Agenda – Day 1

12:30-12:40	Welcome – Greg Kilchenstein - ODASD(MPP)
1240 – 1245	Forum Objective: Greg Kilchenstein
12:30-12:40	Forum Rules of Engagement – Debbie Lilu - NCMS
1250 – 1630	**Presentation of Ongoing DoD Laser Coating Removal Projects (Military Services)**
1250 – 1345	Automated Rotor Blade Stripping System (ARBSS) – FRC-East
1345 – 1415	NAVSEA Laser Coating Removal from Ships Program – NAVSEA
1415 – 1430	Break
1430 – 1545	Air Force Laser Depaint Program – OO-ALC at Hill AFB
1620 – 1630	Wrap Up – Greg Kilchenstein

Welcome

Greg Kilchenstein
OSD (Maintenance Policy & Programs)

Forum Objective

- Initiate DoD-Industry dialogue
- Share information
- Identify common needs
- Identify transition challenges and barriers
- Develop common solutions to involving laser coating removal capabilities
- Create a unity of effort

Problem Statement

- Coating removal is a critical step in the equipment refurbishment process
- Current processes commonly use a combination of media blasting, chemical stripping, and hand sanding which are:
  - *Labor intensive and slow….expensive*
  - *Can result in damage to the equipment*
  - *Can cause health and safety issues for workers*
  - *Generate secondary hazardous waste*

Solution

- DoD needs a coating removal system that is faster, safer, less costly, and more effective
- For > 20 years the military Services and Industry have been actively pursuing laser coating removal technology as an alternative
- Technology advances in lasers, robotics, and IT (hardware/software) have improved the effectiveness (reliability, speed, coverage, accuracy and cost) of "COTS" tools
- Share lessons learned and develop common solutions as a community

Forum Discussion

- *Day One:*

  The Services will present ongoing DoD laser coating removal projects

- *Day Two:*

  A panel of Service and Industry SMEs will discuss challenges, enablers, transition lessons learned, and potential solutions in order to initiate development of a community action plan

Forum Rules of Engagement

Debbie Lilu
Senior Program Manager - NCMS

- DCO/Teleconference Event
- Always keep phone on mute unless you are speaking
- DO NOT put your phone on hold
- Keep computer speakers turned down except during video playback
- Q&A Panel is for questions relevant to forum content. It is NOT a chat area
- All other questions - Debbie Lilu at debral@ncms.org

Automated Rotor Blade Stripping System (ARBSS)

Fleet Readiness Center East, Cherry Pt.
Ben Thompson, Robbie Mehring

Automated Rotor Blade Stripping System (ARBSS)

3-4 December 2013

Presented to:

Laser Coating Removal Virtual Forum

Presented by:

Fleet Readiness Center East, Cherry Pt.

Ben Thompson, Robbie Mehring

NAVAIR

Overview

Automated Rotor Blade Stripping System (ARBSS)

- Background/Need
- Development Effort (Successes & Challenges)
- Production Implementation (Successes & Challenges)
- Lessons Learned
- Path Forward

Background

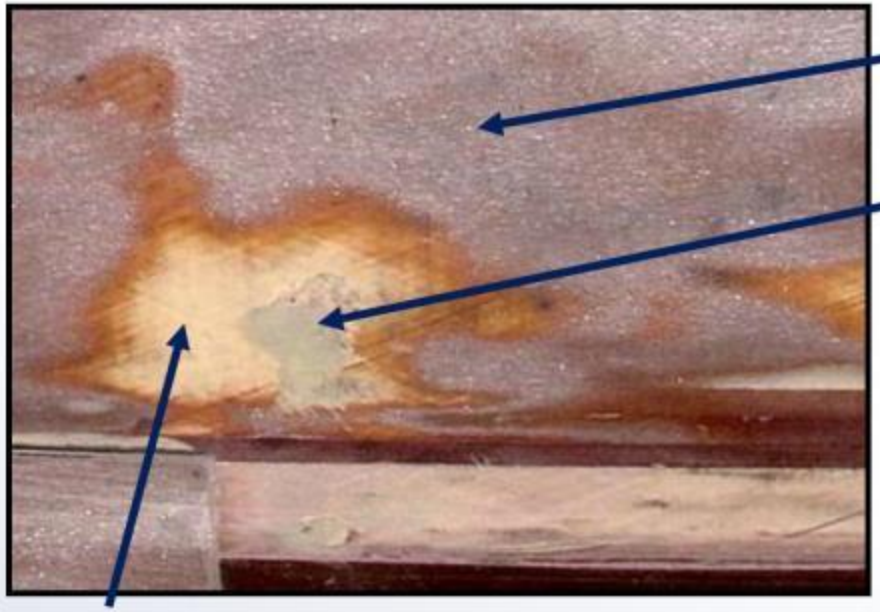
- Fleet Readiness Center East, Cherry Point:
  - Refurbishes rotor blades of various platforms
    - (*H-53E*, H-46, V-22, H-60, H-1 upgrade)
  - Paint removal required (spot or full removal)
    - Pneumatic sanding tools
    - Labor intensive (H-53E full depaint approx. 24 mhrs)
    - Process can damage the substrate
    - Generates hazardous dust, PPE requirements

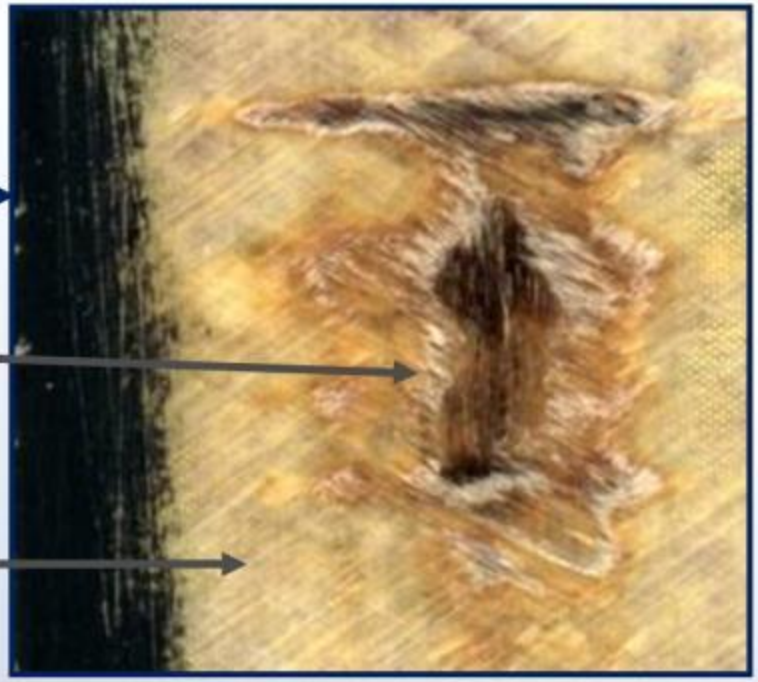
"Sanding Pit" Conditions

- Artisan relies on visual feedback to know when to stop sanding.
- Color variation between topcoat/primer/substrate

- Topcoat = Black
- Primer = Yellow or Green
- Fiberglass = Yellow
- Wire Mesh = Silver
- Adhesive = Purple or Pink

Damage from Aggressive Sanding





Laser Stripping Considered

- Concerns with using thermal process on a critical item such as a rotor blade
  - Process safe on composite materials?

- Proprietary technology involving laser removal with color recognition was targeted, thus ensuring protection of the substrate

Collaborative Effort

Fleet Readiness Center East
Marine Corps Air Station Cherry Point, NC 28533

NAVAIR

PENNSTATE
IBSS
ARL

Sikorsky
A United Technologies Company

General Lasertronics Corporation

NCMS
An NCMS/DoD Partnership

NAVSEA
KEYPORT
Undersea Warfare Center Division

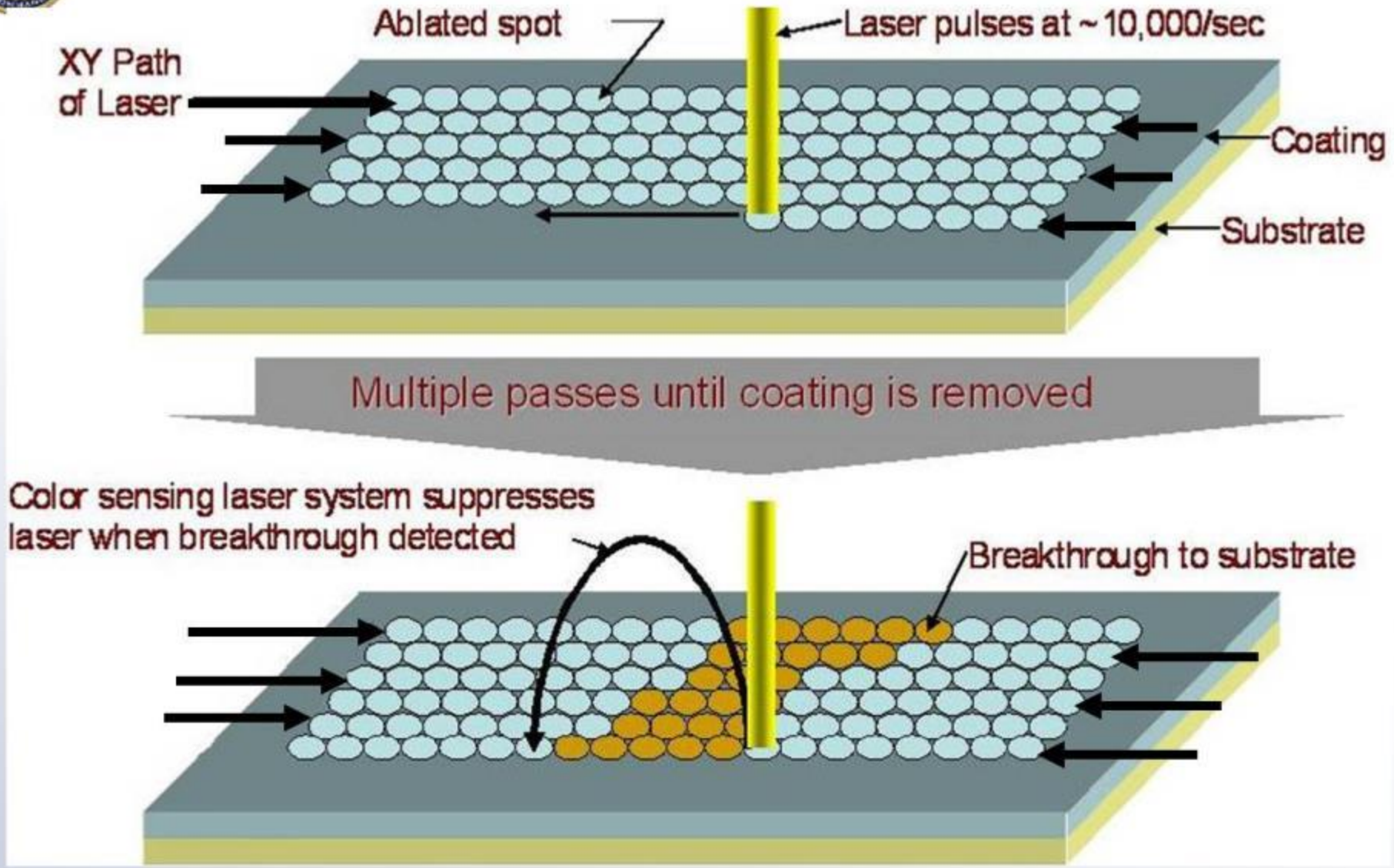
CTMA

Koops
FACTORY AUTOMATION SYSTEMS

Implementation Pathway

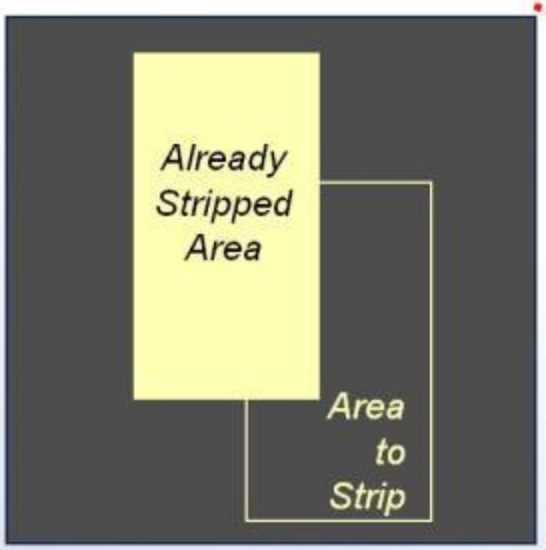
1. Determine if laser depainting technology is viable and cost-effective (FY03)
2. Define Testing Requirements (H-53 & H-60) (FY04)
   a. OEM
   b. NAVAIR (NAWC-AD & ISSC-East FST engineering)
3. Testing (FY05-07)
   a. Recipe development, thermal effects, mechanical effects, environmental, etc.
4. System Development (FY07-08)
   a. Software/hardware integration, fabrication
   b. Functional testing
5. Obtain OEM approval/spec.(FY09)
6. Issue engineering instructions (FST engineering approval) & implementation (FY08-09)

Color Recognition Technology

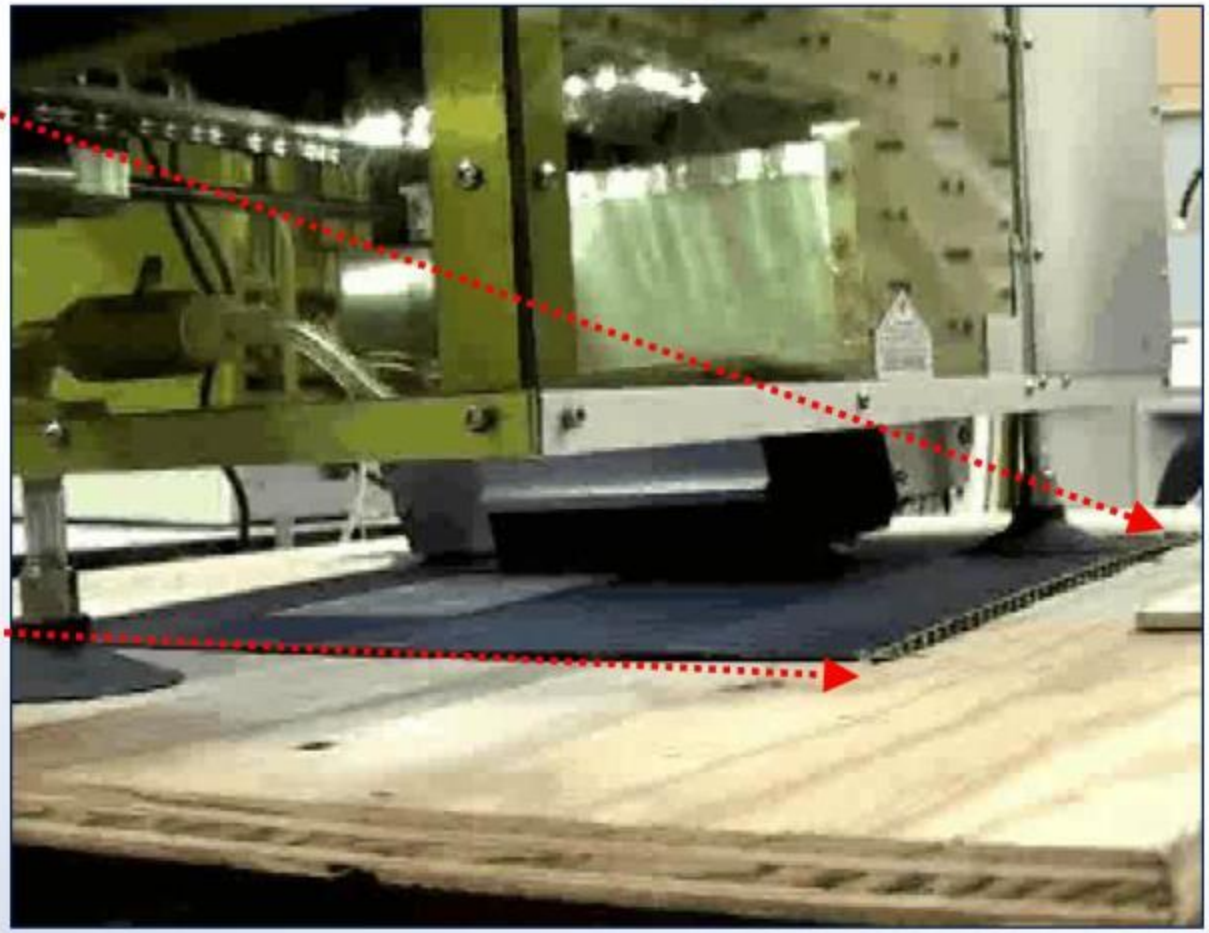


Courtesy of General Lasertronics Corporation (Mitch Wool, 408-947-1181)

Bench-Top Demo of Laser Process with Color Scanning



Topside View of Test Panel



Video courtesy of General Lasertronics Corporation (Mitch Wool, 408-947-1181) and Pacific Northwest National Laboratory (Norm Olson, 509-372-4810)

System Integration & Functional Test

Ability to Handle:

- **Multiple coating layers**
- **Blade damage**
- **Previous repair sites**
- **Different primer colors**

Challenges in Development

I. Test requirement creep as system/process was developing
   A. NAVAIR
   B. OEM

II. Major challenge with budget for build of prototype unit (cost-sharing project)
   A. Lasers donated to keep project moving
      1) 10 years old (obsolete)
      2) Half power (2-3X increase in estimated strip times)

Installed System in 2009

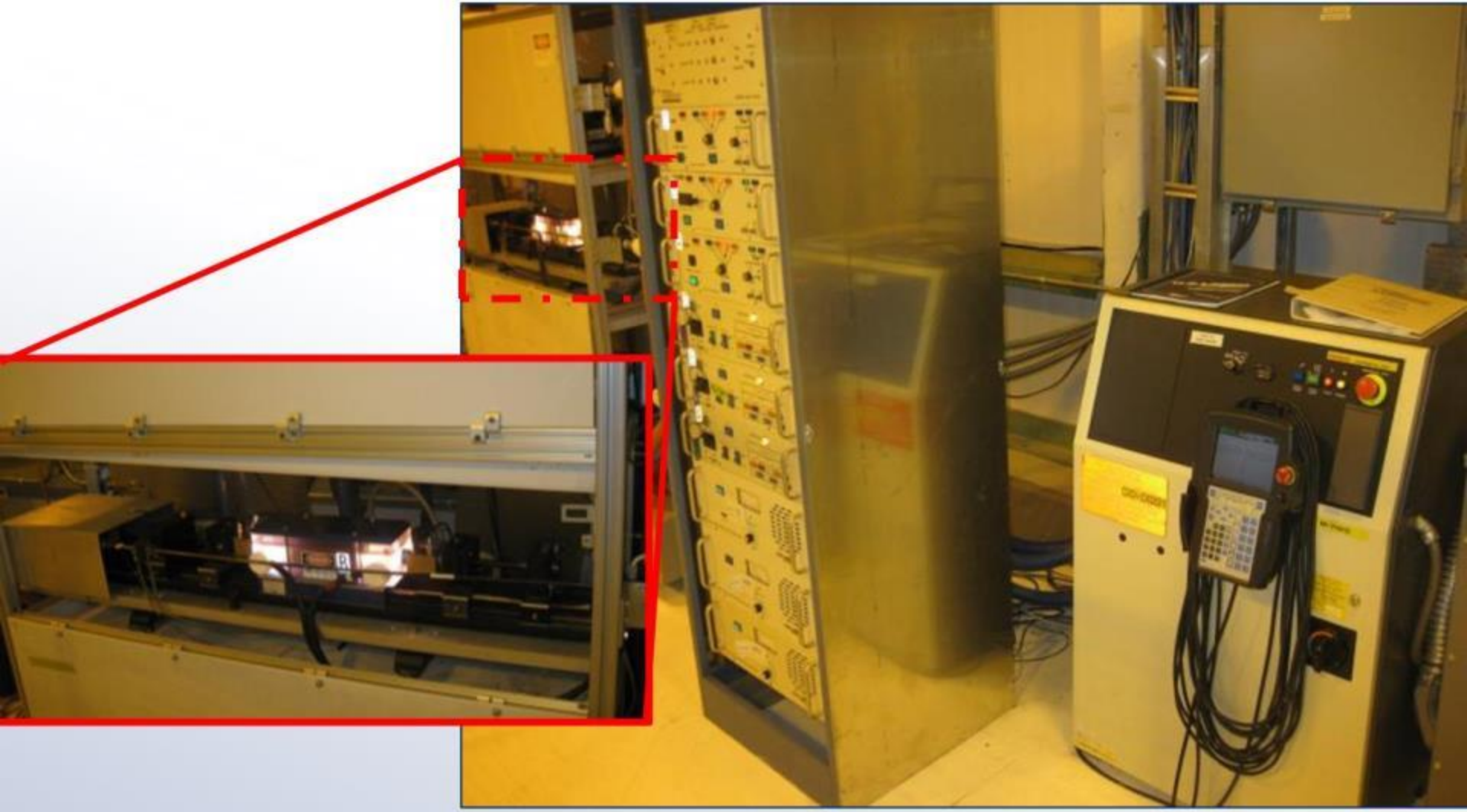
Video

Challenges in Production

I. Maintenance
   A. Hardware/component replacement
      1) Spares, long-lead times, etc.
   B. Software debugging
   C. Experience of Local Maintenance Personnel
   D. Facility Issues

II. Production Buy-In
   A. Reliability
   B. Workload

Laser Technology



Lessons Learned

I. Money – The technology must be fully financed, to include facility preparations.

II. Maintenance – The system must be capable of being maintained with COTs and local personnel.

III. Man-hours –The system must show a tangible increase in Production or benefit to the agency.

IV. Management – System technology must be included as part of the manufacturing process.

V. Engagement - Approving authorities and personnel turnover created test creep & schedule slip

Successful Outcomes

- Testing/development led to approval of technology to be used on critical safety items (H-53 & H-60)
- Concept works as designed and does provide benefits for throughput and worker fatigue

Path Forward

Expand Capabilities of ARBSS

I. Capital Improvement Project (CIP) to upgrade and improve flexibility -- FY15

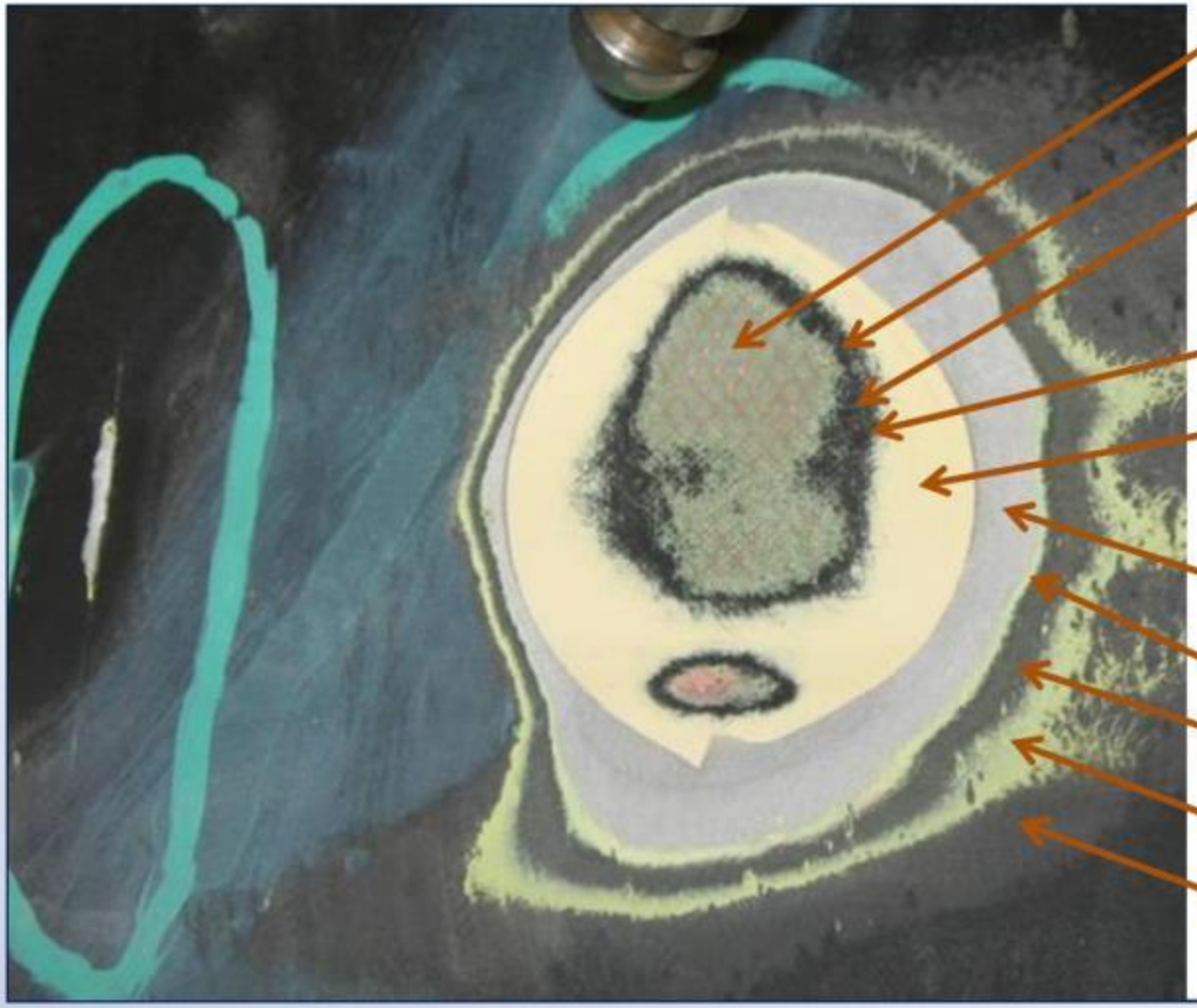
A. Upgrade lasers and supporting equipment

1) Hardware/Software

B. Integrate H-60, V-22, & H-1

1) Support fixtures/carts

Expand Capabilities of ARBSS



- Copper Mesh
- Primer
- Conductive Coating
- Primer
- Sanding Sealer
- Gray Filler
- Primer
- Topcoat
- Primer
- Topcoat

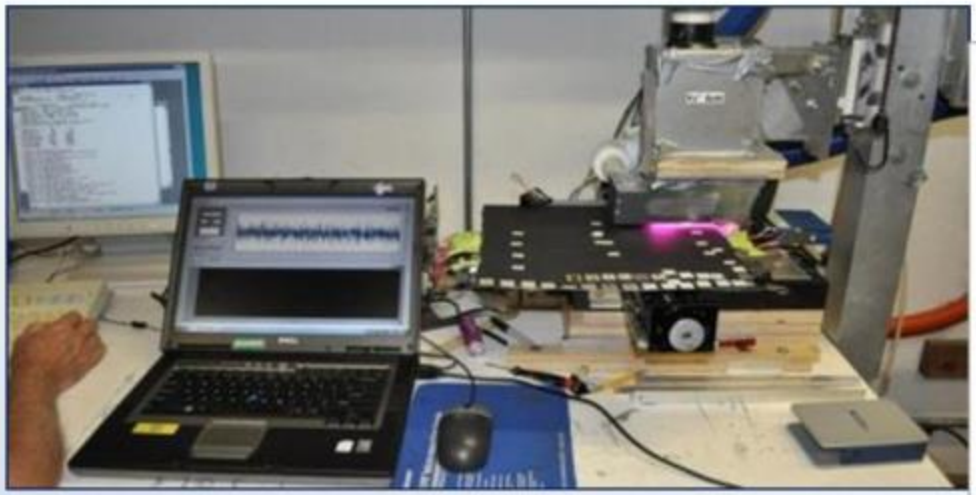
Coating Layers of V-22 prop rotor blade

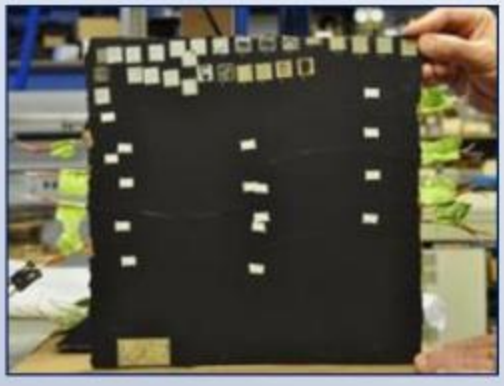
Expand Capabilities of ARBSS

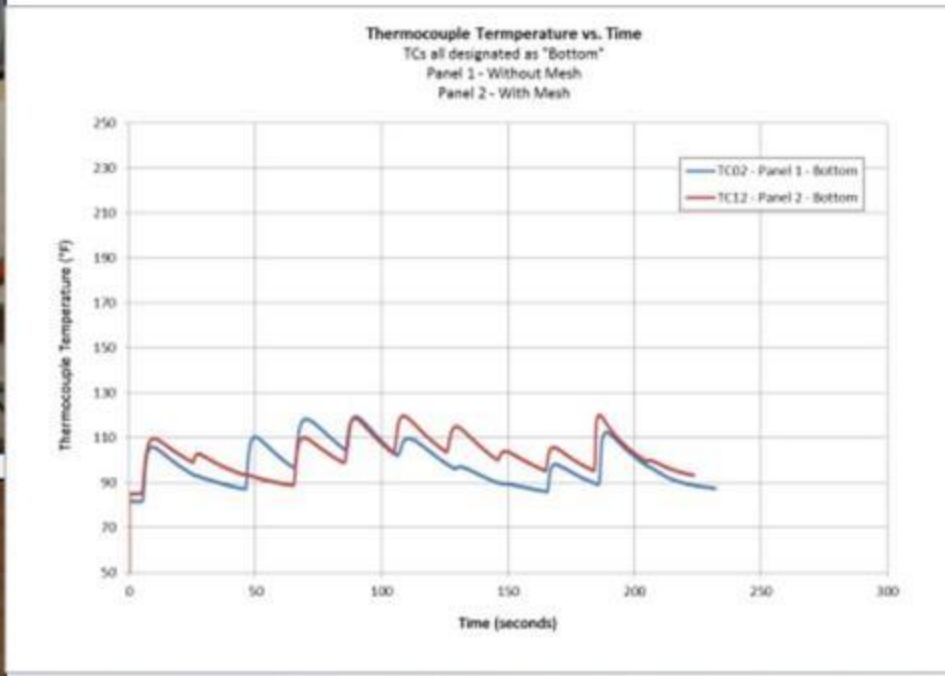
I. AERMIP project to expand platforms

A. Bench-top testing for V-22 & H-1 approval -- FY13/14

1) Thermal and mechanical impacts







Thank You

Laser Coating Removal From Ships

NAVSEA
Kurt Doehnert, Randall Santiago

Laser Ablation for the NAVY

DoD Joint Technology Exchange Group (JTEG)
Laser Coating Removal Forum Brief

Prepared by Randall Santiago

PHOTO COURTESY OF ADAPT LASER SYSTEMS AND CONCURRENT TECHNOLOGIES CORPORATION

POINTS OF CONTACT

- Kurt Doehnert
  - NAVSEA 04X
  - kurt.doehnert@navy.mil
  - 202-781-3312
- Randall Santiago
  - Norfolk Naval Shipyard (NNSY)
  - Submarine Structural/Preservation Engineer
  - Randall.santiago@navy.mil
  - 757-396-5465

LASER ABLATION

- CWP-371 is a joint venture with NAVSEA, the four Naval shipyards, private shipyards, several key vendors, contractors and universities.
  - Testing was done as three independent projects utilizing various parameters and Neodymium-doped Yttrium Aluminum Garnet (Nd: YAG) laser systems.
    - National Shipbuilding Research Program (NSRP) project - General Lasertronics Corporation (GLC or Lasertronics), BAE Systems, Vigor Shipyards and Pennsylvania State University Applied Research Laboratory utilized a GLC 400 Watt closed loop laser system.
    - Commonwealth Center for Advanced Manufacturing (CCAM) project – Newport News Shipbuilding (Huntington Ingalls (HII)) and the University of Virginia utilized an Adapt CL 1000 watt and (some limited samples with the) GLC 400 watt laser systems focusing on open loop system.
    - Norfolk Naval Shipyard (NNSY) project – NNSY and the Mid Atlantic Regional Test Laboratory utilized the Adapt CL 1000 watt laser system focusing on open loop system.

Summary of Objectives

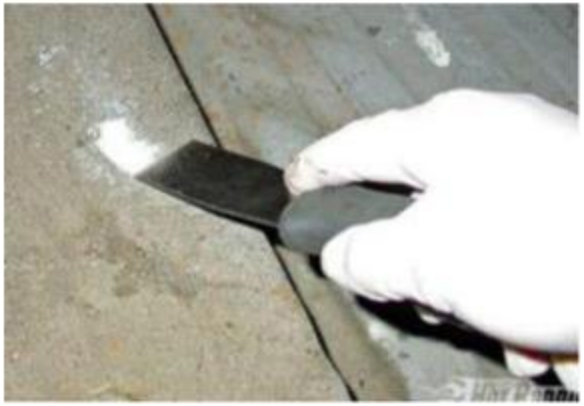
- Identify Issues and Solutions to use lasers on a Naval Vessel
  - Identify target platform for Laser use
    - Surface Ships, Carrier, Submarine – Tank, Bilge, Hull
    - Naval Vessel Inspection periodicities – typically time between Inspections 6 to 10 years
  - Navy Coatings
    - Ultra High Solids or solvent based epoxy coating; typically high mils in the range of 12-45 mils
  - Metallurgical Effects
    - Phase change / Molten layer / Fatigue Life
    - Heat effects produced during laser use on the substrate
  - Radiological Evaluation
    - Vacuum System Design
    - Exposure Savings
  - Safety Requirements

Target Platform

- Tanks, Bilges, Hull
  - Required surface prep is SSPC-SP-10/SP-11
    - SP-10 abrasive blast to near white metal
    - SP-11 power tool clean to near white metal (e.g. needle gun)
  - Some areas are inaccessible to work with current tooling
  - Some areas are constructed of complex shapes
  - Some Areas have radioactive contamination or hazardous material
    - Extensive Mixed Waste generation with current means
    - Laser Ablation has been shown to reduces waste by 2/3

Current Paint Removal Methods

Power Sanding



Hand Scraping

Needle Gunning

Example of Portable Laser Equipment

PHOTO COURTESY OF ADAPT LASER SYSTEMS

End Effector

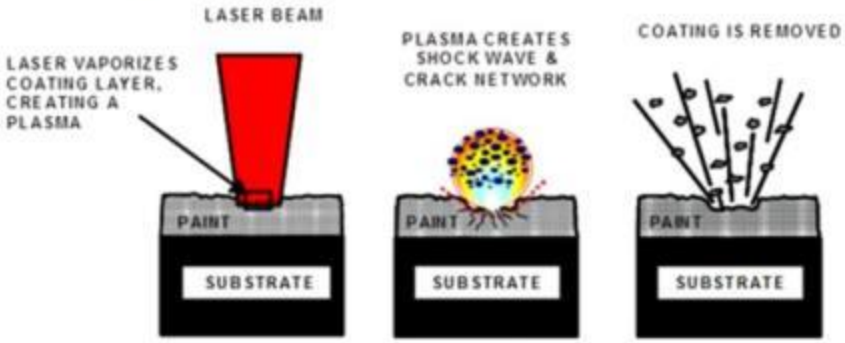
Photos courtesy of Adapt Laser Inc

FREE HAND NOZZLE

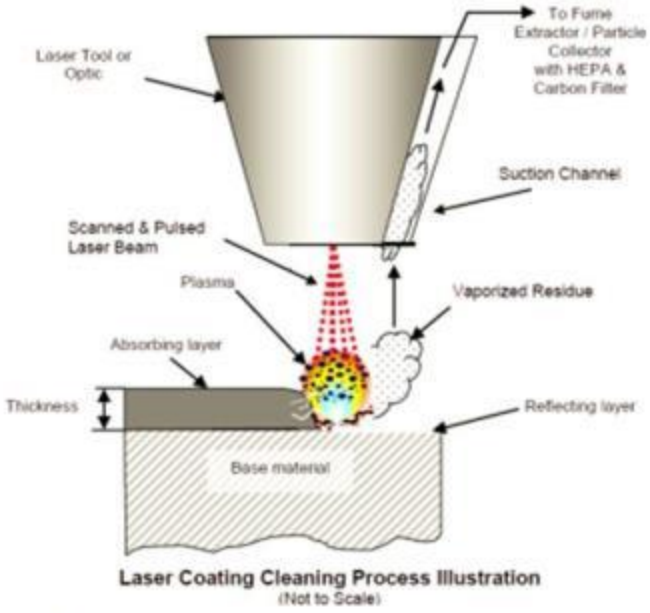
With through vacuum attached

Introduction - Laser Ablation paint removal for the Navy

- The ablation process is a mechanical process where a thin layer of coating is vaporized and converted into plasma creating a shock wave. This shock wave removes the coating and creates a crack network in the remaining coating.
- Fumes/particles/vapors are collected by the vacuum system.



(Illustration courtesy of ESTCP Report (WP-0027))



(Illustration courtesy of Adapt Laser Systems)

LASER ABLATION OVERCOMING
A COMPLEX SHAPE BY UTILIZING
REFLECTIVE SURFACES

PHOTO COURTESY OF ADAPT LASER SYSTEMS

Metallurgical Evaluation Summary

- Test analysis of laser-ablated samples prove that the laser ablation process does not produce any measurable or adverse changes in the mechanical properties including (Tensile Strength, Yield Strength, Elongation, Reduction of Area, Strain at Yield, Strain at Fracture, and Poisson Ratio) of Steel (including OSS/MS, HSS/HTS, HY-80, HSLA-100) or aluminum alloy including (5456 and 5086).

- Test analysis of laser-ablated samples prove that the laser ablation process does not produce any measurable or adverse changes in the (Vickers & Knoop) Micro-Hardness gradients or Charpy V-notch fracture toughness of Steel (including OSS/MS, HSS/HTS, HY-80, HSLA-100) or aluminum alloy including (5456 and 5086). Note: Changes in Micro-Hardness gradients are indicative of metallurgical phase transformations and/or recrystallization effects. This conclusion is also supported by metallographic analysis of sample cross-sections that shows no changes in the microstructure or grain sizes occurring within the near-surface areas of the laser-processed coupons.

- Test analysis of laser-ablated samples prove that the laser ablation process does not produce any considerable or adverse changes in the Fatigue life or fatigue resistance based on testing of HSS steel or aluminum alloy including (2024-T3).

- Furthermore, laser-ablated does not produce any visible melting of the profile features on the metal substrate surface when Inspected with a 10X hand lens and is at such a magnitude that it is only detectable by Scanning electron micrograph (SEM), optical microscopy, or similar equipment and based on all the test analysis laser ablation process does not produce any measurable or adverse changes in Steel (including OSS/MS, HSS/HTS, HY-80, HSLA-100) or aluminum alloy including (2024-T3, 5456 and 5086). The degree of melting is in the 3 µm to 20 µm range (0.000118110236 inches to 0. 0.000787401575 inches).

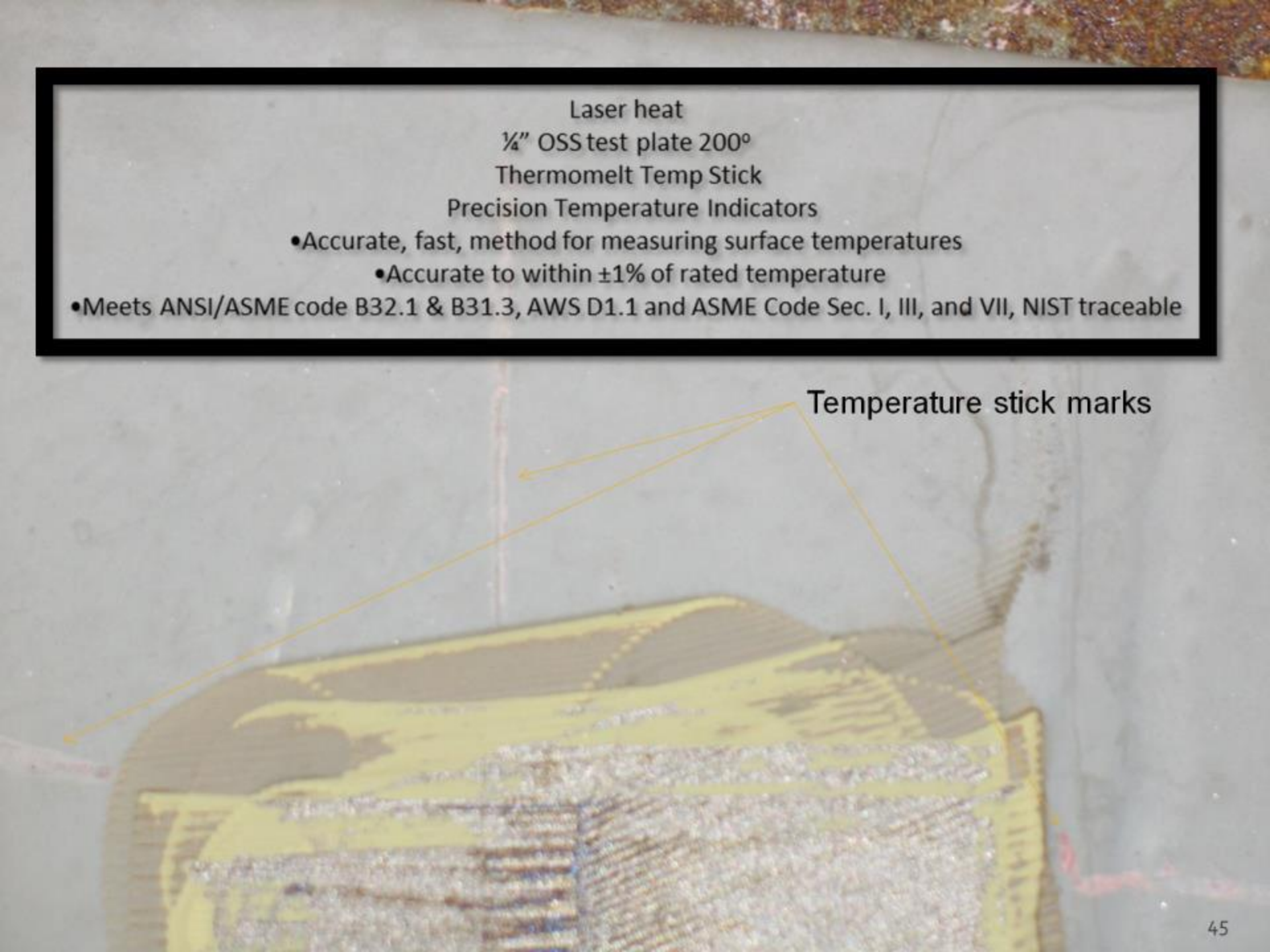
Laser heat

¼" OSS test plate 200°

Thermomelt Temp Stick

Precision Temperature Indicators

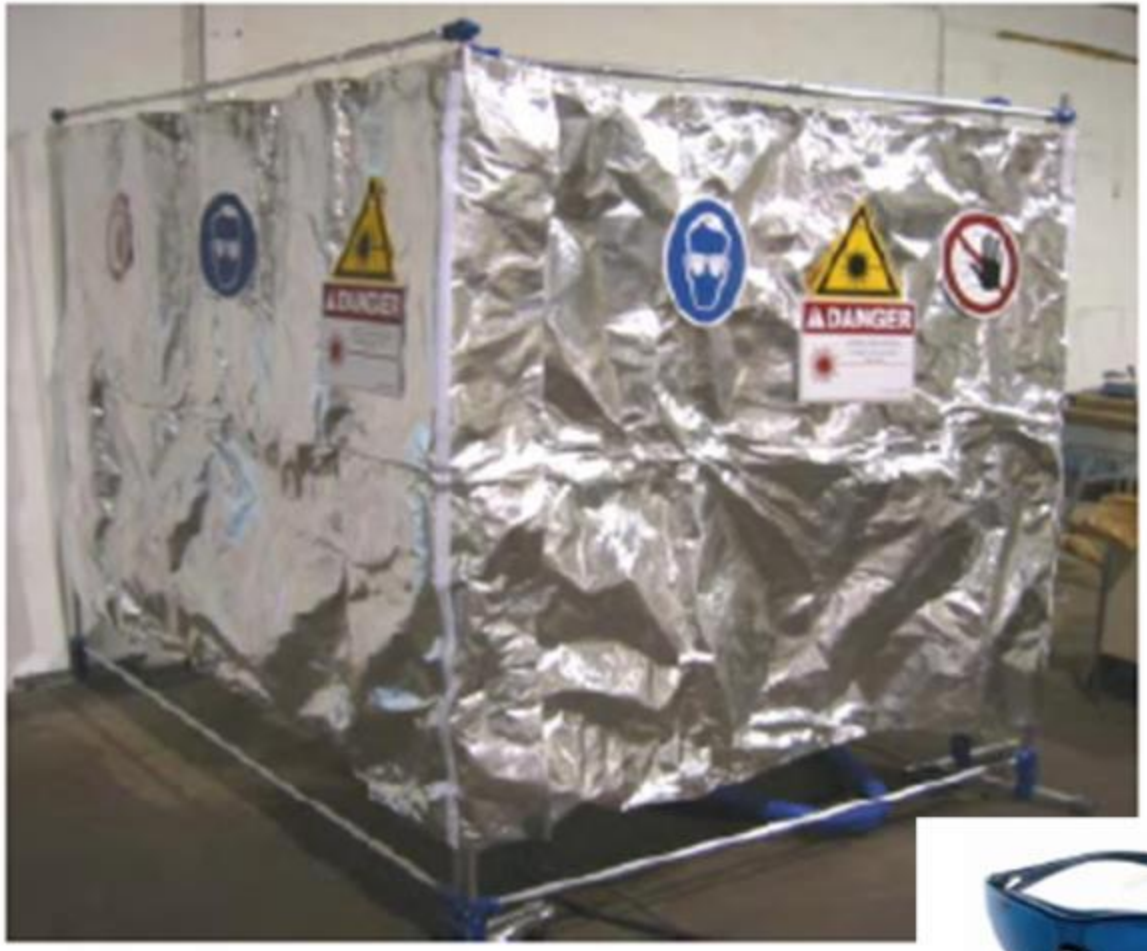
- Accurate, fast, method for measuring surface temperatures
- Accurate to within ±1% of rated temperature
- Meets ANSI/ASME code B32.1 & B31.3, AWS D1.1 and ASME Code Sec. I, III, and VII, NIST traceable



Vacuum System

Width: 28”
Height: 68”
Depth: 33”

Laser Safety



Laser Controlled Area (LCA) established

Laser safety glasses required.

OSHE requirements

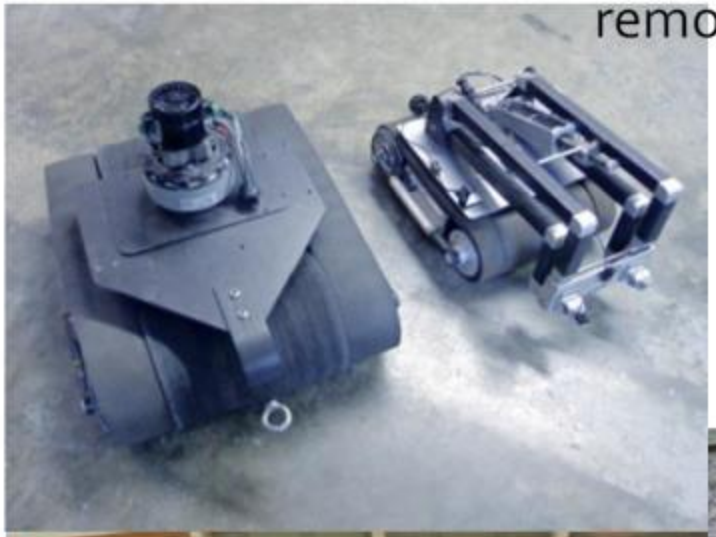
- Permissible Exposure Limit (PEL) is not exceeded while using the laser, except elevated levels of Carbon Monoxide were detected. These levels can be controlled by using proper general area ventilation.

Radiological Controls

Photos courtesy of AREVA, NP

OPTIONAL DELIVERY SYSTEM FOR LASER ABLATION

- Vacuum operated crawler allows paint removal to be worked remotely. Examples of Standard & Mini Crawler.



Mini Climber in a mockup of a nominal 24-inch frame bay

Photos courtesy of ICM

Summary

- Laser ablation can eliminate time consuming paint removal techniques or work in areas where other methods wont
- Testing has found no adverse effects on material
- Vacuum System design
- Safety/Health Organization endorses method
- Radiological risks mitigated
- On-going efforts to gain approval or an industry standard process

Break

Air Force Laser Depaint Program

OO-ALC at Hill AFB
Rick Crowther, Jim Arthur

US Air Force
Laser Coating Removal Program

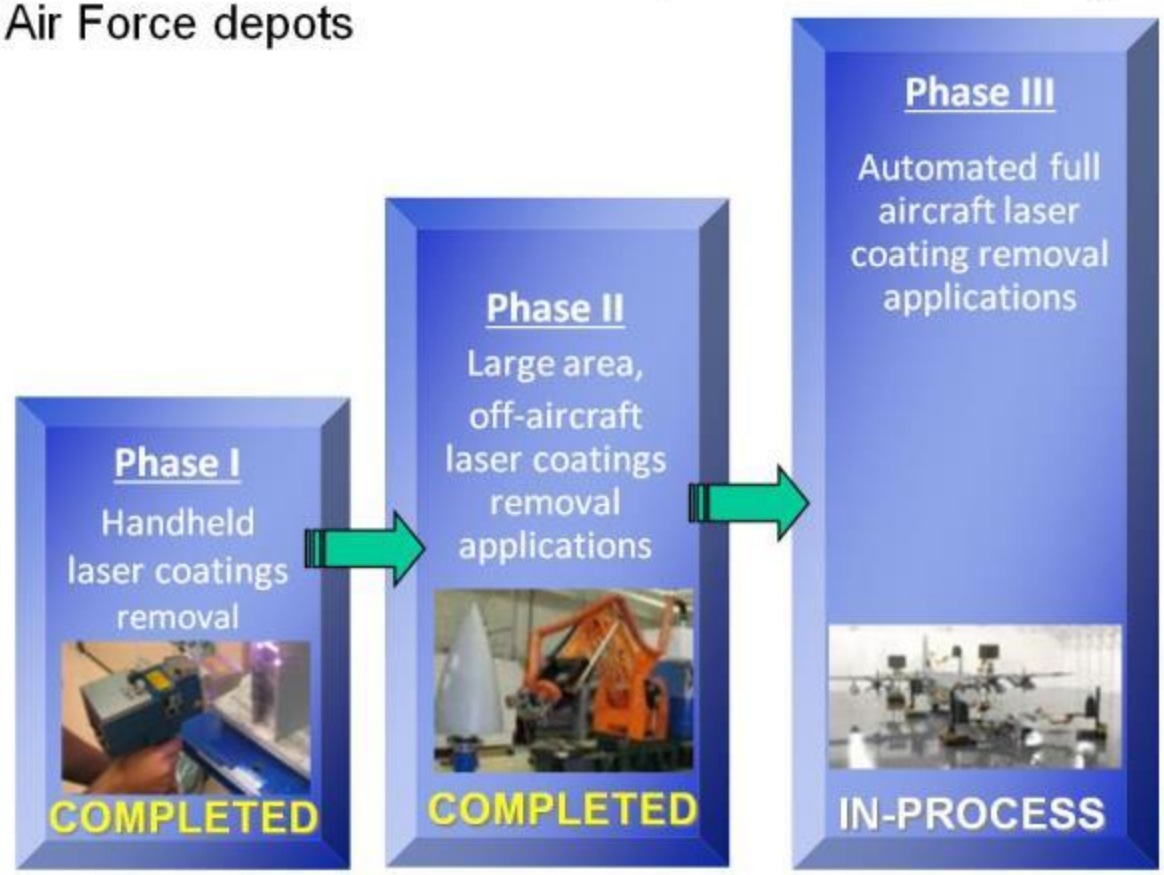
Mr. Tom Naguy (HQ AFMC/A4U)

Mr. Rick Crowther (Hill AFB–AMXG)

Mr. Jim Arthur (CTC)

Air Force Laser Program

Phased approach taken to validate and implement laser coating removal technology throughout Air Force depots



PHASE I

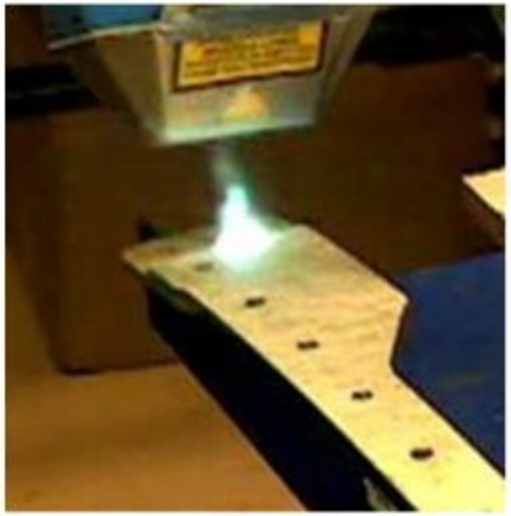
Handheld Laser Coatings Removal Systems

Objective:

- Evaluate hand-held laser systems to supplement existing small-area depainting processes on components and aircraft at depots

Benefits/Impacts:

- Increase production rate
- Replace chemicals, blast media and hand sanding
  - Reduce hazardous waste generation
  - Reduce hazardous air emissions
  - Reduce storage/handling and worker exposure to hazardous materials



Cost Benefits Analysis Results

$100K Annual savings, $1.2M Life Cycle Cost Savings,
And 2.2 year Return On Investment (ROI)

PHASE I

Handheld Laser Coatings Removal Systems (cont.)

- Evaluated 40, 120, and 500 W Nd:YAG and 250 W CO_2 handheld lasers
- Results:
  - Adequate average removal rate for small area/nitpicking operations (≈14 in^2/min)
  - No visual indication of surface damage
  - Measurements confirmed temperature spikes are not high enough to cause damage (<200° F)
  - All clad substrates tested indicated no clad penetration occurred
  - No indication of excessive surface roughness
  - Adhesion properties not adversely affected
  - Fatigue and tensile results comparable to published results from other stripping methods

Published all testing reports for DoD, DOE, NASA, and Aircraft OEM's
www.estcp.org (Project # WP-0027)

Handheld Laser Coating Removal

- OO-ALC procured seven handheld lasers to supplement the full aircraft systems and to perform small area stripping operations
  - Received Preliminary Approvals from F-16 and C-130 SPOs. Currently working process optimization and additional testing for T-38 and A-10 Aircraft
- Several end effector modifications are currently being developed to add to system safety
  - **Motion sensor** - This sensor will detect when the end effector optic is moving and allows laser firing only if the optic is moving.
  - **Temperature sensor** - This sensor will detect temperature of surface on which the laser is being used. It will shut off laser firing if temperatures reach certain thresholds to be specified later.
  - **Distance sensor** - This sensor will detect if the optic is at an allowable distance from the surface. The laser will only fire if the optic is in a certain distance window.

PHASE II

Advanced Robotic Laser Coating Removal System (ARLCRS)

Objective:

- Replace Laser Automated De-coating System (LADS) for OO-ALC
  - Integrate proven laser technology with a large robotic platform to create automated system for depainting radomes and other off-aircraft components

Requirements:

- Ability to strip A-10, F-16 and C-130 radomes and off-aircraft parts
- Incorporate commercially available and production proven laser, robot and control components to maximum extent possible
- Integrate contour following to maintain accurate stand-off and focal length
- Perform stripping in +/- x direction

PHASE II
ARCLRS (cont.)

Benefits/Impacts:

- Uses commercially available and production proven laser components
  - Real-time contour following capability – no specific path programming required
  - Real-time surface temperature measurements
  - Smaller footprint
- Faster strip rates
  - LADS took 4+ hours to strip F-16 radome and ARLCRS takes approximately 1 hour.
- Currently used strip F-16 and Navy C-130 radomes
- Cost savings of ~$330,000 annually for F-16 radomes
  - Additional savings will be realized as system is used on other large off-aircraft parts

LADS took 4+ hours to strip F-16 radome
ARLCRS (LADS II) takes 1 hour

Full Aircraft
Laser Coating Removal

Full Aircraft Laser Coating Removal is a state-of-the-art technology that can improve depot depaint operations

Benefits:

- **Significant reduction in process flow times**
  - Estimated 75% reduction in man hours for F-16 and C-130
  - Flow time savings enables increased facility capacity
- **High cost savings**
  - Estimated $2.5M/yr savings for F-16 and $11M/yr for C-130 vs. PMB
- **Selective coating removal is possible**
  - Able to leave primer layer intact
- **Safety Compliant**
  - Significantly reduces worker exposure to repetitive motion injuries & hazardous chemicals/waste

Phase III

Full Aircraft Coating Removal Systems

Objective:

- **Design/develop/implement robotic laser coating removal system for multiple aircraft types**
- **Requirements:**
  - Maximize quality and coverage
  - Maximize throughput
    - Minimize preparation & manpower requirements
    - Robust to handle variations in aircraft shape
  - Scalable to multiple robots and aircraft types
  - Design for multi-purpose use such as NDI or corrosion inspection
  - Maintainable by maximizing the use of standard COTS components and modular subsystems
  - Low-impact infrastructural footprint

Phase III

Full Aircraft Coating Removal Systems (cont.)

Status:

- Prototype System has been developed
- Validation of design concepts has been completed
- Ongoing optimization and enhancement is being performed
- OO-ALC has contracted construction of production units for F-16 and C-130 use
  - Design Specifications have been delivered and approved
  - Systems are currently in production
  - F-16 System scheduled to be delivered to Hill AFB Feb 2014 and complete June 2014
  - C-130 System scheduled to be delivered to Hill AFB April 2014 and complete November 2014

Phase III

Full Aircraft Coating Removal Systems (cont.)

- Robotic System was viewed as the key to the full aircraft system
  - Conceptual design studies were commissioned to competitively evaluate
  - 7 unique design concepts from several vendors were evaluated
  - Semi-Autonomous Mobile System from National Robotics Engineering Center was selected for production
    - System utilizes advanced sensors and autonomy providing intelligent robotic motions to achieve optimal processing time and results during coating removal operations
    - Surface Classification Software & Selective Coating Removal
      - Online discrimination of paint, primer, and substrate (i.e. bare metal)
    - Additional sensors may be incorporated for other operations (corrosion detection, etc.)
    - 3D aircraft model creation with stored surface properties
    - Collaborative robotics
      - the system dynamically adapts to unforeseen events and hardware failure.

Phase III

Full Aircraft Coating Removal Systems (cont.)

System Advantages

- **COTS vs. Custom**: System is designed to use as many COTS components as possible. This approach will ensure low duplication cost, long term maintenance, and future upgrade path.
- **Scalability**: the system is designed to scale to various size aircraft with minimal to no hardware changes and additional robots.
- **Redundancy**: identical robots are easy to swap out and replace each other.
- **Ease of setup**: the system can be installed in a new building with minimal infrastructure (only laser, tether, fiducial marker installation)
- **Flexibility**: because the robot is mounted on a mobile platform, the approach angle can be adjusted in a very flexible way. For example, the robot can be positioned between the two tail fins that are on some airplane.
- **Precise closed-loop robot to airplane positioning**: not relying on just the encoders in the robot arm for the precise positioning.
- **Model Based Planning**: doesn't require costly path training by the operator.

Phase III

Full Aircraft Coating Removal Systems (cont.)

- Prototype System assembled and validated

Video

- Mute Telephone
- Turn UP volume on computer speakers

Phase III

Full Aircraft Coating Removal Systems (cont.)

- Prototype System assembled and validated

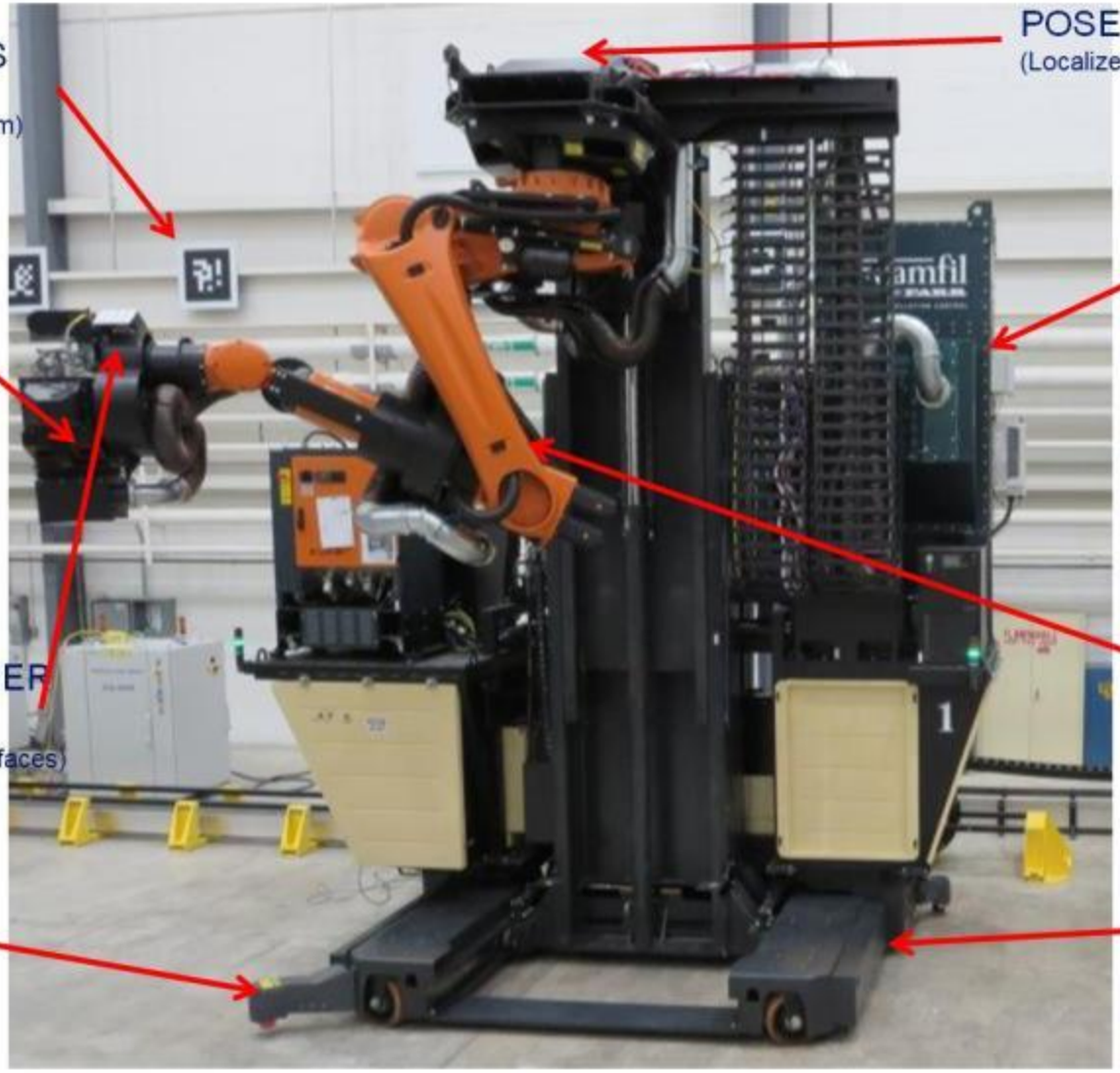
Phase III

Full Aircraft Coating Removal Systems (cont.)

- Full Aircraft Laser Coating Removal Systems are being manufactured for installation at Hill AFB
  - F-16 System will be installed in B576
  - C-130 System will be installed in B269
- Production systems being manufactured include many improvements over the previously demonstrated prototype
  - Mast redesign, end effector redesign, change to new Kuka arms, ablation control improvements including wider stripping path, automation of aircraft mapping steps, planning improvements to more efficiently process aircraft, cable track improvements

Phase III

Full Aircraft Coating Removal Systems (cont.)



FIDUCIAL MARKERS
(Used by vision system to localize position of Robotic Arm)

POSE BOX
(Localizes position of Robotic Arm)

ABLATION LASER HEAD AND SURFACE ANALYSIS POD
(Gathers data for laser stripping process)

PARTICLE COLLECTION SYSTEM

ARM MOUNTED LASER SCANNER
(Creates 3D model of work surfaces)

COTS 6-DOF MANIPULATOR

BASE MOUNTED LASER SCANNER
(Acts as "Virtual Safety Bumpers")

COTS MOBILE BASE w/ Mast

F-16 System

C-130 System

Full Aircraft Laser Coating Removal

Milestones

- Manufacturing of production units has been progressing on schedule
  - Remaining Milestones:

Jan 2014	F-16 System Demo at CTC
Feb 2014	F-16 System Install at Hill
Jun 2014	F-16 System Demo at Hill
April 2014	C-130 System Delivered to Hill
July 2014	C-130 System Integration Complete
Aug 2014	C-130 System Testing
Jan 2015	C-130 System Demo

Phase III

Full Aircraft Coating Removal Systems (cont.)

Combination of fiber laser source and scanning optics have been extensively tested for coating removal feasibility and substrate effects

- Validation performed according to approved Joint Test Protocols
  - Aluminum 2024-T3 and 7075-T6 0.025" and 0.016" thickness
  - Removal of several different coating systems evaluated
    - Standard Coating System - MIL-PRF-23377, Type 1, Class C / MIL-PRF-85285, Type 1, Class H
    - Advanced Performance Coating System - MIL-PRF-23377, Type 1, Class C / Deft Extended Life
    - Coating systems artificially aged for 7 days at room temperature followed by 7 days at 150° F
  - Panels subjected to four coating and coating removal cycles
- Mechanical Testing included:
  - Hardness
  - Tensile Properties
  - Substrate Temperature
  - Light Optical Microscopy
  - Conductivity
  - Fatigue
  - Scanning Electron Microscope
  - Microhardness
- Other Testing / Evaluation Performed
  - Fire / Explosion Testing
  - Occupational Health and Safety

Testing demonstrated results comparable or better than traditional stripping methods (PMB, Chemicals, Hand Sanding) in all areas

Phase III

Full Aircraft Coating Removal Systems (cont.)

- Additional testing requested to the specifications of the targeted SPO's
  - Targeted Aircraft: F-16, C-130
  - Depainting Technologies:
    - Evaluating:
      - Full Aircraft ARLCRS and 300W Nd:YAG Handheld Laser
    - Baseline Comparison:
      - Chemical Stripping, Plastic Media Blasting, Sanding
  - Materials:
    - 2024- T3 (0.16" bare, 0.032" bare and anodized)
    - 7075-T6 (0.040" bare and anodized)
    - 4340 Steel (0.190" bare)
    - GE (4 ply and 16 ply)
  - Completing 5 Cycles of Paint / Depaint
    - All panels painted with PreKote, Primer (MIL-PRF-23377, Ty 1), and APC Topcoat (MIL-PRF-85285, Ty IV), 10 mils total thickness
  - Materials Testing
    - Full Aircraft ARLCRS Panels
      - Metallic panels - Fatigue and Material Characterization
      - Composite panels - 4 Point Flexure, In-Plane Sheer, SEM-EDS, and ESCA
    - Handheld Panels (all metallic panels)
      - Fatigue, Material Characterization, and Tensile

LO Laser Depaint

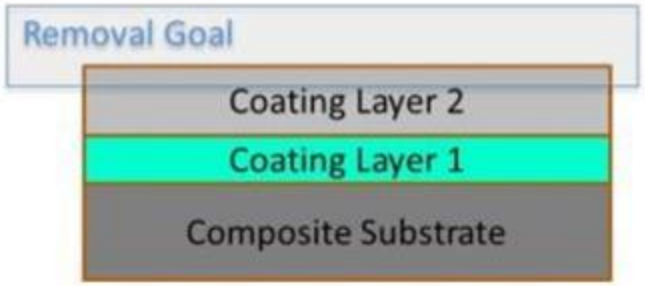
- Department of Defense (DoD) has critical need for high performance, non-media, non-chemical, low observable (LO) coating removal from weapon systems
- Current Removal Methods
  - Include abrasive technologies (i.e., media blasting and sanding) and chemicals
  - Time consuming (removal processes are principally manual in nature)
  - High cost
  - Use hazardous materials
  - Generate large volumes of waste streams
  - Manual techniques can be an ergonomic challenge
  - No selective coating removal
- Alternative Laser Removal Process
  - Efforts underway to evaluate high-powered 6 kW fiber laser for removing LO materials from modern aircraft
  - Primary weapon systems of interest include B-2, F-22, and F-35 aircraft
    - Laser coating removal could also have potential for use on other DoD weapon systems such as legacy aircraft with stealth treatments (B-1, F-16, F/A-18) and unmanned aerial vehicles (UAV)
- Potential Benefits of Laser Coating Removal
  - Automated solution that can be applied to future full aircraft coating removal systems
  - Effective coating removal without causing damage to underlying substrates/treatments
  - Selective coating removal capabilities
  - No secondary waste
  - Effluent and coating debris capture method to manage process cleanliness
  - Reduce depaint process time
  - Reduce long-term impacts and costs associated with worker damage to hands and wrists from repetitive motion injuries

LO Laser Depaint (cont.)

- LO laser removal activities leverage knowledge from previous efforts and current full-aircraft automated laser coating removal effort for F-16 and C-130
  - Leverages high powered fiber laser and scanner technologies that have matured in last few years that will allow quick and safe coating removal
  - Leverages sensor technologies developed for full-aircraft automated laser efforts
  - Automated process that can be adapted for future robotic full aircraft applications

LO Laser Depaint (cont.)

- Currently developing and testing sensor control technologies combined with laser controls for LO removal applications
  - Spectral light sensors
  - Color recognition camera sensors
  - Thickness measurement sensors
- Coating Removal Goals to Achieve
  - Selective removal of specific coating layers
  - Partial removal within the same coating layer



LO Laser Depaint (cont.)

Future Activities

- **Evaluation Testing**
  - Perform 1-cycle laser coating removal in accordance with removal goals
  - Test remaining coatings and effects of re-application of coating layers
  - Test substrate materials for possible effects of laser removal

Laser Depaint of Air Inlets

- Current methods for aircraft inlet depainting require use of abrasive blast media or chemical strippers
  - Currently, operators in full suits must crawl inside and lay in inlet while manually blasting coating
  - F-16 inlets: 2000 lbs of waste per inlet, 250 man hours, 5 ½ days
- Program is proposed to develop a laser coating removal system to automate the selective stripping of these air inlets
  - Project will combine proven laser coating removal technology with automation and innovative substrate sensors to create integrated package
  - System will be developed, validated, and installed at OO-ALC

Wrap-Up

Greg Kilchenstein

Thank You

See you tomorrow!