We are in the business of deploying the world’s foremost talent and knowledge to address the fabrication solution needs of our customers.

mike davis – project manager

mark schaub – business & technology development
Objective
This effort will help close the widening gap in the use of robotic welding automation versus foreign shipbuilders. This project will take a major step toward solving ‘THE’ critical bottleneck to the application of robotic welding technologies; automated robotic path and process solution generation (i.e. shift from manual offline to CAR programming).
US Defense Shipbuilding vs. Commercial Shipbuilding

**High Mix, Low Volume**
- Add people to the Plant
- Programming cost barriers limit robotic use
- Low Manpower Unitization weakens Profits

**Low Mix, High Volumes**
- Add Automation to the Plant
- Programming Costs are a normal cost of business
- Lower Asset Utilization weakens ROI’s

CAR-W will enable low volume robotic use by automating programming
EGG-CRATE HULL STRUCTURE

- Robots are automatically lowered into place by an NC overhead gantry system
- Sensors are used to position the robots with respect to the weld joints
Block Assembly Welding

EGG-CRATE HULL STRUCTURE

- At this shipyard, 16 robots are operated by 2 workers in this application
OTHER ROBOTIC WELDING APPLICATIONS

1) Stiffener-to-web sub-assemblies, linear fillets (Gantry-type robotic system)

2) Stiffener-to-web sub-assemblies, curved and straight joint fillets (Multi-axis, multi-robotic welding system)

3) Closed double hull welding of longitudinal faces and webs, and bottom shell plate butt joints (Portable robotic system)

AUTOMATED, OFF-LINE PROGRAMMING

Eliminate off-line programming

CAD Model Data ➔ Path Planning Software ➔ Fab Process Data
Also benefit from the project...
EWI’s mission is to shape the future of manufacturing through innovative technology solutions.

**Edison Welding Institute** – Columbus, Ohio
Wolf Robotics, LLC – Fort Collins, Colorado
The NSRP Project Team

Computer Aided Robotics Welding

Dr. Tony Maciejewski, PhD

“...enabling automation for shipbuilders”
Project General Objectives

- **Development of a general - executable Business Process Flow** (organizational and technical) for implementing Computer Aided Robotic Welding

- **Standardization of the CAD and processes data elements** required to drive CAR-W applications

- **Development of a CAR-W process database structure** that captures critical welding process data and leverages it for future use in the design and manufacturing planning processes.

- **Development of a methodology to allow changes to the Sequence of Welds** in part and assembly build-up without the requirement for manually re-programming the robot.

- **The development of Computer Aided Robotics Path Planning algorithms** for typical high-use weld types in the shipbuilding industry

- **Conduct technical demonstrations, virtual and live**, highlighting each year’s CAR-W achievements so that both knowledge and technology transfer can occur rapidly among yards
80/20 Weld Volume Assessments

- Identify High Volume Weld Types
- Identify Basic Application Requirements
- Rate Complexity of Welds / Applications
- Set CAR-W Development Priorities

CAR-W CAD Ingredient Standardization

- Identify Required CAR-W Data Elements
- Modify ShipConstructor & Generate Model Data
- Write & Test Data Transfer Protocols
- Document Standards for AWS Future Publication

CAR-W Process Ingredient Standardization

- Identify Standard CAR-W Process Ingredients
- Develop Baseline CAR-W Tech Welding Sheet
- Conduct Planning Gap analysis & Population Strategy
- Document Standards for Future AWS Publication

Process Database Development & Long Term Strategy

- Develop Process Ingredient Database
- Develop Short and Long Term Population Strategy
- Investigate Process Best Practice Data “Tags”
- Evaluate Potential for Industry Data Sharing
**Technical Demonstration & Transfer**

- Work on Weld Identification & Sequence Tags
- Identify flexible tool to change sequencing
- Identify potential deformation software tools
- Beta Test Link between DM tools & Algorithms

**Sequence of Weld & Deformation Strategy**

- Model the robot system configuration
- Make the Path Planning Software Drive the Robot
- Validate Software Commands = Robot Actions
- Beta Test CAR-W First Generation Parts

**CAR-W Path Planning Development**

- CAR-W Automated Path Planning Development
- CAD & Process Data Integration Protocols
- Develop Robot Studio Review Methodology
- CAR-W Virtual Demonstration of Success

**Equipment Translation**

- Technical Demonstrations of Selected Welds
- Create Awareness of CAR-W Capabilities
- Leverage Participating Member Facilities / Outreach
- CAR-W Technology Transfer throughout the Industry
Computer Aided Robotics – Welding (CAR-W)

- Challenges include Qualifying Data... “preliminary, standard, qualified”, etc.
- Qualifying systems for use of best practice data
- Sharing data inter-company, inter-industry and beyond
- Who, what, when, where and why... one process may not fit all
**Designer**
- Auto identify welds in drawings
- “Tag” Process Data to Welds Lines directly from Database using CAPP - Computer Aided Process Planning methods
- Utilize DFR – “Design For Robotics” concepts

**Programmer**
- Minimize Programming
- Limit Programming to complex systems configurations & weld types

**Process Engineer**
- “Tagged” Drawing Process Reviews
- Automatic Path Validation
- Weld Sequencing
- Process Validation & Improvement with Welder
- Process Database Updates
- “Approve” process data for future “tagging” to drawings
- “New” Process Generation

**Welder**
- Use Prove-For-Production methods to validate the process
- Provide input to improve processes
- Monitor Weld Sequencing for best results
- Provide knowledge and experience for capture & transfer to process database

**Process Planner Work Station**
Planer Work Station is the interface for path and process review

**Welder’s Robot Work Station**
Capturing the knowledge of operator closest to the process

**Embed Process Knowledge into Design Tools**

**Auto Path Generation Software**
Part / Assembly Drawings... 3-D Model Data, & Welding Tag Data Transferred Electronically

**Tag Data**

**Automated Link to Update**

**Real World** Process Validation & Knowledge Capture

**Ship Building**
Standardized CAR-W Weld Database could foster company, inter-company, & Industry-Wide Progressive Learning
Computer Aided Robotics – Welding (CAR-W Process Map)

- Expected to be a living, evolving document for the duration of the project
1. Standardize CAD & Process Data Ingredients
2. Modified CAD Package to Tag Information to Welds
3. Process Data made available electronically for basic High Volume Weld Types
4. Build foundational Path Planning algorithms
5. Develop CAR-W Process Map & workflows
6. Path planning software limited to specific robot platforms & systems
7. Socialization of the Infrastructure required to support the coming CAR-W advancements

Crawl
1-2  

Walk
3-5  

Run
6-10  

1. Very basic Sequence of Weld flexibility
2. Published CAD to Path Planning Software protocols
3. Introductory CAR-W Standardized Process Technical Data Sheets
4. Specific path planning algorithms for basic multi-pass weld types
5. Virtual CAR-W demonstrations followed by TRL 7-8 demonstrations
6. Multiple Working CAR applications in each Yard

Embedded Process data in CAD Packages (CAPP)
Design for Robotics (DFR) awareness in Design Process
Process Data entirely electronic & robotic weld algorithms library expanded for most weld types
Mature - Optimized Path Planning Algorithms
CAR-W Process Workflows electronic and lean
Vision Systems and Sensor Technologies actively integrated into path planning software
Deformation Management analysis software integrated into the sequence of welds path planning process
NSRP CAR-W Project Presentation – Takeaways

• A collaboration of industry leaders working with the National Shipbuilding Research Program (NSRP) to make advancements in the area of computer-aided robotics for welding (CAR-W).

• CAR-W is a software technology that strives to use robotic systems to automate the manual welding typically found in shipbuilding.

• Focus on developing the ability for a robotic system to generate weld paths automatically and directly from CAD models, and leveraging process data for complete welding solutions.

• This will reduce the large amount of manual programming time currently required for robotic systems that are used in high-mix, low-volume shipyard environments.

• One of the goals of the project is to enable shipyards to implement robotics into their production processes with greater ease.

• We have to start now to build the systems, processes, workflows and electronic infrastructure to support the coming CAR software revolution... it’s coming.