

# Introduction to ARM Automation

IACMI Member's Meeting

February 1, 2017

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# ARM Automation - Overview

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- Originally founded in 1993 to commercialize modular robotics technology developed at the University of Texas at Austin
- ARM is a custom machine builder and a turn-key robotic systems integrator that specializes in the development of automated manufacturing solutions for unique and challenging industrial applications
- 25 member team of engineers and technicians
- 5 Master's degrees and 1 PhD in robotics/automation on staff
- 3 Full-time field support technicians
- 20,000 square foot engineering/build facility in Austin, TX
- Prime contractor to federal government and multiple Fortune 100 companies

# Markets Served

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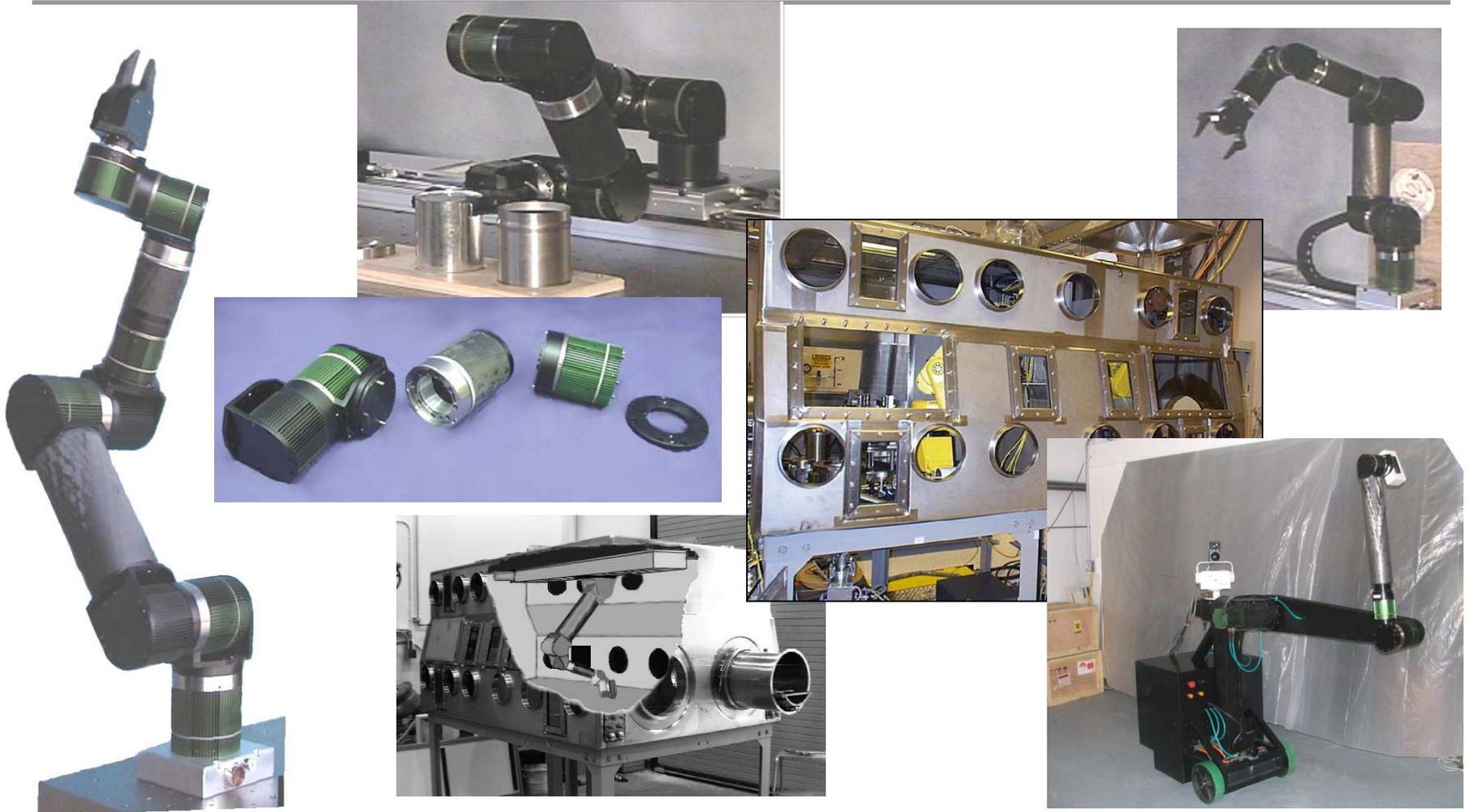
## High-Value, Challenging Applications in:

- Automated Fastening and Joining for Transportation Industries:
  - Drilling and Trimming
  - Fastener Feed and Placement
  - Surface Preparation and Inspection for Bonding
  - Fastener Cavity Fill and Finish
- Composites Manufacturing:
  - Automated Fiber Placement
  - Composites and Special Materials Finishing – Sanding/Benching/Blasting/Blending
  - De-Painting/Coating of Composites
  - Ply Picking and Sortation
  - Automated Cut Ply Picking, Kitting and Layup
- Additionally, ARM still serves several legacy customers in medical device manufacturing, niche solutions for oil and gas equipment as well as building custom robotic manipulators for unique/challenging applications

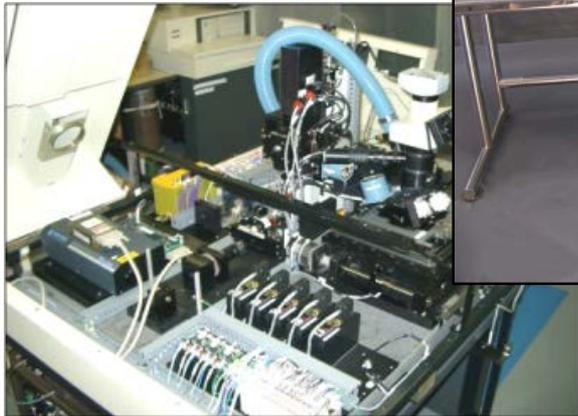
# Background and Example Applications

(limited to non-proprietary or out-moded  
customer processes)

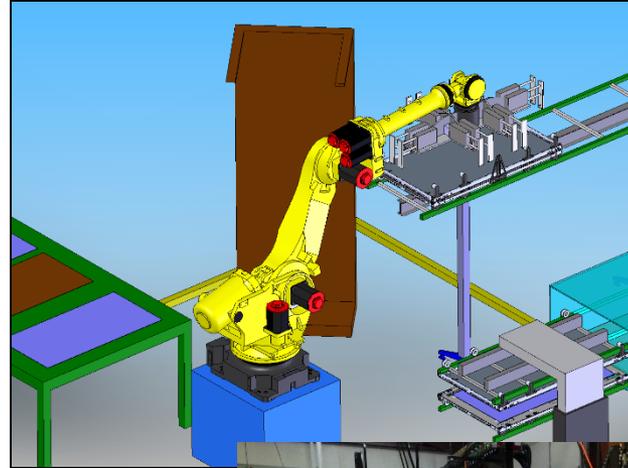
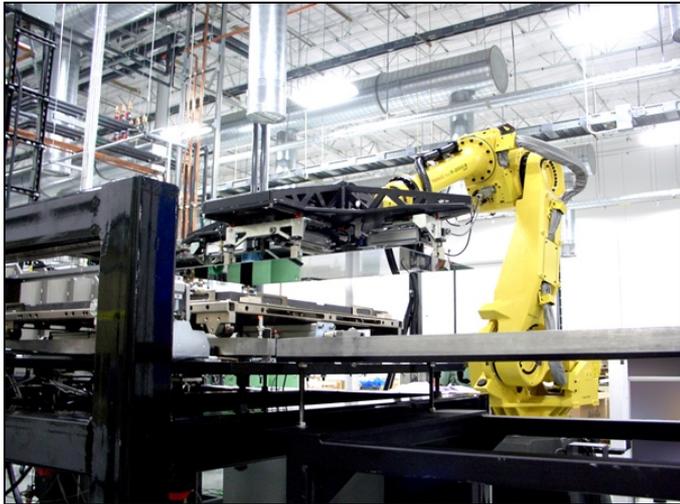
# ARM Automation Origins – Ground up Development of Modular Robot Systems for Nuclear Materials Handling



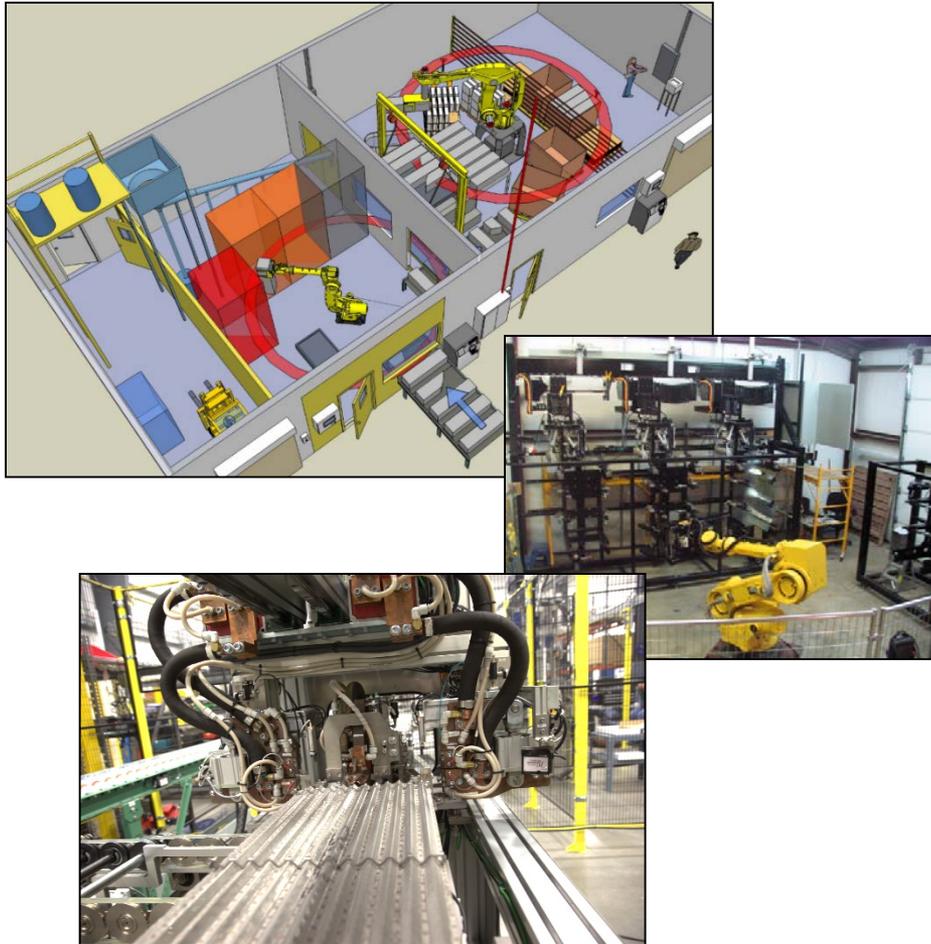
# Sub-Micron, Laser Micro-Machining and 3D Printing of Metallic Structures



# Solar – Process Tooling and Material Handling for Thin Film Solar Panel Manufacturing



# Hazardous Material Handling, Container Assembly and Packaging Production Line



- Complex, multi-step scheduling and production control system for high-mix, multi-variable product
- Multiple layers of variable length corrugated wire mesh tube plates are stacked and joined using spacer bars which are formed to shape on demand
- In-line inspection of incoming feed material and quality control/quarantine
- Material delivery of granular toxic/pyrophoric ceramic materials
- Precision filling, closing and welding
- Wax coating of modules and dynamic pattern pallet build
- Turn-key System Development, Design, Build, Integration and Support

# High-Speed Sorting and Kitting Solutions



ARM High-Speed Sorting, Storage and Retrieval  
Systems for Medical Products

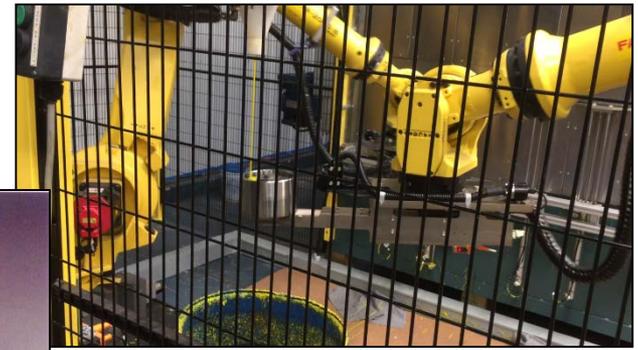
- ARM has built many custom automated sortation systems for medical devices, semiconductor and high-value consumer products
- These high-speed ASRS systems include development of substantial part tracking and kit management software
- Systems have been designed for clean-room environments as well as harsh-duty applications
- Multi-layer, moving carriages enable increased storage density for high-value products in valuable floor space
- Top-load magazines of sterile medical products are shown here
- Vision-based part registration

# ... and Many Other Industries and Applications

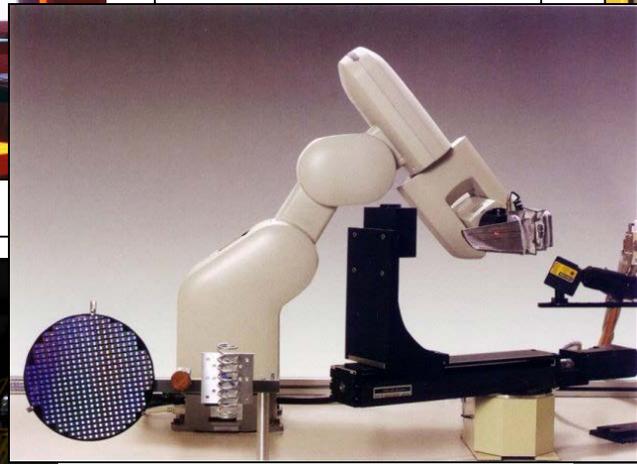


Vision Guided Assembly of Electronics

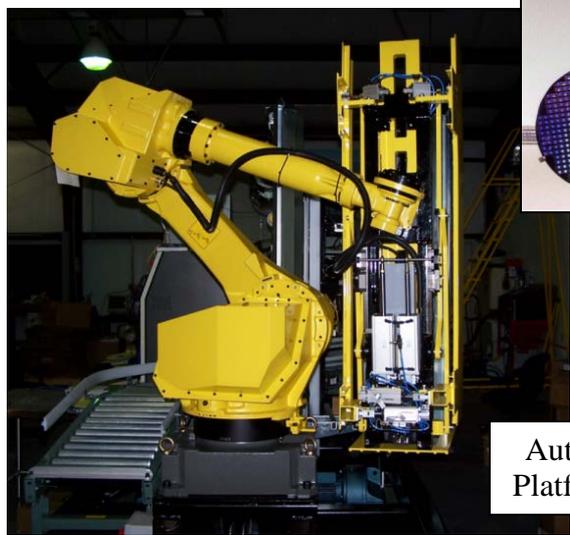
X-Ray Inspection of Gas Turbine Blades



Polymer Pouring/Bonding Process



Ultrasonic Inspect-in-Place System for GE Steam Turbine Blades



Automated Mobile Robot Platform for Truck Loading



Past Areas of Work  
Relevant to  
Composites and Aerostructures

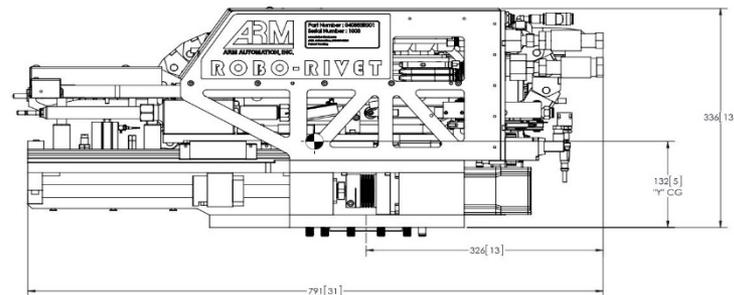
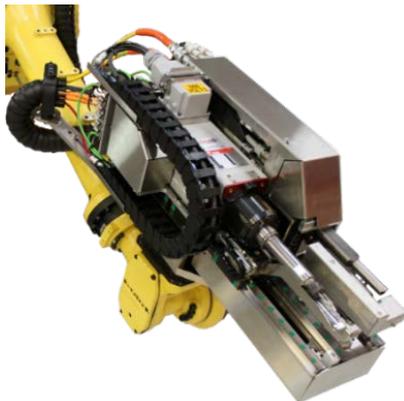
(limited to protect specific  
customer information)

# Robo-Rivet – Fully Automated Drill and Blind Fastener Placement System

- Fully-Automated drilling and blind fastener riveting of mixed material structures
- Aimed at high-throughput automotive and lower-precision aerospace applications
- Small fraction of the cost of current drilling systems in aerospace
- Supports multiple fastener types and materials



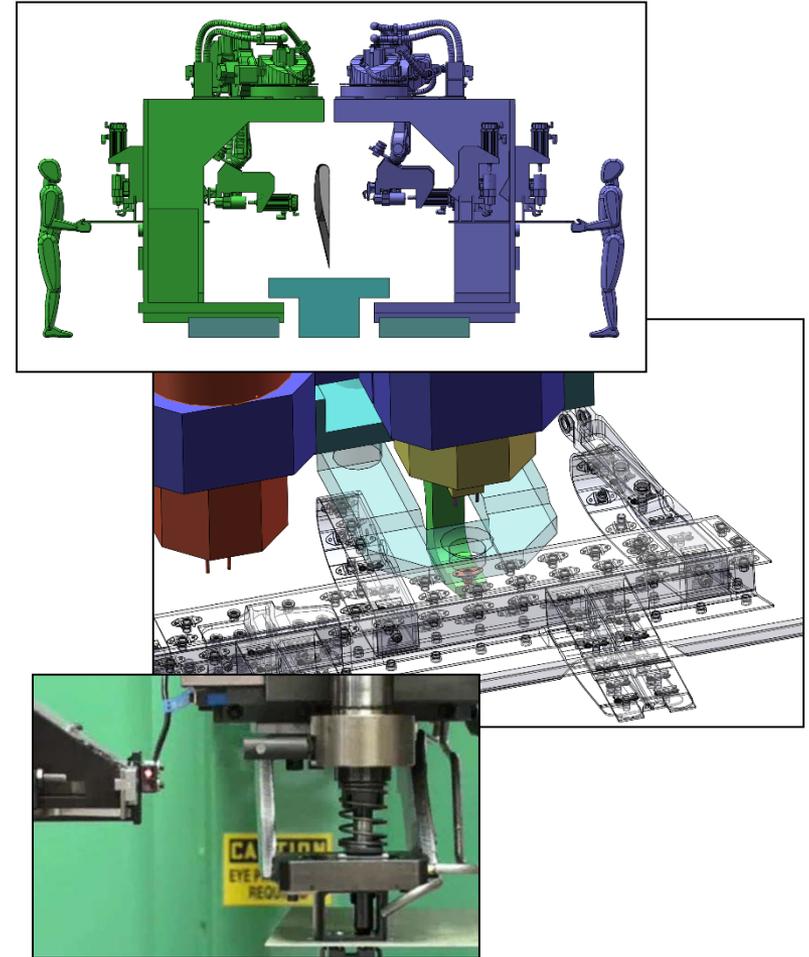
Tesla Model X line



See [www.Robo-Rivet.com](http://www.Robo-Rivet.com) for more information

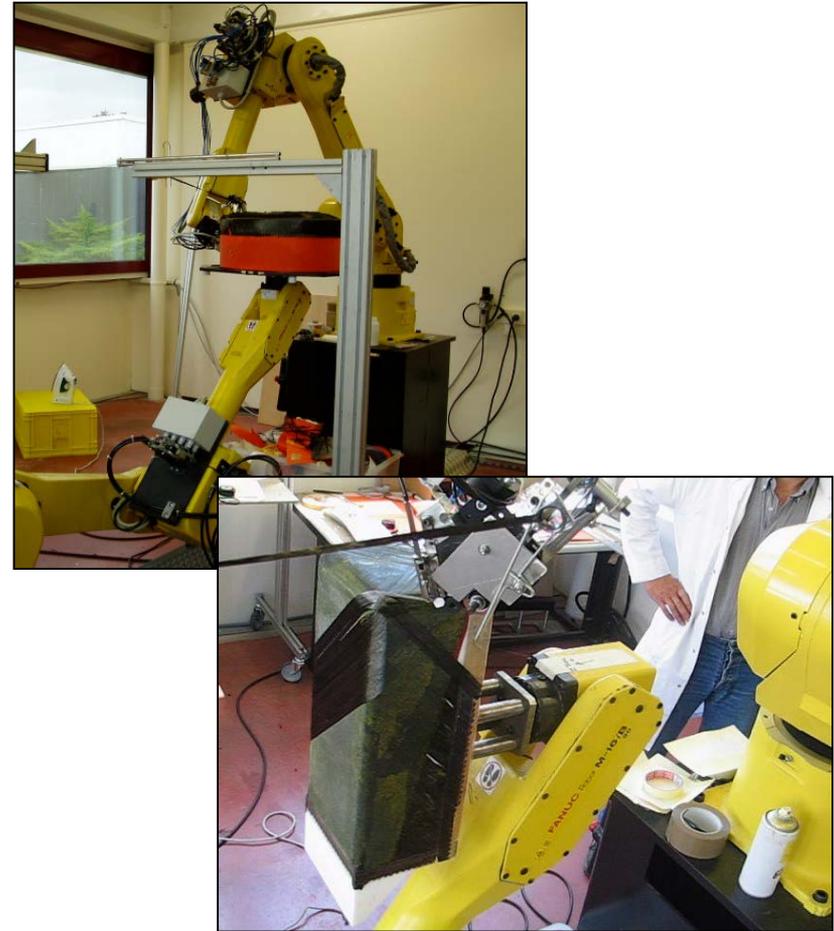
# Robotic Nut Plate Installation and Form-in-Place Carbon Fiber Reinforced Fasteners

- Based on its Robo-Rivet experience, ARM is currently developing 2 custom drilling and riveting solutions for unique aerostructure nut plate attachment
- These solutions are separately suited to drill, locate and rivet a select range of nut plates into partially completed metal and composite flap assemblies
- This experience and product plan is also applicable to preparation and placement of bonded composite plates and components



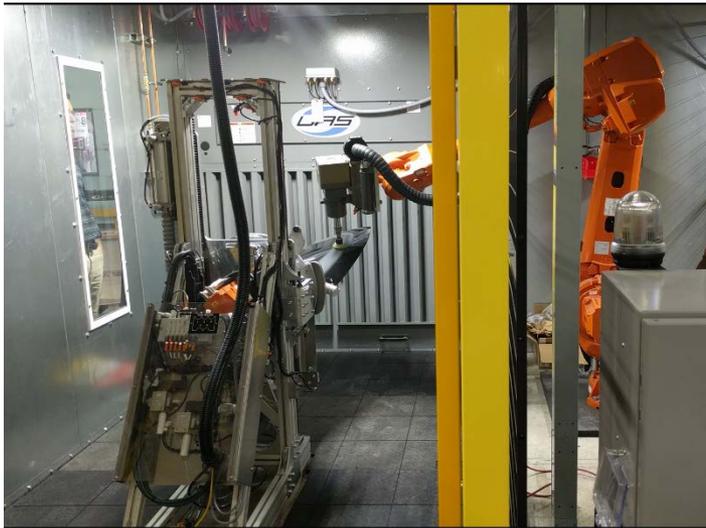
# Past Projects in Direct Fiber Placement

- ARM has previously designed and built direct fiber placement tools and systems for 3<sup>rd</sup> parties which are used in fabricating aerospace components
- These solutions were limited to smaller scale systems and product development systems
- This experience has given ARM significant insight into the challenges and requirements of composite layup processes
- Based on this past work and other, more recent projects related to cut ply inspection, ARM has identified specific opportunities in carbon fiber ply picking, handling and layup



Ongoing Work  
in  
Composites and Aerostructures

# Intelligent Coating Removal System for Composite Substrates



- To address quality limitations and cost in removing challenging polymer coatings from composite/mixed material surfaces, ARM has recently developed an intelligent robotic abrasive removal system
- This application shows a composite and titanium part being stripped of just one of its 2 layers of protective coating without substantially impacting the sensitive layer of material beneath

- Unlike conventional robotic sanding, this solution utilizes active 2-D surface scanning and vision techniques while processing parts and between passes to modify process parameters and prevent over-sanding past pre-defined limits, particularly on soft substrates, such as composite surfaces

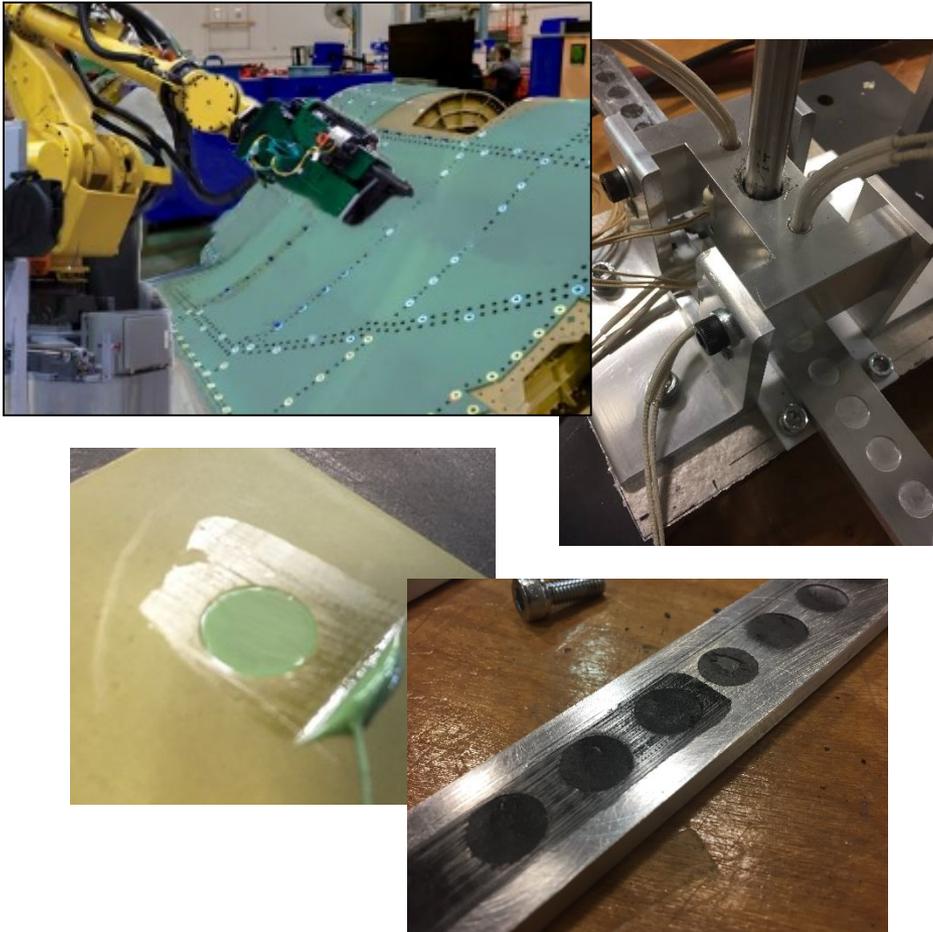


# Blending and Surface Finishing of Composite and Mixed Material Components



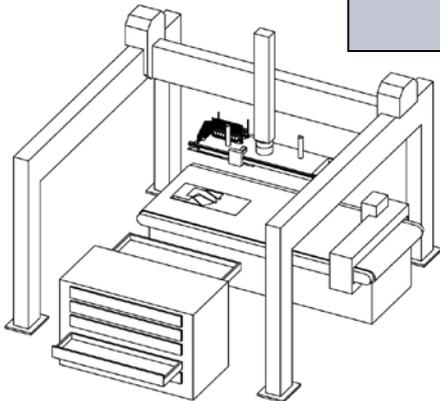
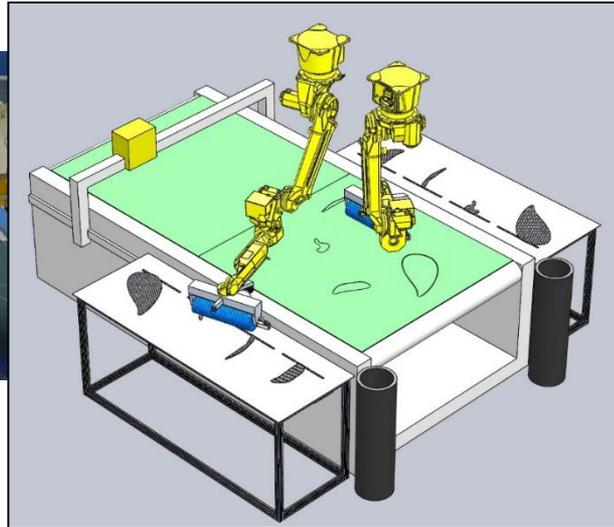
- ARM is leveraging its experience in smart 2-D material removal to deploy 3-D surface finishing systems
- This process technology leverages 3-D scanning, robotic path planning and dynamic process control to allow blending and shaping of surfaces using iterative, non-deterministic abrasive material removal techniques which have heretofore required manual labor and have had no direct means of quality control over the finished result
- This process is applicable to sanding, grinding, blast media or any other non-deterministic removal method

# Automated Fastener Fill and Finish in Composite Structures



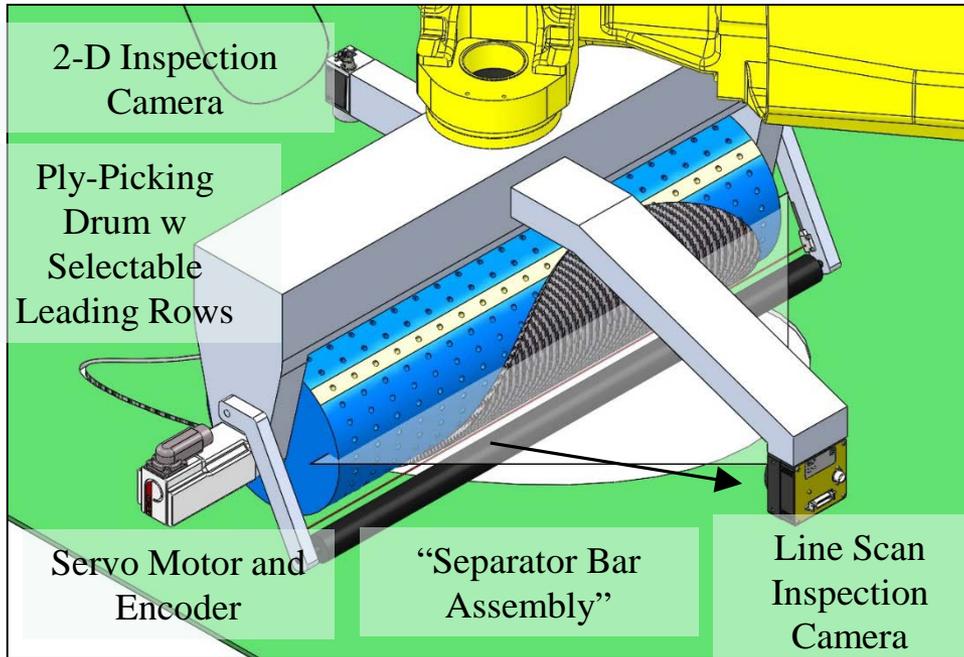
- Various manufacturers of composite structures require flush finishes for fasteners in composites
- ARM has developed a tool system and method for robotic fastener head fill and finishing with viscous chemical cure and thermoplastic materials
- Solution provides for fill, flush and automated inspection

# Picking, Inspection, Kitting and Lamination of Cut-Ply Composites



- In response to the need for more reliable cut ply picking where uncut fibers are common, ARM has recently developed and has applied for patents on a novel means of picking and handling cut pieces of carbon fiber material
- ARM is currently developing this concept and are testing it against the challenges of uncut fibers and piece-to-piece adhesion commonly found in pre-preg materials

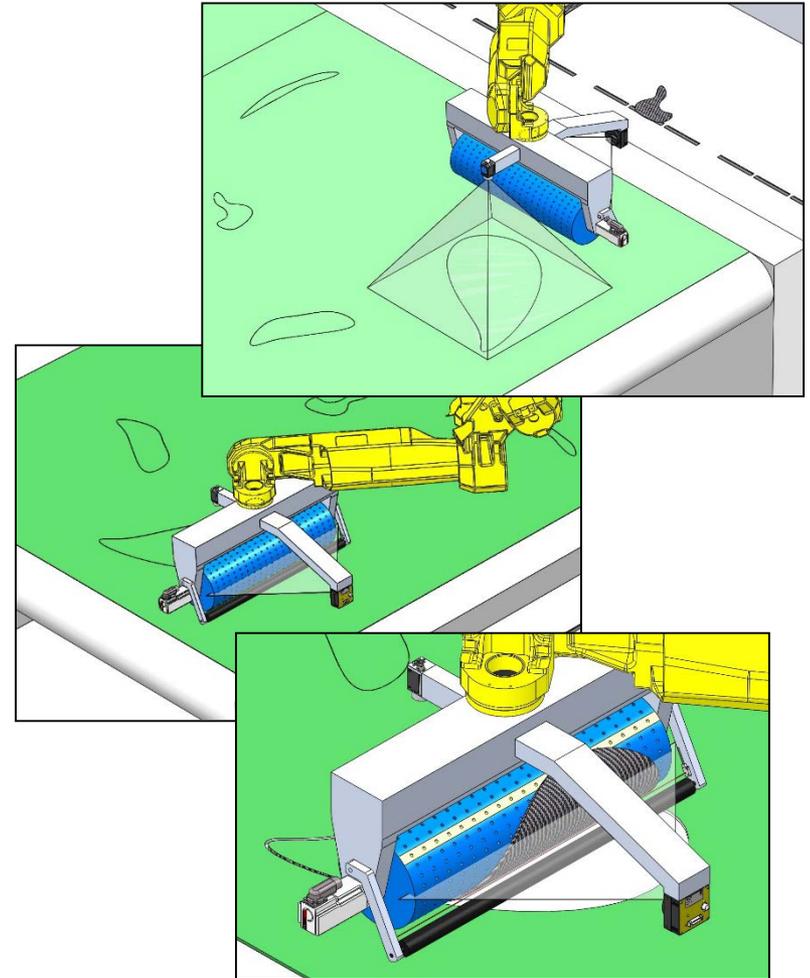
# Drum Roller Pick and Peel Tool



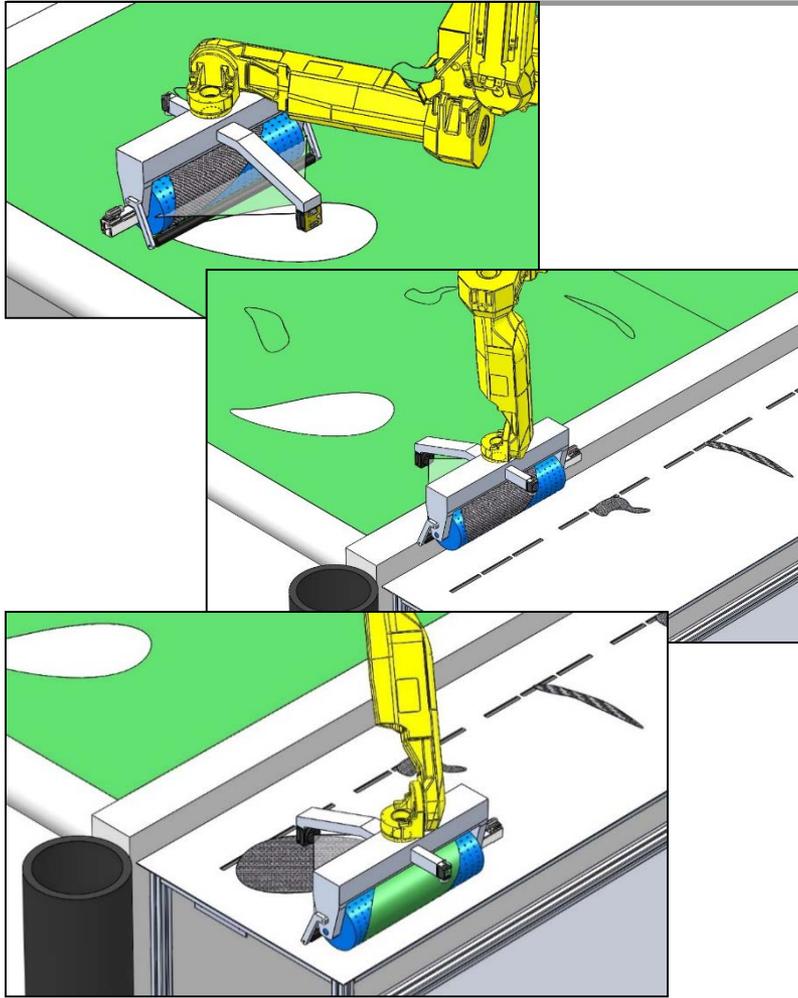
# Patent Pending Pick Method and Tool for PMC Materials

## Pick

- Camera verifies part and aligns with registration (or to best-fit profile)
- Row of individually controlled vacuum ports are mated with leading edge of select ply
- Select ports are activated to attach to leading edge of ply
- Drum is rolled and trailing “separator bar” assembly holds down adjacent material and monitors for uncut fibers
- As ply advances, a line-scan camera inspects ply profile for fine alignment, edge quality and for FOD



# Patent Pending Pick Method and Tool for Picking and Lamination of Composites

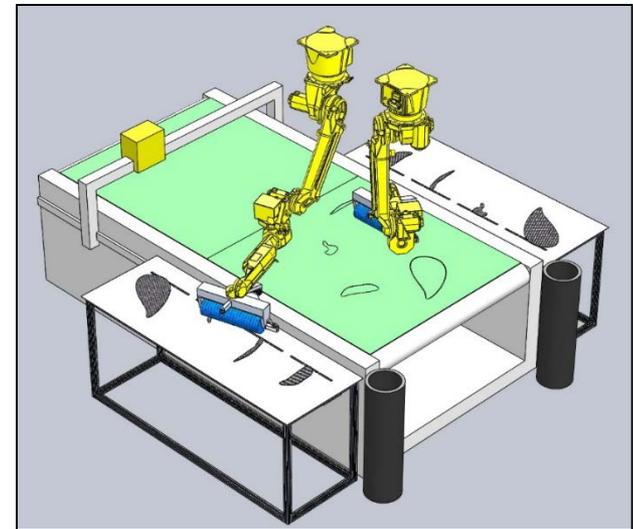


## Place

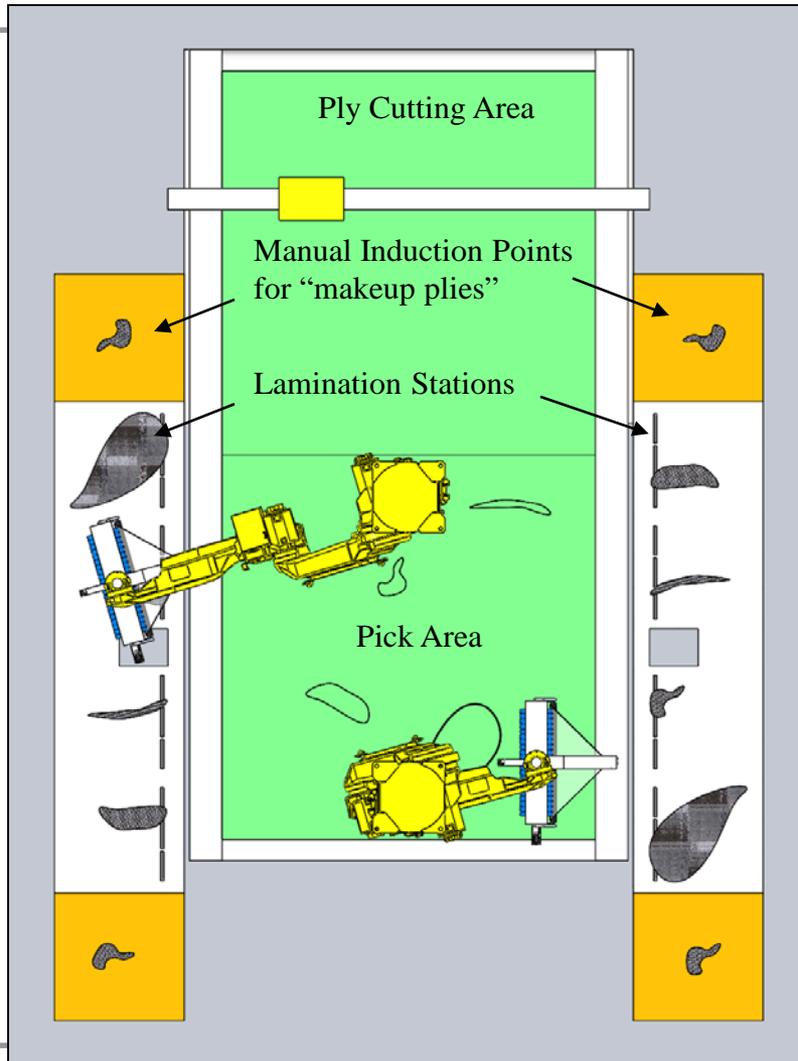
- Robot moves ply to respective lamination station
- Leading edge of 1<sup>st</sup> ply is placed onto a proprietary, non-contaminating “hold down” surface exposed through table
- Drum is advanced while vacuum holds poly layer against drum surface
- Poly is peeled from pre-preg material along its length leaving part on table
- Robot moves drum to vacuum collector for disposal of poly backer material

## Laminate Additional Plies

- Robot moves 2<sup>nd</sup>-xth ply to respective lamination station
- Optional vision inspection of laminate stack provides additional FOD detection
- Leading edge of ply is placed onto preceding layer, which is in-turn held down by the resin-tape below
- Again, the drum is advanced while vacuum holds the poly layer against drum surface
- Non-stick surfaces on both drum and table mitigate resin transfer during any direct contact between drum and any ply overlap during lamination
- Drum may be both visually inspected for resin and/or scraped clean by an optional auxiliary blade during the return to pick table



# Example System Layout, Access and Options



- Operators access one pre-form build table while robots tend to 2nd
- Build tables can be located off either side, off end, be parallel or perpendicular
- Trash collection ports can be located conveniently near each layup station to minimize cycle time impact
- Overhead robots may be large SCARA, gantry or serial 6-dof with each working in tandem
- ARM also has solutions in the works for thermoplastic pre-form layup as well

# Collaboration with IACMI Members

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- While new to IACMI, ARM Automation has worked with many supplier partners and end-users throughout its 20+ years to develop and deliver scores of automated solutions.
- If any of the technology areas presented are of particular interest, we would welcome any feedback or suggestions. Although we currently have early adopter partners for each of the technologies mentioned here, ARM retains the core rights to these developments and would welcome additional opportunities/applications for development and deployment.
- Similarly, if ARM can help to provide machine design/build resources or systems integration/robotics expertise to an existing IACMI project, we would be glad to discuss the opportunity.