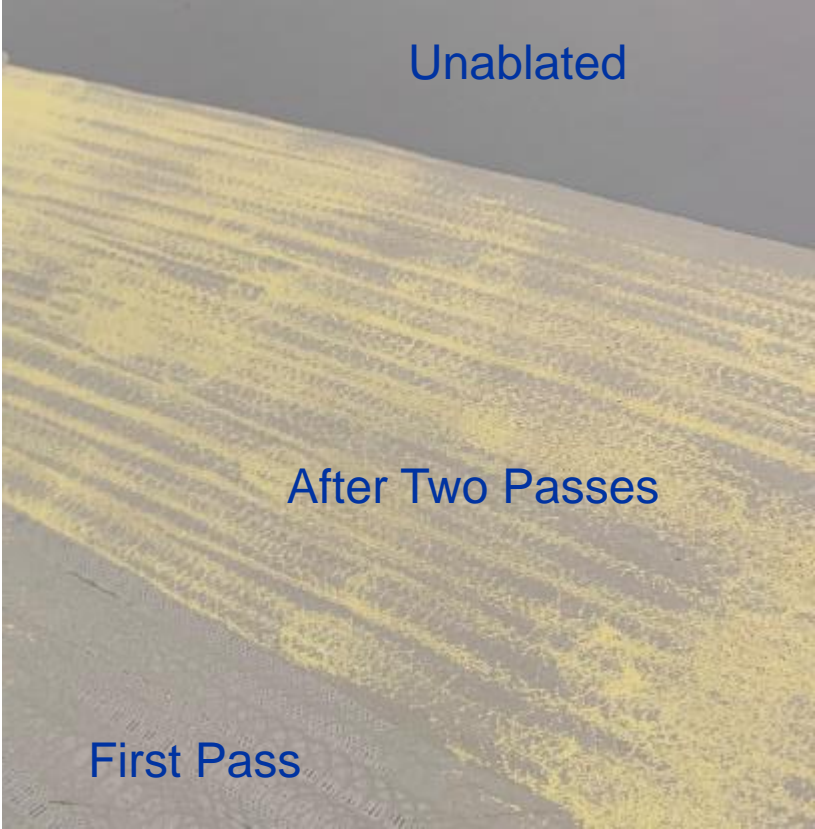
# Potential Solutions - Cultural

- New Technology Adoption
  - Trained workforce
  - Retraining to jobs in safer, more sustainable areas
  - Maintain knowledge
- Looking Forward
  - Incremental steps
  - Smart automation



**Benefits can only be obtained if advancements are implemented**

# First Production Trials of Handheld Laser on Fly Away Part

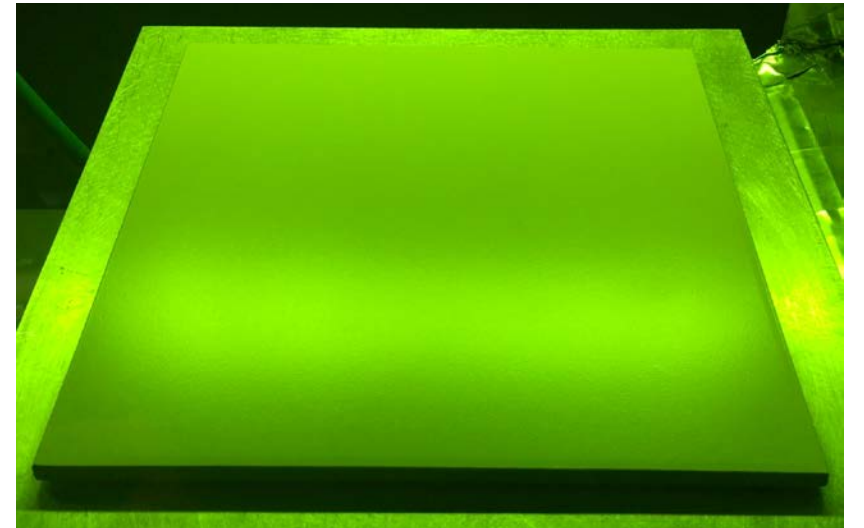


**Success!**



# Conclusions and Next Steps

- Significant advances in the laser industry in the past decade
  - Lasers are more powerful and more reliable
  - Automation is scaling to meet demands
- Implementation into production can be challenging
  - Systems must consider rate, dusty environments, safety, & culture
  - Green space is not always an option and need to be inserted into established facilities
- Additional advancements needed
  - Bigger, faster, lower cost
  - Localized containment for handheld & complex geometries
  - Smart automation



# Acknowledgements

## ■ Laser Process Development

- Kay Blohowiak
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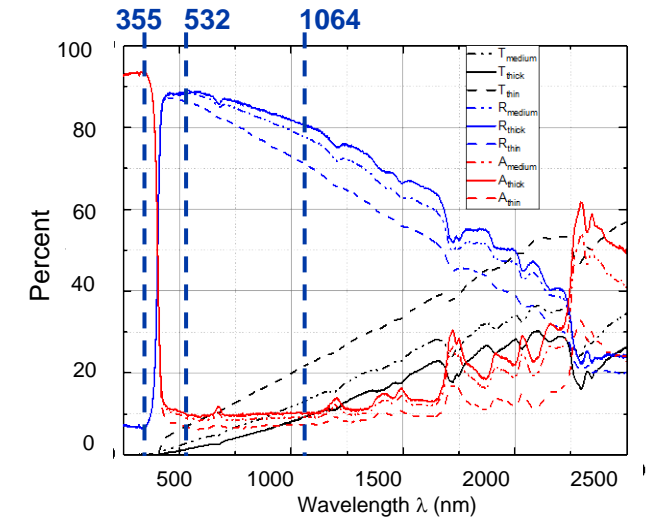
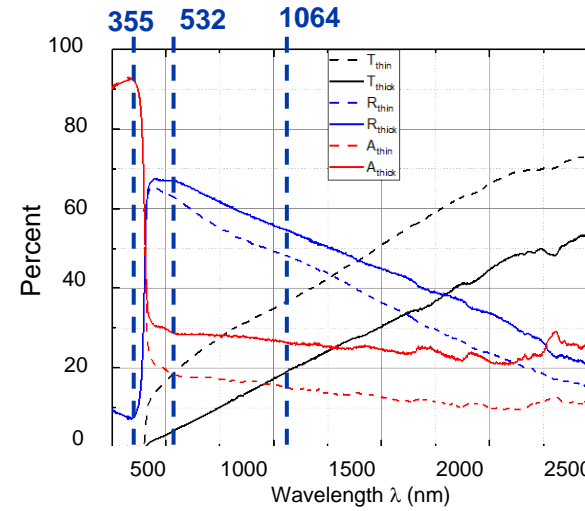
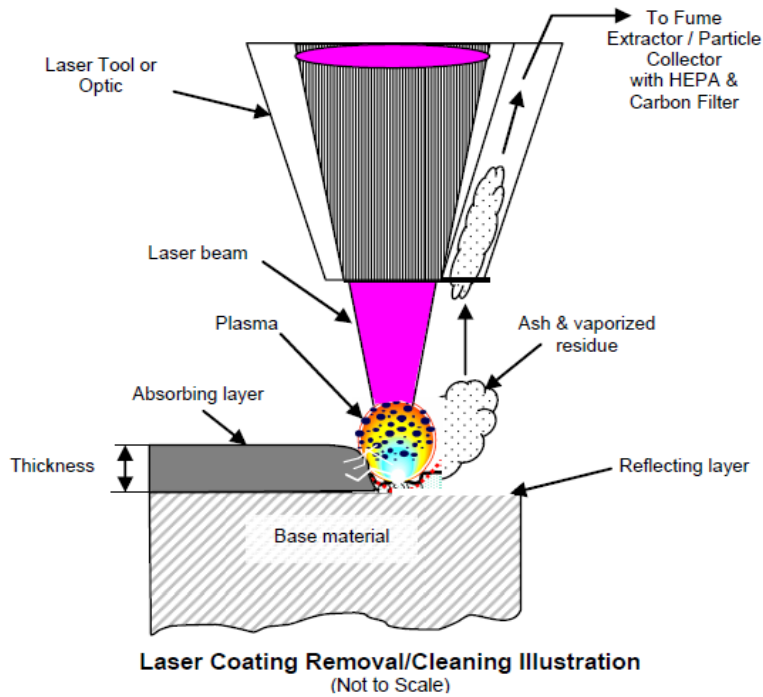
**Thank you!**



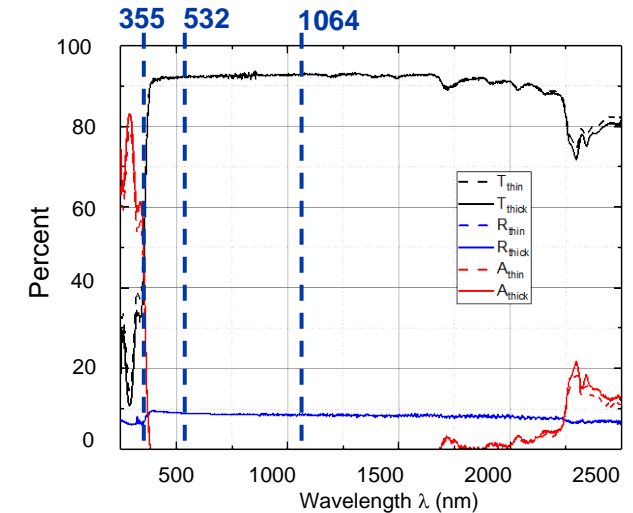
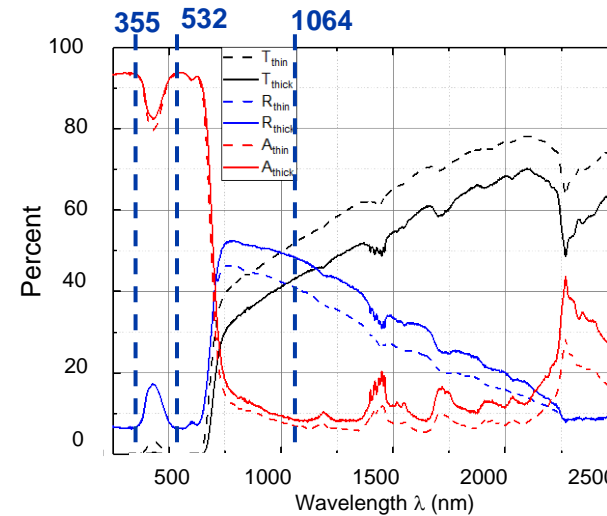
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# Laser Ablation Process

- Pulsed vs Continuous
- Size
- Wavelength
- Substrate

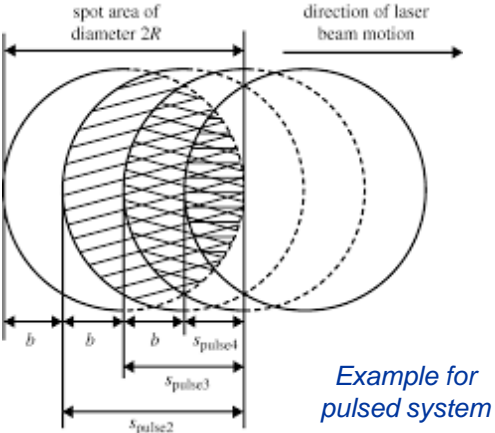


*Different coatings absorb different wavelengths*



**Laser process optimized for precise, selective removal of material**  
**One size does not fit all**

# Laser Ablation Process



*Complex shapes also possible*



*Ablated Boeing Logo*

**Laser process optimized for precise, selective removal of material**