Robotic Automation
for Environment, Safety, and Occupational Health (ESOH) Risk Reduction, Throughput Increase, and Improved Quality

Shane Groves (Lead Equipment Engineer)
WR-ALC 402nd Commodities Maintenance Group
shane.groves@us.af.mil
Problem

Today we ask people to perform tasks that may be dangerous, time consuming, ergonomic challenging or all of the above. These factors limit personnel’s effectiveness. Aircraft maintenance activities contain inherent risks for personnel, human error drives quality inconsistencies, and worker fatigue limits efficiency and throughput.

ESOH/Safety
- Heavy Metal Exposure
- Hazardous Chemicals
- Ergonomic Issues

Quality Issues
- Following Technical Data
- Low Repeatability
- Lack of Data

High Cost
- Rework
- Inefficiencies
- Throughput
- Constraints
Solution

Adapt commercial off the shelf (COTS) industrial robots for use in the maintenance environment. Removing the human from the dangerous, repetitive, strenuous task, allows them to focus on the important decisions that improve quality and production rates.

**Improved Quality**
- Technical Data Assurance
- High Repeatability
- Data Collection / Visualization

**ESOH/Safety**
- Remove Personnel from Hazardous Environment
- Follow Hierarchy of Controls

**Reduced Cost**
- No Rework
- High Efficiency
- Reduced Flow Days
- Material Savings
- COTS Equipment
- Flexibility

**Risk**
- Operator Acceptance
- Part Damage
- Complexity

**Challenges**
- Technology Immaturity
- EOAT
- SPO
- Cybersecurity
- Maintenance
Solution Comparison

Other solutions come close but miss the mark.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Safety</th>
<th>Improved Quality</th>
<th>Reduced Cost</th>
<th>Flexibility</th>
<th>Challenges/Risk</th>
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<tbody>
<tr>
<td>Custom Equipment</td>
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<tr>
<td>COTS Solution</td>
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<td>Innovative COTS Solution</td>
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Custom Equipment

Simple COTS Solution

Innovative COTS Solution
Innovative Solution

Taking a piece of COTS equipment designed for a high yield single process operation and utilizing it in a low yield multi-process operation. These robots are coupled with advanced technologies, human machine interfaces, and specialized end of arm tooling (EOAT) to perform aerospace/defense specific task with operators that may not have robotic experience.
Robins CMXG is currently employing robotics in 17 different processes, we have contracts awarded for 6 additional processes, and plans to expand that to another 6 for a total of

42 robotic systems performing 29 different processes

**Current (17)**
- Painting
- Microwave Mapping
- Borescope
- FPI Blade Processing
- Walnut Media Blasting
- Glass Media Blasting
- Aluminum Oxide Media Blasting
- Plastic Media Blasting
- Flash Jet
- Low Plasticity Burnishing
- HVOF Thermal Spray
- Cold Spray
- Belt Grinding
- High Pressure Water Blasting
- Shot Peen
- Wing Defastening
- Core Milling

**Future – Awarded (6)**
- Sanding
- Grit Blasting for Bonding Prep
- Laser Depaint
- Mobile Wing Defastening
- Mobile Core Milling
- Mobile Structured Light Scanning

**Future – Proposed (6)**
- Composite (Radome) Repair
- Collaborative Microwave Mapping
- Welding
- Chromic Acid Anodize / Acid Pickling
- Stenciling
- Ultrasonic Inspection
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Innovation Path – Cont.

Robot Installation Over Time

- COTS Robots with Simple EOAT
- Advanced HMI
- Simplified Teaching
- Specialized EOAT
- Automated Part Location / Path Planning
- Collision Avoidance
- Collaboration

Today
Benefits

Reasons for implementing robotic automation. Typically all robotic systems will benefit all areas.

ESOH Risk Reduction
- Prop Grinding
- B180 Paint

Improved Quality
- Shot Peen

Throughput Increase
- Borescope

Reasons for implementing robotic automation. Typically all robotic systems will benefit all areas.
Benefits – Cont.

Improve Safety

– This is the big one. Following the hierarchy of controls, removing the person from the hazard is the #1 priority.
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Benefits – Cont.

Save Money

– Custom equipment ($1 – 2 Million) vs. COTS equipment ($100,000 - $200,000)
– Standardized maintenance procedures/parts
– Decrease in rework
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Benefits – Cont.

Increase Throughput:

4 Props / 24 man hours

8 Props / 16 man hours
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Benefits – Cont.

Improve Quality

- The robot will perform the task the same way every time

455 pictures reviewed/transferred to defect map in 3 hours
455 pictures taken/recorded in 6 min. Can be reviewed at leisure/off-shift in 1.5 hours

- F15 Radome Range Failure Decrease

  - Historically 2 range failures/month (manual painting) vs. 0 failures in the last 8 months (robotic painting)
Benefits – Cont.

Flexibility

– All are COTS robotic arms with specialized EOAT
– Robot can be re-tasked if necessary by changing the EOAT/sub-system components
  • FlashJet to Laser Depaint
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2018 DoD Maintenance Innovation Challenge

Benefits – Cont.

Flexibility / Data Collection

- One robot can perform multiple processes
  
  • B670 Radome Paint System
    - Robotic Paint / Microwave Mapping (SBIR Technology)
  
  • Mobile Multi-Use Robotic System (MMURS)
    - Fastener Drilling/Defastening, Milling, Scanning/Data Projecting
Benefits – Cont.

Data Visualization / Projection

– Once the data is collected - displaying it such that it is useful to the operator is key

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Benefits – Cont.

Training

- Train operators, process engineers, and maintenance personnel
- Familiarization on “non production” system
- Demonstrate robotic capabilities to the work-force, triggering ideas for more potential uses
- Test new technologies and ideas
- Test robotic vision both 2D and 3D, for automatic part location
Challenges & Risks - Mitigation

• Challenges
  – The Pairing Technologies’ Immaturity – SBIR / AFRL
  – Business Case / Economic Analysis – Highlight Cost Savings and Safety
  – End of Arm Tooling (EOAT) – Simulation / K.I.S.S.
  – SPO Buy In (New Processes) – Testing/Coupons
  – Cybersecurity – Risk Management Framework
  – Maintenance – COTS Equipment Standardization / Organic Support
  – Sustainability – Organic Programming Support

• Risks
  – Operator Acceptance – Early Involvement / Show Personal Benefits
  – Part Damage – Camera/Laser Tracking, Collision Avoidance Software
  – Overly Complex Sub-Systems – Consider Maintenance Early-On
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Innovation Future

Mobility
- No Dedicated Spaces
- "No Limit" on Part Size

Flexibility
- Multiple EOAT
- Multiple Process Support

HMI
- Simplified Interface
- Advanced Features
- Process Driven Steps

New Technologies
- Camera Tracking
- Large Area Scanning/Projecting
- Improved Accuracy for Robotic Milling/Drilling
- Microwave Mapping
- HoloLens Guidance

Collaboration
- Physical and Data
- True Human/Machine Interaction
Vision / Final Thoughts

Steps to integrate this idea throughout the DoD. We are currently part of the AFMC Robotics Working Group.

- **Review**
  - Evaluate Current Process
  - Determine Fit

- **Specify**
  - Standardization / Brand Name
  - Reference T.O. Requirements
  - Pay for IP / Data
  - Chose the Right Technologies

- **Simulate**
  - Made Easier with Robot OEM Software
  - Find Issues Early

- **Implement**
  - Involve Stakeholders
  - Build Organic Support

- **Improve**
  - Leverage Flexibility to Adjust to Issues
  - Look for New Technologies to Integrate
Questions