Shipbuilding CoBot Alliance

"Establishment and Operation of a Shipbuilding CoBot Training and Development Center"

(NSRP RA No. 24-02)

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Prime Contractor and Alliance Director

Why, How and What

- Need/drivers
  - CoBots are changing the face of manufacturing worldwide
  - CoBots have inherent characteristics that make them well suited for shipbuilding (ease of training, collaborative working, portability, ease of use)
  - High rates of adoption in other manufacturing industries
  - All shipyards are wrestling with how to learn, train, implement CoBots right now
- Shipbuilding CoBot Alliance
  - Consortium framework to provide regional locations for:
    - Training, demonstration, design for implementation, support, growing community of learners, new workforce development
  - Model to develop curriculum, space, collaborations
  - Develops tools (curriculum, resources, techniques) that will be freely shared to expand or create more training centers near areas of high need
- Physical centers
  - Training cells with multiple CoBots from major vendors for shipbuilding community including Miller Copilot, Lincoln Cooper, RTT Switchweld and ESAB Edge
  - Trainers and support personnel both full time and as needed
  - Cells available for practice, training, demonstration, evaluation for shipyards and suppliers
  - Each center to have 1-2 implementation demonstrations; demonstration of practice and in-field demonstration
  - Centers will provide access to testing for Level I qualifications and collect statistical data on CoBot performance

What is a CoBot?

- CoBot – Collaborative roBot
  - Robot intended for direct human interaction with shared space or proximity (IFR)
    - Traditional robotics – achieve safety by separating robots from human contact during operation
    - CoBots – achieve safety through weight, materials, geometry, sensing, controls
  - Recent development (1997 patent) stemming from GM robotics center and University research

Four Levels of Collaboration between worker and CoBot (IFR)		
Coexistence	Work side by side (no protective barrier)	
Sequential Collaboration	Share the workspace	
Cooperation	Work on the same part, at the same time	
Responsive Collaboration	CoBot responds to worker	

CoBot Companies - Timeline

- CoBotics (late 1990's) - Automotive assembly
- Kuka CoBot – 2004 (LBR series)
- Universal Robotics (2008)
- Rethink Robotics – (2011) Baxter
- Yasakawa (Motoman, 2013)
- AUBO robotics (2014, Smokie Robotics
- FANUC (2015) CR series
- ABB (2015) Yumi
- Welding Examples
  - Fabtech 2018 – 2 welding CoBots
  - Fabtech 2023 - 20+?

CoBot Theory, Standards and Guidelines

- ISO 10218-1/2:2011 Safety Requirements for Industrial Robots
- ISO/TS 15066:2016 Robots and robotics devices – Collaborative robots
- Subject to Quasi-static and transient effects
- Bounds on mass, speed control, and torque sensing

Operational impacts on CoBot design

- Weight/mass
- Speed
- Accuracy
- Stiffness
- Exterior shell

CoBot features

- Real-time force sensing
- Speed-limiting
- Defined working boundaries

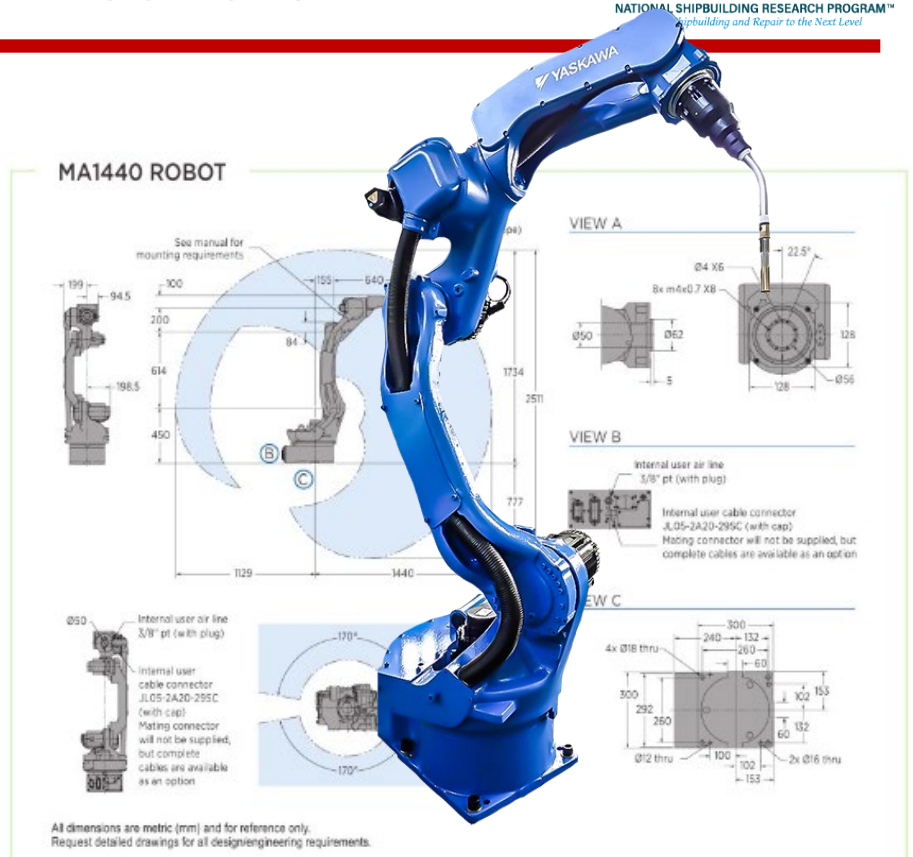
Comparing robot specifications: Collaborative vs. Traditional

UR10 Technical specifications

Item no. 110110

6-axis robot arm with a working radius of 1300 mm / 51.2 in

Weight:	28.9 kg / 63.7 lbs
Payload:	10 kg / 22 lbs
Reach:	1300 mm / 51.2 in
Joint ranges:	+/- 360°
Speed:	Base and Shoulder: 120°/s. Elbow, Wrist 1, Wrist 2, Wrist 3: 180°/s. Tool: Typical 1 m/s. / 39.4 in/s.
Repeatability:	+/- 0.1 mm / +/- 0.0039 in (4 mils)
Footprint:	Ø190 mm / 7.5 in
Degrees of freedom:	6 rotating joints
Control box size (WxHxD):	475 mm x 423 mm x 268 mm / 18.7 x 16.7 x 10.6 in



SPECIFICATIONS

Axes	Maximum motion range [°]	Maximum speed [°/sec.]	Allowable moment [N•m]	Allowable moment of inertia [kg•m²]
S	±170	230	-	-
L	+155/-90	200	-	-
U	+240/-175	230	-	-
R	±150	430	10.5	0.28
B	+90/-135	430	10.5	0.28
T	±210	630	3.2	0.06

Controlled axes	6
Maximum payload [kg]	6
Repeatability [mm]	±0.08
Horizontal reach [mm]	1,440
Vertical reach [mm]	2,511
Temperature [°C]	0 to +45
Humidity [%]	20 - 80
Weight [kg]	130
Power rating [kVA]	1.5
Internal I/O cable (feeder control)	18 conductors
Internal gas line	(1) 3/8" connection

Similar payload and reach, 29 vs. 130kg arm mass

Hurdles to Implementation

- Tech_Pub_248_S9074-AQ-GIB-010_248_rev1_11.12.19 specifies requirements for robotic welding for U.S. Navy applications
- Rev – required Level 1 Qualification (including failure tests on specimens) at the serial number level plus essential elements (amps, volts, gas type, material, grade, filler etc.) for a qualified Weld Procedure Specification (WPS)
- Rev 1 requires Level 1 Qualification at the make/model level plus essential elements for a qualified Weld Procedure Specification (WPS)
  - Additional machines in the same make/model with same essential elements only require level 2 Qualification (visual inspection) to a qualified WPS
- Other applications (cutting, weld prep, coating removal, gouging) do not have to be qualified for use with a CoBot beyond finished product inspection

Shipbuilding CoBot Alliance

- Objective – Establish a pipeline for personnel training and qualification, application development, CoBot qualification for Navy work and Research and Development to improve CoBot functionality and versatility in ship construction and repair applications.
- Method –
  - Establish 2 regional Centers, one at NWTC in Marinette, WI run by Northern Wisconsin Technical College and a second at Tabet Manufacturing in Norfolk, VA run by GENEDGE, the VA MEP.
  - Equip each center with CoBot application cells with an emphasis on welding
    - » Other applications include cutting, grinding, paint removal, weld prep
  - Centers will be equipped with access to testing equipment to fully qualify to NAVSEA Tech Pub 248.1 for Level 1 Weld Qualifications
  - NASA Langley to provide testing facility in cooperation with GENEDGE

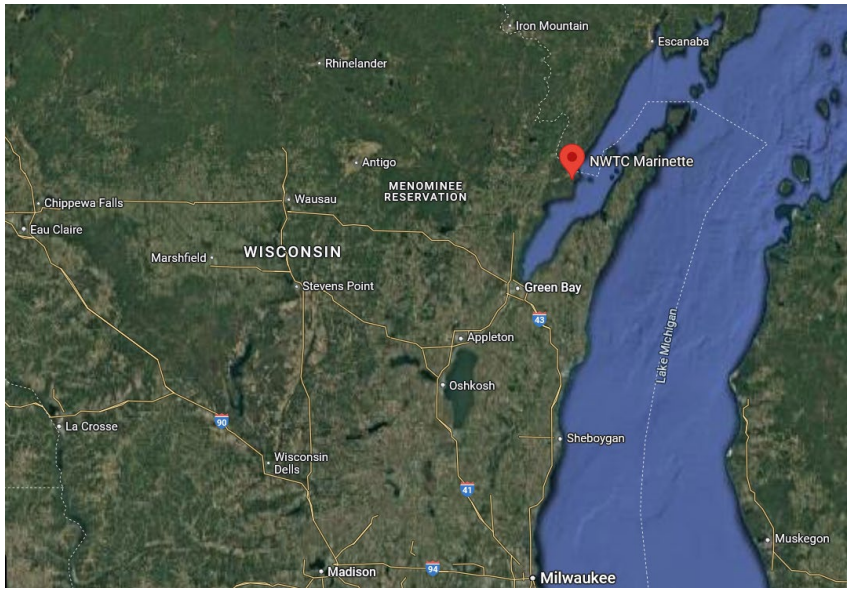
Business Case

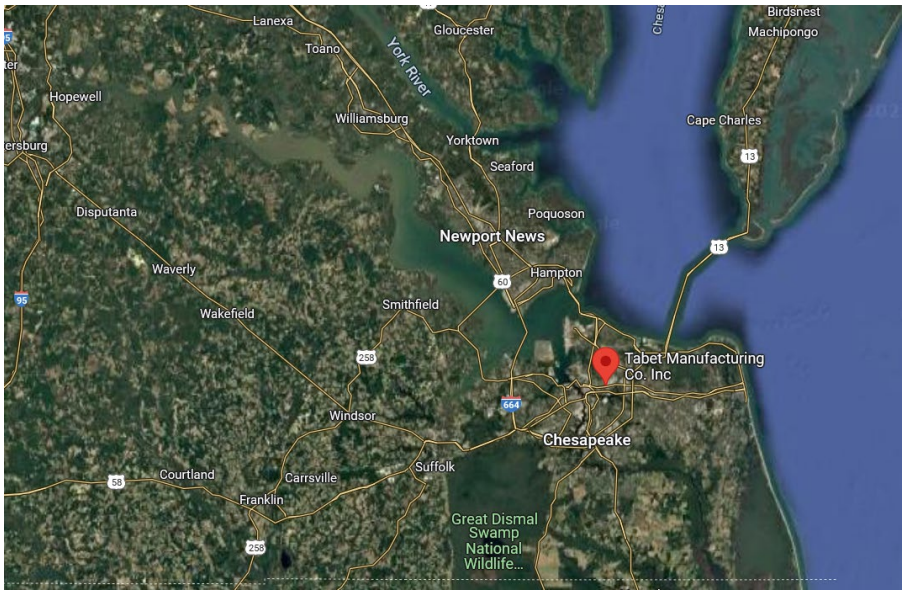
- CoBot suppliers provide equipment to centers as cost share
  - Labor support is funded
- Centers provide a pathway to qualifying multiple WPS on a specific make model
  - Independent trainer provides operator training to a standardized curriculum
- Shipyards and suppliers have access to training with an end result of Welder and CoBot qualified to an approved WPS
  - Training can be on multiple systems to support investment decisions or on a specific system if one has been chosen
  - Performing entity is required to sign off on their own WPS and then submit for approval
- NAVSEA is engaged to provide guidance on the qualification process
- Suppliers can sell the qualified system off the floor

Alliance Mission

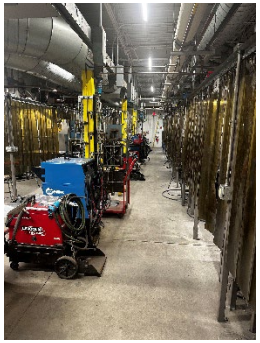
The Shipbuilding CoBot Alliance is established as a loosely structured consortium of shipbuilders, CoBot suppliers, shipyard supply chain suppliers, Navy technical authorities and industry experts. The purpose of the Alliance is to accelerate the implementation of CoBots in shipbuilding applications by providing a streamlined and efficient path to qualification of personnel and equipment to Navy and industry standards. A specific focus is the identification and resolution of issues and roadblocks currently impeding the use of CoBots in shipyard welding applications. The mission will be accomplished through training and qualification centers established in Norfolk, VA and Marinette, WI with potential for expansion as the need requires.

Initial Locations

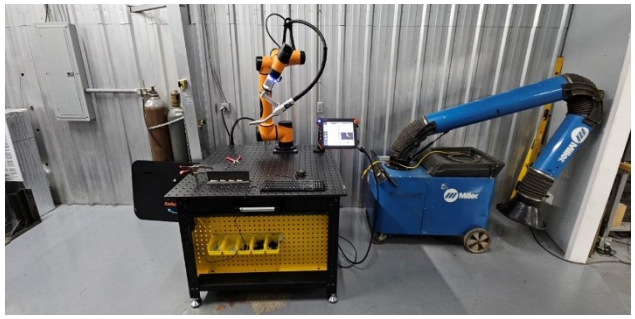




NWTC, Marinette, WI



Tabet Manufacturing, Norfolk, VA



Alliance Charter Members

- CoBot Suppliers
  - Lincoln Electric
  - Miller
  - ESAB
  - Switchweld
  - Atmospheric Plasma Solutions
- Shipyards
  - FMM Marinette
  - Newport News Shipbuilding
  - Master Boatbuilders
  - Pacific Shipyards
- Management Team
  - CahillConsulting, LLC
  - Hepinstall Consulting Group, LLC
- Center Management
  - NWTC (host and manager)
  - GENEDGE (manager)
  - Tabet Manufacturing (host)
- Technology Team
  - Robotic Technologies of Tennessee
  - Edison Welding Institute
  - VA Digital Maritime Center

Project Status

- Late starting due to contractual delays
- Changed location to Tabet and lost some champions from team members due to contract delays
- Lab space at Tabet 90% completed
- Switchweld unit delivered and tested
- ESAB, Lincoln and Miller units to be delivered over next 3 weeks
- APS Plasma Blast unit to be delivered next week (snow delay)
- Open House April 3rd – registration information available NOW
- Train the trainers in April
- Begin training in May
- Stand up second center at NWTC in Marinette in May
- Begin training at NWTC in June
- Phase 1 ends September
- Phase 2 to expand training and initial implementation with feedback

Example CoBot Cell: Switchweld™

Curriculum Outline for Trainees

Proposed CoBot Training Modules and deployment schedule (details in Appendix)			
Title (Year 1)	Primary objectives	Title (Year 2)	Primary objectives
Collaborative robot operations	Fundamentals of programming and working with CoBots	Integrating vision systems with CoBots in manufacturing:	Integrating weld sensors with CoBots
Collaborative Robotics Welding I	Fundamentals of programming weld operations with CoBots	Collaborative Robotics in advanced manufacturing roles	Applications of CoBots to other manufacturing tasks (plasma arc, grinding, cold spray, etc.) case studies.
Collaborative Robotics Welding II	Intermediate skills at CoBot weld programming: complex shapes, simple sensors	CoBot safety: implementation to meet technical standards on safety	Review of ISO 10218-1,2 and ISO/TS 15066 standards for CoBot safety
Collaborative Robot Mechanical, Electrical, Maintenance	perform CoBot maintenance	Collaborative Robotics Portable Welding	Using CoBots in mobile or portable applications

- **Perform fabrication on small runs of small to medium size components**
- **Direct implementation of commercial systems**
- **Located in welding shop**
- **Available for on-sight training/practice when not in production use**

Curriculum

Curriculum - Overview of courses

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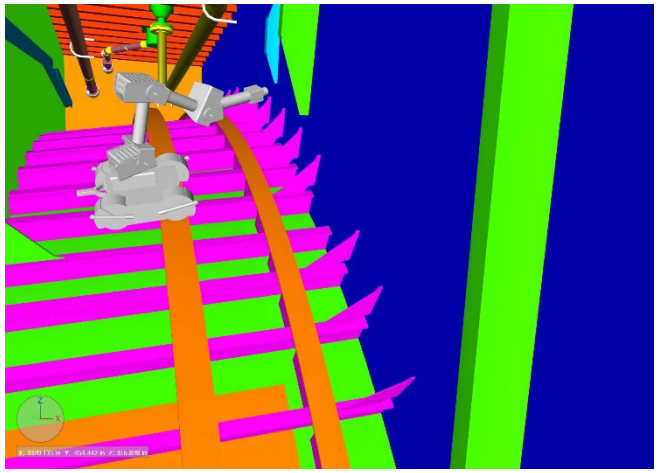
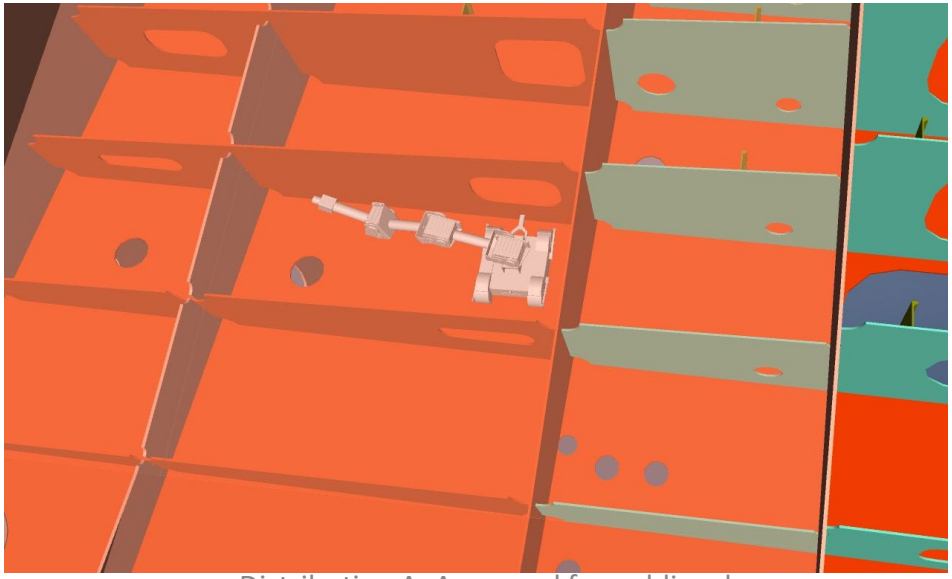
Collaborative Robot Mechanical, Electrical, Maintenance	perform CoBot maintenance	Collaborative Robotics Portable Welding	Using CoBots in mobile or portable applications

Portable CoBot Applications



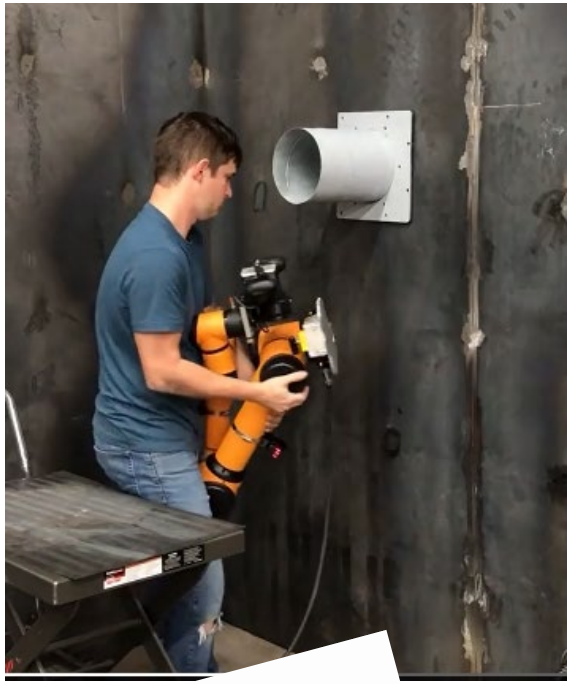


Portable CoBot Examples - RTT

HMMR (CoBot on mobile platform)

Man-Portable CoBot systems

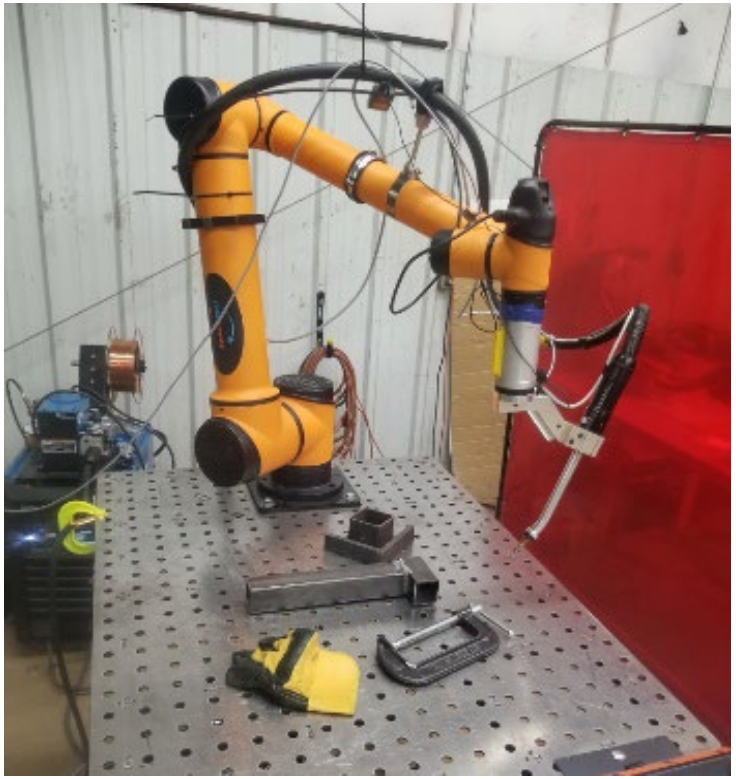
Integration with track/positioners

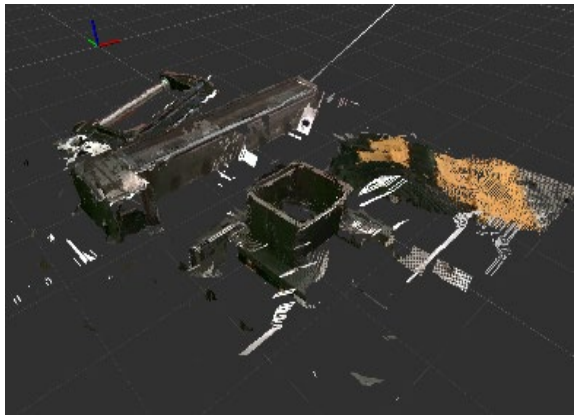


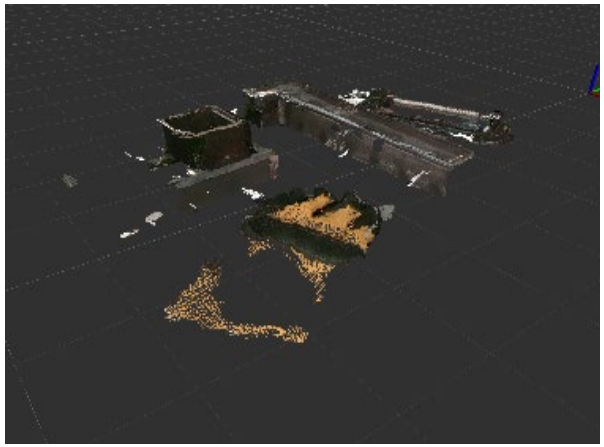
Automated Path Planning - RTT

Portable Welding CoBot with end-effector-mounted depth camera

Scan Workspace, ID trained workpiece







Lincoln Electric

This or similar model. Cart is good for training and shop environment. Arm is removable for other applications.

Cooper™ GoFa-10 Air-Cooled Welding Cobot Cart

AD2501-5

ABB GoFa-10 offers the best-in-class motion controlling arm in its class; with a Payload: 10kg (22lb), Reach: 64in (1620mm) (flange).

Output DC CC CV Input 1/3 PHASE 50/60 Hz

Model

Cooper™ GoFa-10 Air-Cooled Welding Cobot Cart

ABB GoFa-10 offers the best-in-class motion controlling arm in its class; with a Payload: 10kg (22lb), Reach: 64in (1620mm)(flange).

Switch Weld

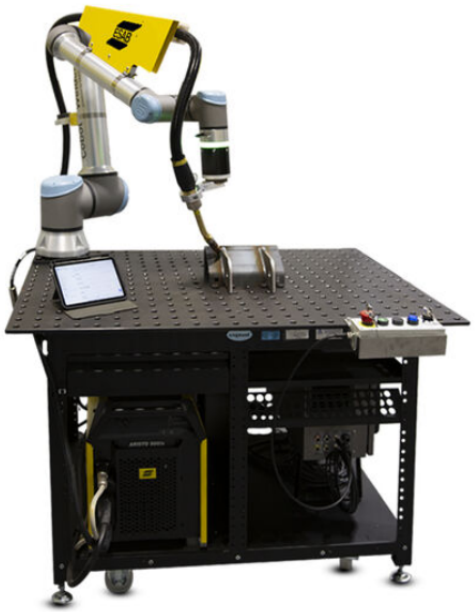
This or similar model. Cart is good for training and shop environment. Arm is removable for other applications.

WHAT'S INCLUDED

- AUBO i5, i10 or i20 Cobot
- AUBO Control Box and Teach Pendant
- Miller Auto DeltaWeld
- 4'x4' Welding Table
- CM Industries, Air-Cooled MIG Robotic Welding Torch
- SwitchWeld™ Navigator Puck
- SwitchWeld™ Joystick
- SwitchWeld™ Plugin Box
- SwitchWeld™ Operator's job controller
- SwitchWeld™ Software

ESAB

This or similar model. Cart is good for training and shop environment. Arm is removable for other applications.



ESAB Cobot

ESAB Cobots solve today's toughest challenges in the most demanding environments, including industries with a high mix of low-volume parts. It allows for increased output and productivity –without more manpower –all in a small footprint.Best of all, there's no complicated programming like with traditional robotics. Cobots are made for welders, not programmers, with app-based software that is simple and intuitive.Combined with the best-quality UR arm in the market plus the Aristo 500ix, a heavy industrial pulse power source, and the RobustFeed U8$_2$, ESAB Cobot is the ideal solution for superior feed-ability and arc performance.

READ LESS...

Request Virtual Demo Now

Request Information

Miller

This or similar model. Cart is good for training and shop environment. Arm is removable for other applications. Unit contributed by RTT, not Miller.

Click here to open in a new window.

Copilot™ with Auto Deltaweld™ 350 System with Touch Sensing

951000110

Entry-level collaborative welding system with advanced features that is great for welders who are new to robotic welding automation.

Select One Compare

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With Auto Deltaweld 350 Air-Cooled System 230/460v with Touch Sensing & Seam Tracking 951000115

CONTACT AN EXPERT

Shipbuilding CoBot Alliance

Questions?

For more information contact:

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251-751-6622

Or

Register for April 3rd Open House and see for yourself!