



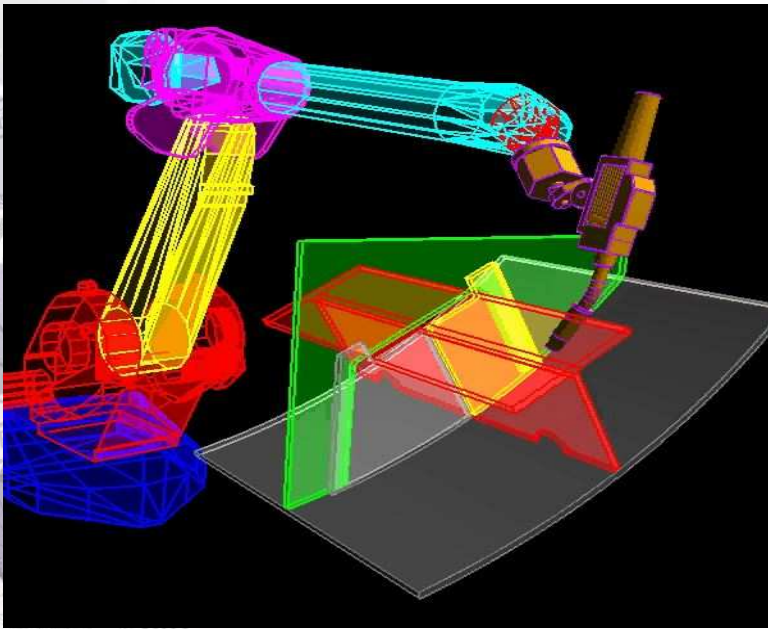
AutoGen

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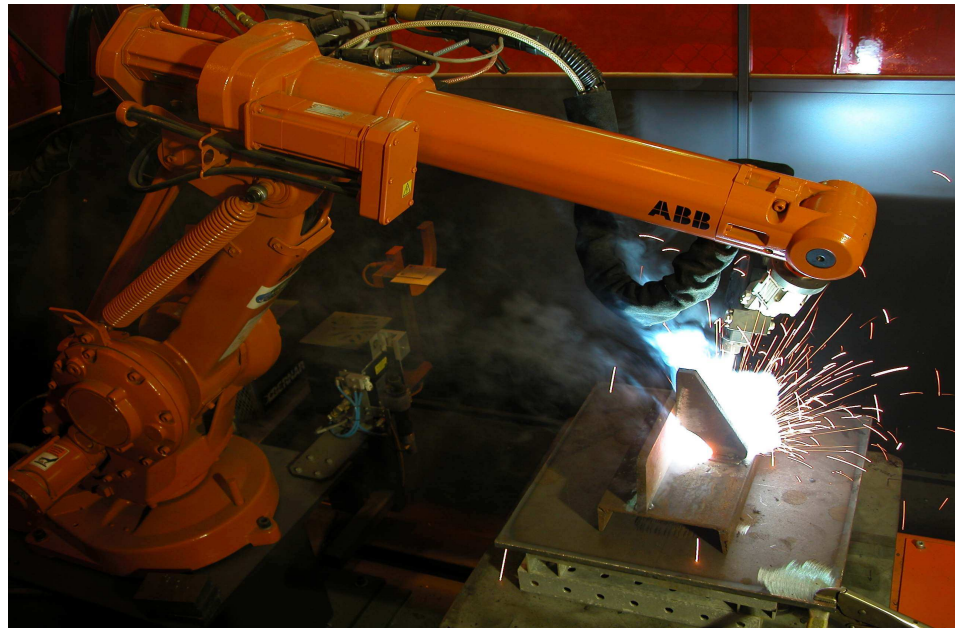


What is AutoGen

Process Centered Automatic Generation of Robotic Welding commands
using Geometric Part Models and Manufacturing Intent



Weld Planning



1st Welding Demo 12/03



CAD Model to OLP Weld Commands

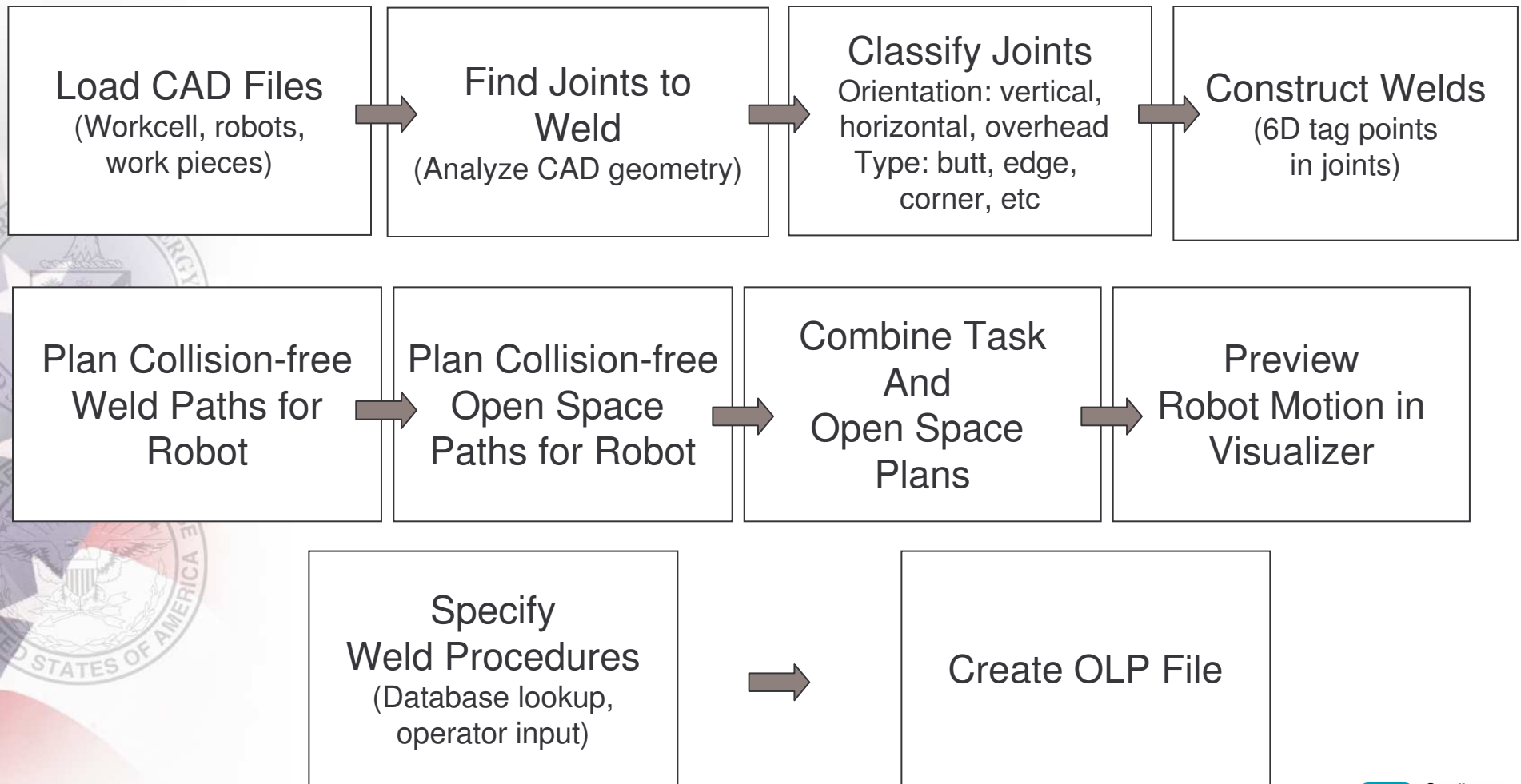
- **Process Centered Automated Planning on the Basis of**
 - Geometric Part Models
 - Manufacturing Intent
 - Weld Process Data
 - Robot Specification
- **Import CAD models for Work Cell and Parts**
 - Create internal data structures
- **Apply geometric reasoning to identify and classify welds**
- **Plan robot motion**
 - Free space
 - Weld
- **Output results**
 - Graphically
 - Robot commands



How AutoGen Works


- **Combines Design and Manufacturing Information to Determine**
 - Part Geometries and Relationships
 - Weld joint types and sizes
 - Presentation of Parts in Manufacturing Space
- **Classifies Welds by Joint Design and Welding Position**
- **Designs Collision Free Manipulation Strategy**
- **Designs Order of Weld Accomplishment**
- **Designs Collision-Free Process Trajectories**
- **Computes Commands for the Robot Controller**

AutoGen Process Flow





AUTOGEN Project Goals

- **General solution:**
 - Complete Cad to Fab processes
 - Independent of robot and of CAD system
 - **Open, well-defined hardware and software interfaces**
 - **Implementation on multiple processes with minimal differential effort**
 - **Same processes as skilled craft and welding engineers**
 - **Affordable modification and expansion**
- 



This year's work for GD Electric Boat

- **Functional requirements produced from EB input**
- **Priority items identified**
 - **Code modularity improvement**
 - **GUI development**
 - **Weld procedure/process information integration**
 - **Robot motion planning**



Code Modularity Improvement

- **Decouple and group software into functional areas**
- **Establish interfaces between components**
 - Graphics, ACIS, etc..
- **Identify and fix memory leaks**
 - Research code to production to commercial



GUI Development

- **Currently based on developer's interface**
 - Command line inputs with details exposed
- **Develop operator GUI with inputs through menus and widgets**
 - Level consistent with operator's view of process
- **Functionality to include:**
 - Select, load, move, remove workcells, parts, tables, etc.
 - Select/deselect and specify order and direction for weld edge and concatenation
 - Run/re-run weld analysis and preview robot motion
 - Operator friendly diagnostics
 - Others with input from EB



Weld Procedure/Process Information Integration

- **Interface to existing weld procedure database**
 - Produced by hand from experienced welders
- **Apply joint preparation data**
 - Beveled edges requiring deep penetration welds
 - New geometric representation required
- **Identify and apply multipass weld data**
 - Number and orientation
- **Identify and apply other procedure information that affects weld planning**
- **Produce IFS file consistent with existing PAWS input**



Robot Motion Planning

- **Improve robot base placement to extend continuous weld regions**
 - Incorporate manual 9th dof
- **Improve collision free torch positioning capabilities**
 - Plan collision free deep penetration/multipass weld paths using supplied offsets
 - Develop true 8 dof inverse kin solver
 - Incorporate torch windup
- **Establish robot start/stop home positions**
- **Plan all collision free space motion**
- **Explore the command of robot motion in joint space**



Path Forward

- **Modularizing code into functional areas**
- **Improving robustness**
- **Developing interface specification for GUI development**
- **Investigating EB weld procedure database information and how to incorporate it**
- **Developing geometric representation for beveled edge preparations**
- **Begin testing at EB with first pass of new functionality**