ARM Leveraging of ROS for its projects

ARM Institute

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We are a 300 strong consortium of the leading Robotic OEM's, Manufacturers, Integrators, Tier 1 research Universities innovators, GOV departments and the **DOD**

Nature
- Public-private partnership

Vision
- A future where people and robots work together to respond to our nation's greatest challenges and to develop and produce the world's most desired products.

Method:

Invigorate US industry by investing in:

1. Robotic manufacturing technology
   - Often enhanced with AI
   - Fabricate, finish, assemble, inspect
   - Scan/map/model/ repair defects, maintain
   - Handle material, tend machines, fetch, kit, store, pack / unpack, load /un-load
2. Education & workforce Development
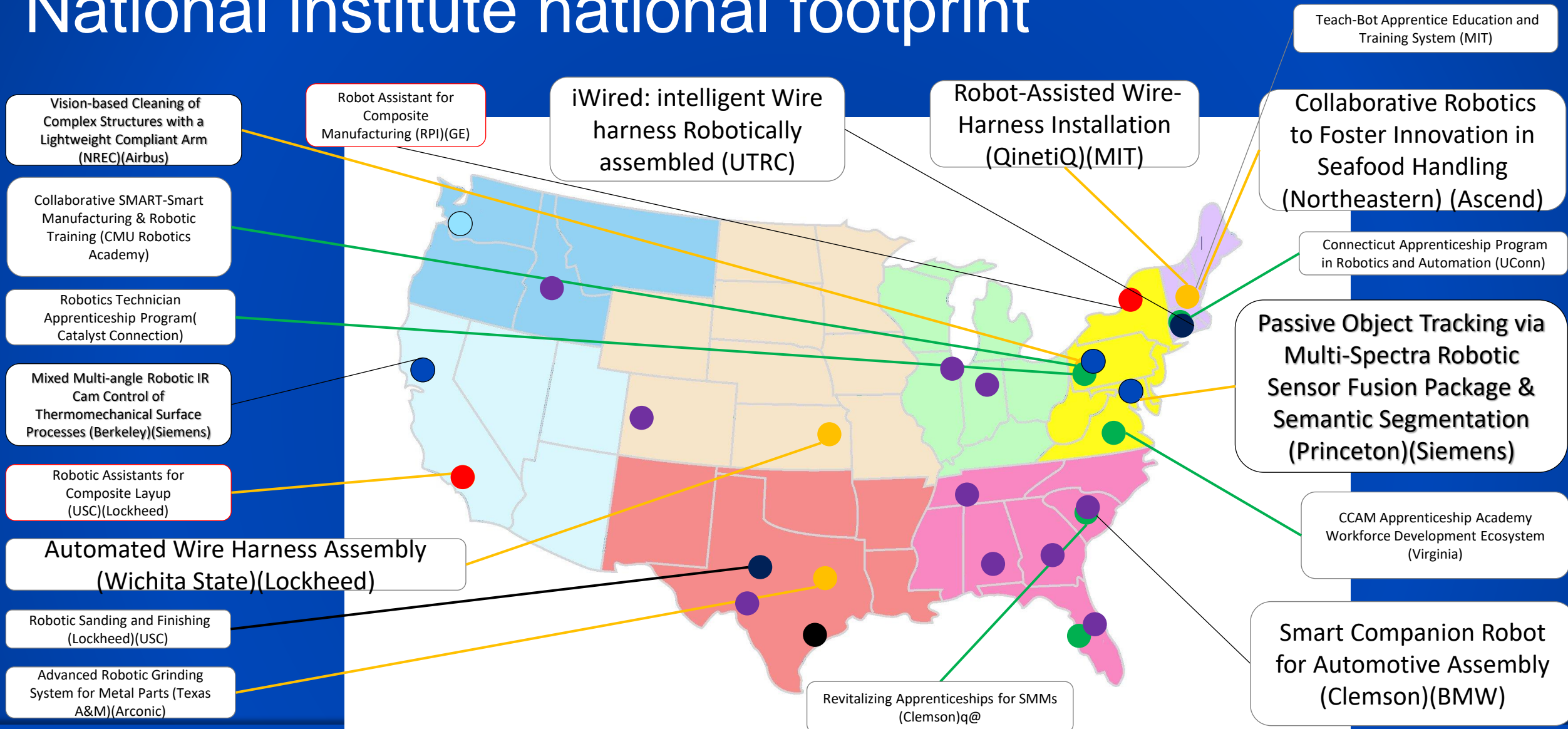3. Developing an eco system

~ $36M on 30 projects in 2020

ROS-Industrial Consortium Americas
2021 Annual Meeting
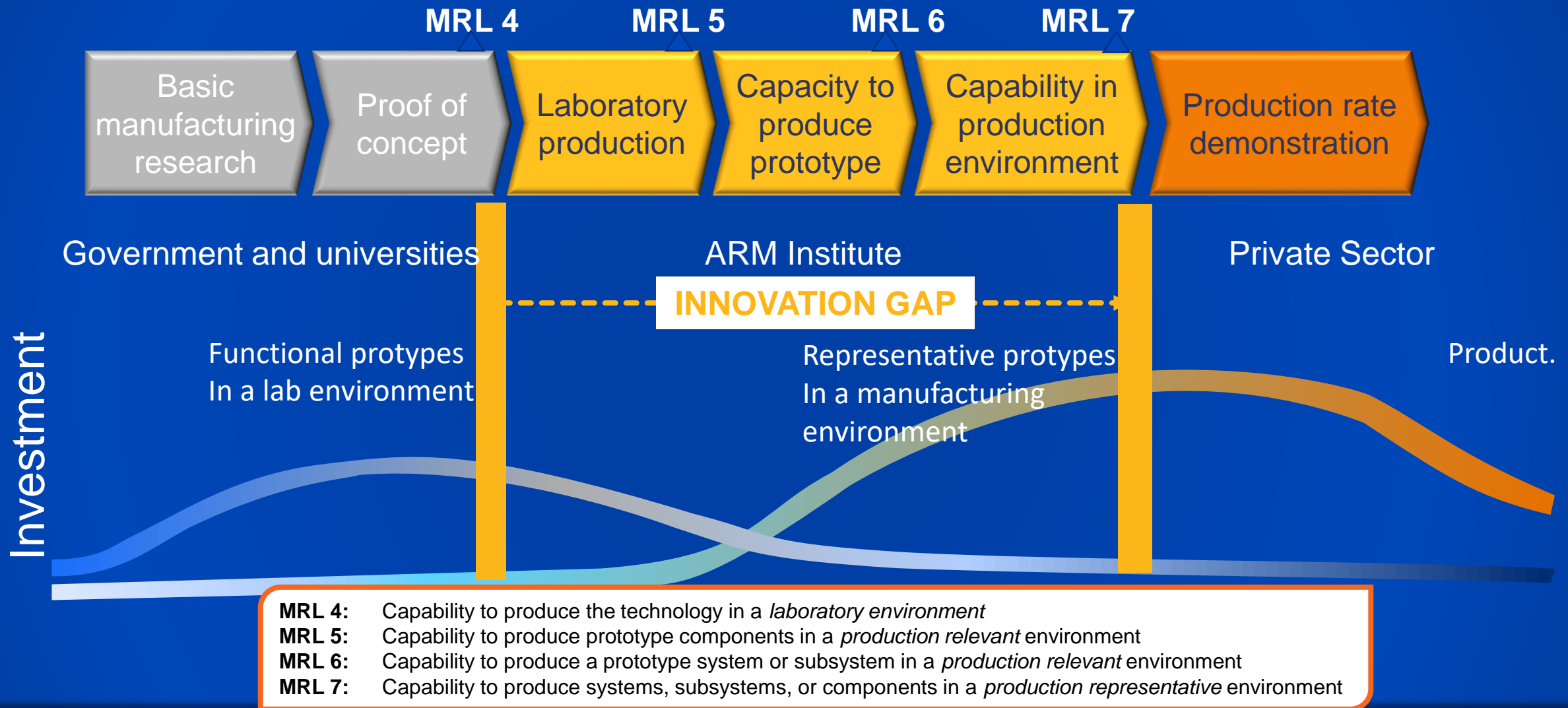
National institute national footprint

Teach-Bot Apprentice Education and Training System (MIT)

Vision-based Cleaning of Complex Structures with a Lightweight Compliant Arm (NREC)(Airbus)

Robot Assistant for Composite Manufacturing (RPI)(GE)

iWired: intelligent Wire harness Robotically assembled (UTRC)

Robot-Assisted Wire-Harness Installation (QinetiQ)(MIT)

Collaborative Robotics to Foster Innovation in Seafood Handling (Northeastern) (Ascend)

Collaborative SMART-Smart Manufacturing & Robotic Training (CMU Robotics Academy)

Connecticut Apprenticeship Program in Robotics and Automation (UConn)

Robotics Technician Apprenticeship Program(Catalyst Connection)

Mixed Multi-angle Robotic IR Cam Control of Thermomechanical Surface Processes (Berkeley)(Siemens)

Passive Object Tracking via Multi-Spectra Robotic Sensor Fusion Package & Semantic Segmentation (Princeton)(Siemens)

Robotic Assistants for Composite Layup (USC)(Lockheed)

CCAM Apprenticeship Academy Workforce Development Ecosystem (Virginia)

Automated Wire Harness Assembly (Wichita State)(Lockheed)

Robotic Sanding and Finishing (Lockheed)(USC)

Smart Companion Robot for Automotive Assembly (Clemson)(BMW)

Advanced Robotic Grinding System for Metal Parts (Texas A&M)(Arconic)

Revitalizing Apprenticeships for SMMs (Clemson)q@

Grinding finishing additive or subtractive manufacturing

Draping composite buildup or handling of textiles

Assembly COBOT IOT downloading files from internet or tied to ERP

Food Inspection or Processing COB tied to IOT

EWD **AI at the edge Vision Processing**

AMRor other mechanical assembly COBOT tied to IOT

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Pushing technology across the innovation gap

MRL 4   MRL 5   MRL 6   MRL 7

Basic manufacturing research	Proof of concept	Laboratory production	Capacity to produce prototype	Capability in production environment	Production rate demonstration

Government and universities   ARM Institute   Private Sector

INNOVATION GAP

Functional protypes
In a lab environment

Representative protypes
In a manufacturing environment

Product.

Investment

MRL 4:   Capability to produce the technology in a *laboratory environment*
MRL 5:   Capability to produce prototype components in a *production relevant* environment
MRL 6:   Capability to produce a prototype system or subsystem in a *production relevant* environment
MRL 7:   Capability to produce systems, subsystems, or components in a *production representative* environment

Developing technology to support market portfolios

1. ***Pliant Material handling and Assembly robots***
   - Fabricate, finish, assemble inspect, Logistics
   - 3D multi-ply composite woven structures
   - Cut, sew, drape, manipulate, align, bond, visual servo

2. ***Automotive/Aerospace/Electronics***
   - Fabricate, finish, assemble inspect, Logistics
   - Composites and Metal structures and skins
   - Coatings

3. ***Factory logistics robots*** (Fetch, hold, and clean inspect)

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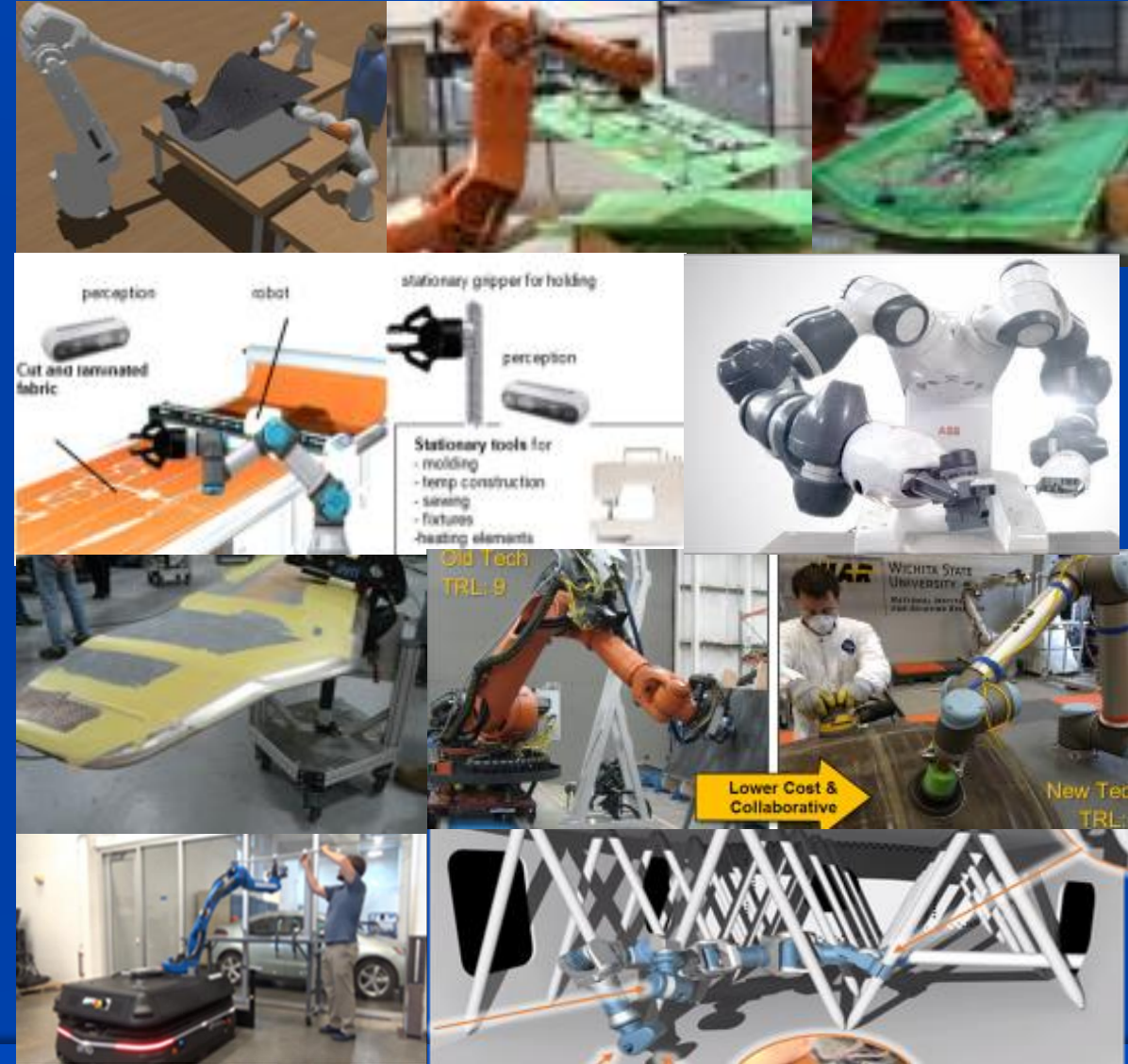
Additional ARM technology market portfolios

4. **Heavy industry –**
   material finishing projects (7)

- Grinding (1)

- Sanding (2)

- Polishing (1)

- Surface treatment (cold working) (1)

- Thermal surface treatment(1)

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Results matter : >33% of completed projects are transitioning and most of then used ROS(gold text)

Transitioned and in Commercial Use (1)

1. ARM-TEC-20-NI-F-01: Agile Laboratory Robot for COVID-19 qPCR Testing,

Transitioned and undergoing TRL 8-9 investment (6)

1. Safe Autonomy Features in the Edge (SAFE), Safety project- Real time Inference for Autonomous mobility

2. Vision-based Cleaning of Complex Structures with a Lightweight Compliant Arm, Snake robot

3. Adv. Robotic Grinding System for Metal Parts, Passive Track & Trace with Semantic Segmentation Grind Chamfer large gears splines

4. Advanced Control for Robotic Surface Treatment, deburring to accommodate batch-to-batch variations.

5. Systematic Robotics Application Assessment Methods and Tools for Decision-making,
   - Private consulting group evaluating a derisking tool for commercial use.

6. Collaborative Robotic Sanding of Aircraft Panels, robotic sanding tech for sanding Nacelle's

Firm Plans (9)

1. Collaborative Composite Sheet Layups for Complex Geometry of Small Plies

2. Seamless Multi-Robot, Multi-Machine Interoperability

3. Open Source Teach Pendant Programming Environment

4. Bot Couture: Robotic Clothing Manufacturing
   - Transition to major garment manufacture reshoring in San Francisco

5. Mobile Autonomous Coating Application for Aircraft Sustainment

6. Interoperability and Orchestration of Autonomous Mobile Robots (IO-AMRs) ,
   - COVID 19 mobile disinfecting robot for use in occupied areas currently Aero Sustainment Autonomous Masking

7. Flexible Drilling System (FDS)

8. Virtual Part Repair Programming for Robotic Thermal Spray Applications

ROS industrial #rica2020 ARM

152 Projects proposed
15 closed

80 Projects Managed
9 planed for transition
1 in commercial use

48 Completed
6 transitioning

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ARM Invests in key technologies, that combine to form numerous manufacturing processes, that make disruptive products in high lift markets
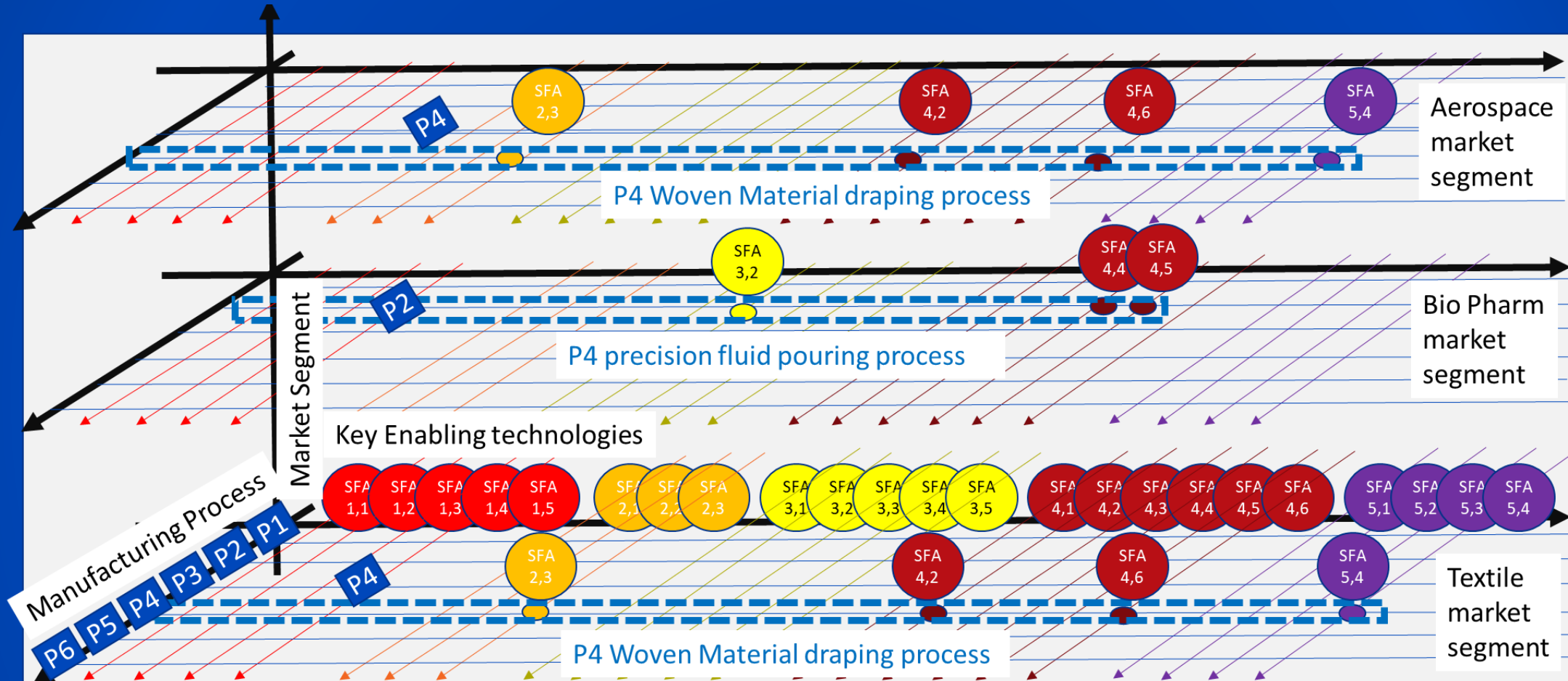
1) _Technologies_ are used by many _Processes_. 2) Processes are used in many _Markets_.

ARM has identified the 13 most urgent and important technologies whose development will have the greatest impact invigorating the US industrial base though the adoption of manufacturing robots enhanced with AI

Focus Areas

Focus Area Sub-categories (Key Enabling technologies)

FA-1 RISK REDUCTION FOR TRANSITION TO THE FACTORY FLOOR

1.1 Methods and tools for successful robotics adoption and expansion

1.2 Methods and tools for streamlining integration

1.3 Methods and tools for assessing industrial readiness of new technology

1.4 Virtual modeling and testing of robotics systems

1.5 Improving design and standards for robot safety

FA-2 HUMAN-ROBOT INTERACTION

2.1 User-friendly interfaces for programming, operation, and maintenance

2.2 Bi-directional communication on the shop floor

2.3 Human-robot trust and safety

FA-3 INTEROPERABILITY

3.1 "Plug-and-play" software and standards (System Level)

3.2 Plug-and -hardware and standards (System Level)

3.3 Open source and open architecture software, methods, and environments

3.4 Master Integration Platform

3.5 Metrics of Interoperability

FA-4 RECONFIGURABLE, AGILE, AND FLEXIBLE ROBOTICS SYSTEMS

4.1 Agile and reconfigurable robotic design

4.2 Modular robotic design

4.3 Smart, flexible tooling and end-effectors

4.4 Smart, flexible sensors and integration

4.5 Automated path planning and robot instruction generation

4.6 Virtual Modeling for Reconfigurable, Agile, and Flexible Robot

FA-5 INTELLIGENT ROBOTIC SYSTEMS

5.1 Self-aware and adaptive systems

5.2 Machine learning and Artificial Intelligence

5.3 Distributed, edge, and cloud computing

5.4 Advisor Robot: Observation, identification, fault detection, and training.

Examples of ROS Modules used on programs

- ROS IPA Coverage Planner
- ROS Navigation and move
- ROS Swarm Control Stack
- ROS MoveIT
- Ros GraspIT
- ROS A5 Software
- ROS Smach-task-level architecture for rapidly creating complex robot behavior

- ROS Noether -geo constrained path planning
- ROS Descarte – path planning
- ROS Gmapping- 2d SLAM
- ROS 1/DDS bridge
- ROS-I/MTConnect bridge
- ROS Middleware Wrapper (RMW) layer
- Gazebo

Examples of ARM Projects using ROS

- ARM-17-01-F-14-Passive Object Tracking via Multi-Spectra Robotic Sensor Fusion Package & Semantic Segmentation
  - Multi-Spectra Sensor Fusion system through tracking algorithm on ROS
- ARM-TEC-20-01-F-17-, Interoperability and Orchestration of Autonomous Mobile Robots (IO-AMRs)
  - Software libraries (in ROS) for AMR interoperability
  - Plug&Play connectivity to AMRs with ROS support,
  - Compatibility through open APIs to open ROS modules such as visualizers
- ARM-TEC-20-02-F-05, LM MAID, Mobile Autonomous Industrial Disinfector.
  - Motion planning algorithms and software to handle positioning

Examples of ARM Projects using ROS

- ARM-TEC-20-02-F-07-Qinetiq: Developing Autonomous Mobile Capability for Room Disinfecting Robots to Automate the Treatment of Multiple Separate Rooms and Spaces in the fight against COVID-19 and other Viruses
    - Motion planning algorithms and software to handle positioning
- ARM-TEC-18-01-F-03-UTRC/RPI, Advanced Control of Robotic Surface Treatments
    - 1. ROS node that subscribes to a single point cloud coming from the depth sensor and publishes voxel occupancy grid and textured mesh;
    - 2. ROS node that subscribes to multiple point clouds of a static ply and ground truth camera pose, then publishes textured polygon mesh;
    - 3. ROS node that subscribes to multiple point clouds of a static ply, infers the pose of the camera, then publishes textured polygon mesh;
    - 4. ROS node that subscribes as above but of an initial static ply to learn the appearance then subsequently flexing ply and published the continuously updated polygon mesh and texture

Summary

- ROS shrinks the time to market by providing; a trusted, "well understood", library of very useful packages, nodes, dashboards, and development- modeling and risk-reduction tools.

- If one desires to stay closed source, one could develop the prototype or pathfinders using ROS and then re-code the final de-risked product to maintain a closed source state.

- Many of the Projects we sponsor use ROS by choice and propose it as discriminator for reducing development risk schedule and development cost.