# Intelligent control towards 100 % automation of GMAW

TOOLS FOR ADAPTIVE AND INTELLIGENT CONTROL OF DISCRETE MANUFACTURING PROCESSES - TANDEM

Erik Åstrand, IWE, Ph.D.

Welding Specialist, Volvo Construction Equipment

*A Project funded under the SMART EUREKA CLUSTER on Advanced Manufacturing programme*

Erik Åstrand

Manufacturing Development/ Welding Specialist

**Volvo Construction Equipment**

Technical Development | Manufacturing Engineering

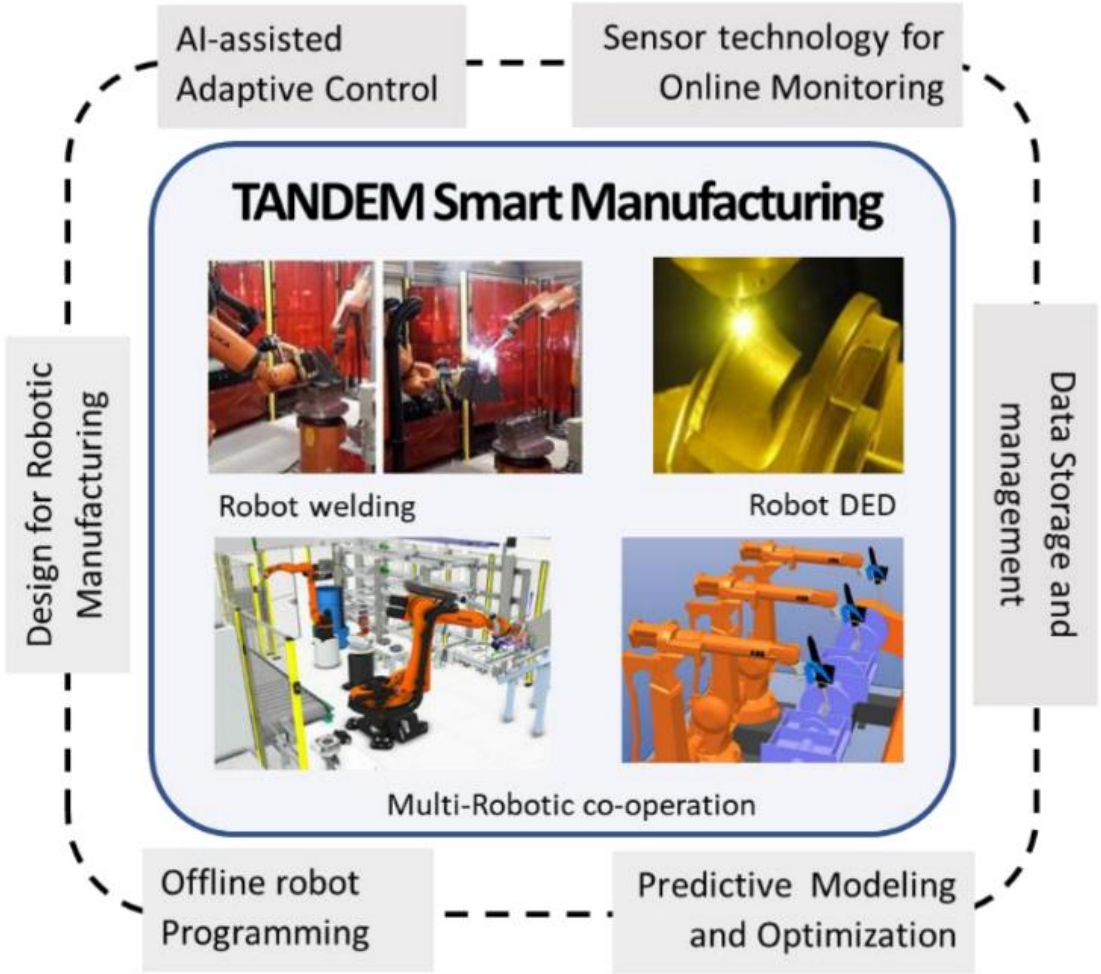
T. +46 70089 75 73

Braås | Sweden

erik.ea.astrand@volvo.com


# Volvo CE i Sverige

# Project overview




| Partner | | Country |
|---|---|---|
| VTT | VTT Technical Research Centre of Finland | |
| VISUAL COMPONENTS | Visual components ( Delfoi) | |
| KESLA | Kesla Oyj | |
| Tampere University | Tampere University, Mech. Engineering and Industrial Systems | |
| Axson | Axson AB | |
| GKN | GKN Aerospace AB | |
| PROCADA | Procada AB | |
| HÖGSKOLAN VÄST | University West, Department of Engineering Science | |
| VOLVO | Volvo Construction Equipment AB | |
| AMP Korea | AMP Korea | |
| KITECH | Korea Institute of Industrial Technology KITECH. Digital Manufacturing Group | |
| EMPOWER OPERATIONS | Empower Operations Corp. | |
| SFU | Simon Fraser University, Product Design and Optimization Lab | |
| JTA CONNECTION | JTA Connection | |
| SANDVIK | Sandvik Mining and Rock Technology | |

Project time: January 2022 - December 2024

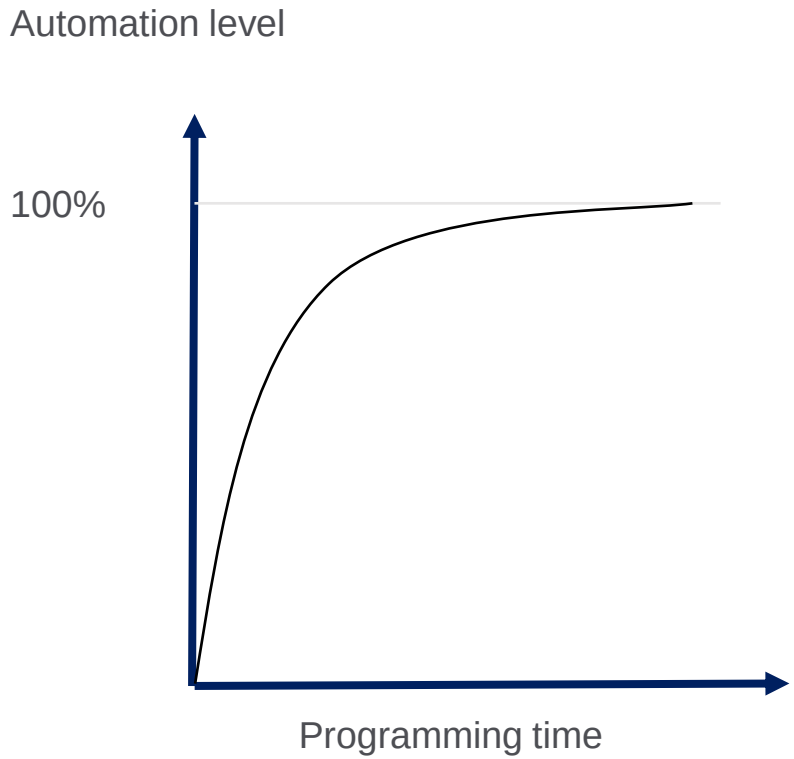
# Project scope and objective - Welding

Scope

- Increase the overall automation level of GMAW
- Improve welding capabilites
- Automate the robot programming
- Create possibilites for 100 % offline programming

Motivations

- Cost efficiency
- Health and safety
  - Ergonomics
  - Robot interaction
  - Heights
  - Smoke
  - …
- and safety, by eliminating manual welding and programing high up..

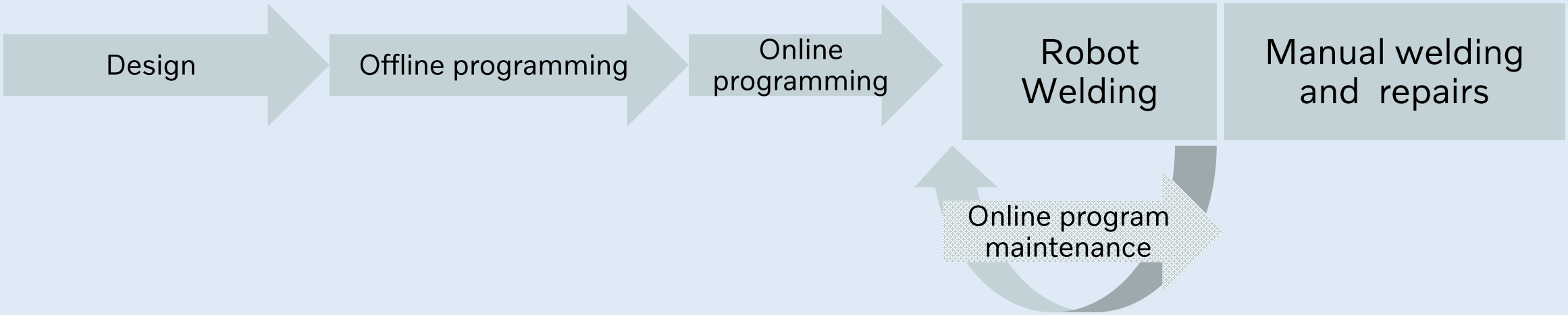


# Project KPI:s

## What to aim for in the project!

| Areas to improve | Improvement target |
|---|---|
| Automatic path planning algorithm speed for a multi-robot system with three robot-arm setup. | 70% |
| Multi-robot system setup speed. | 50 % |
| Number of jigs in welding operations (pcs/setup). Relative reduction | 50 % |
| Increased Automation level of large complicated objects (% of kg welding in robot vs manual) | 33 % |
| Reduction of Programming time (off-line hours). | 50 % |
| Reduction of need for program maintenance and online adjustments | 90 % |

# As is process




# Wanted position

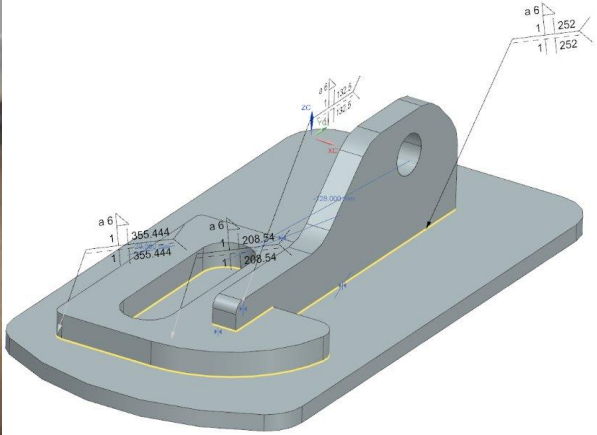
# Project Demonstrators

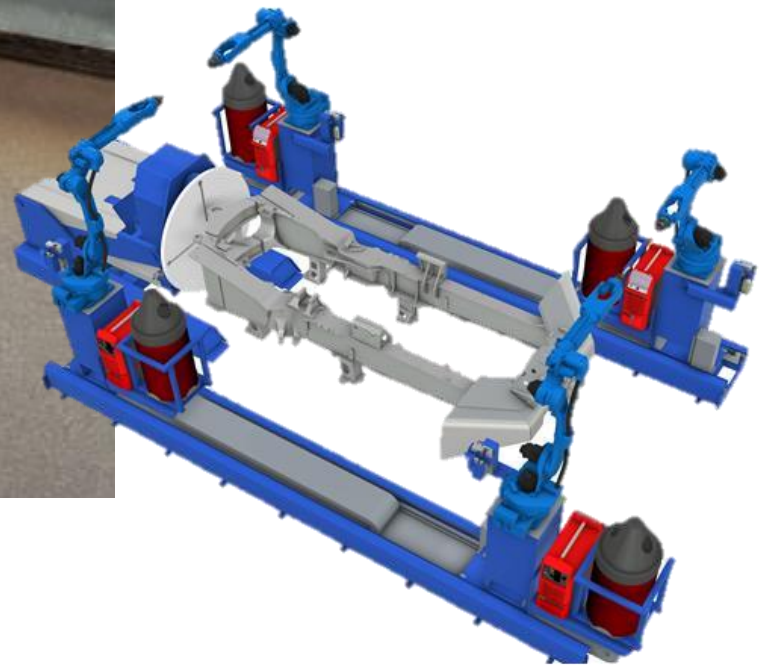
# Current state

Many corners edges and short welds are not welded today.

Reasons for this is e.g.

- Quality issues, if not perfect repairs takes longer times than just weld
- Available time/robot capacity – the arc on factor will be lower for these
- Traditions – We tried it x years ago and it did not work
- Programming accuracy and time
  - Programming time and maintenance of a short weld is similar to a long weld



# Current state

Work steps

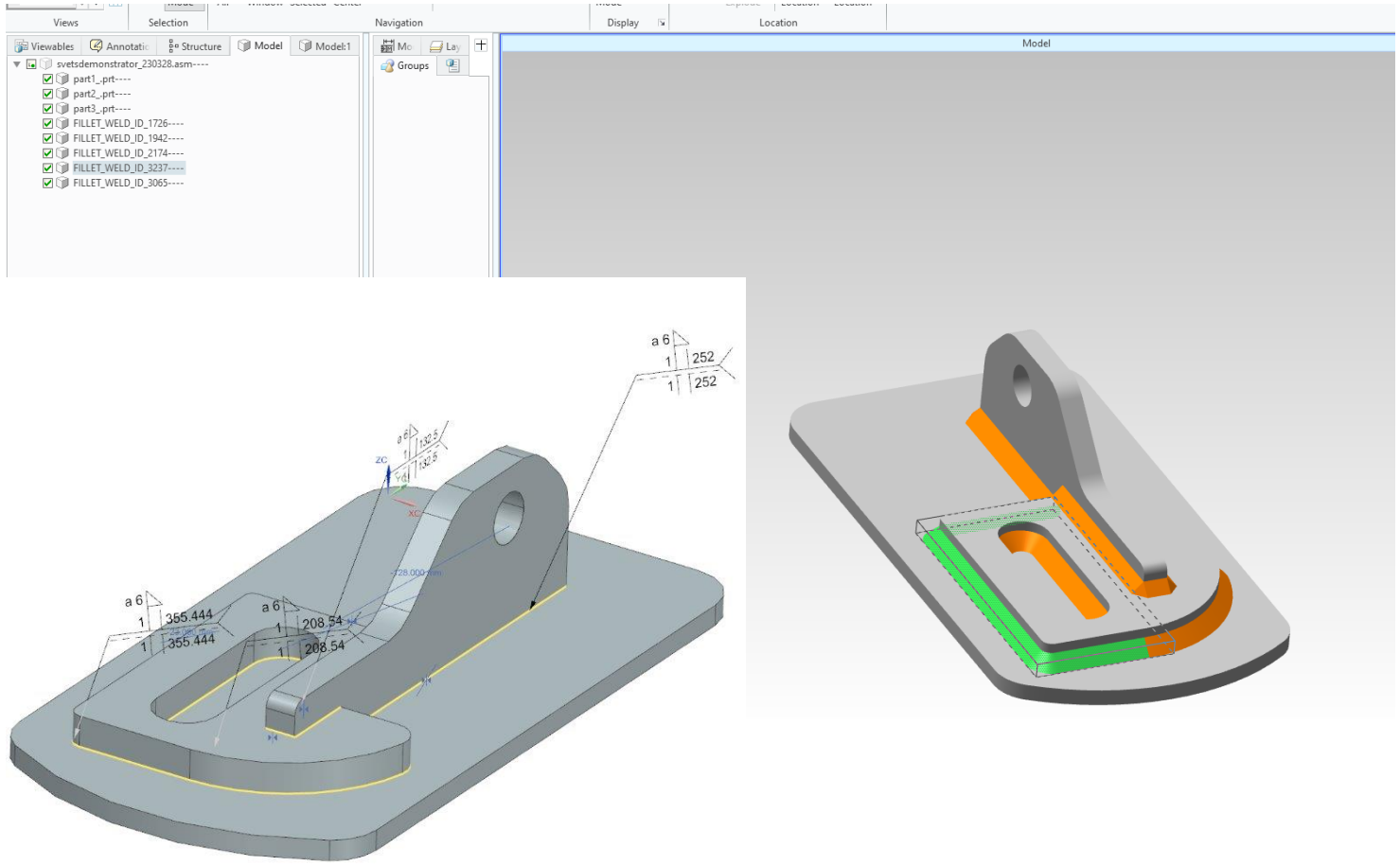
- Prepare offline programming (x min)
  - Import CAD model of work piece
  - Place correctly
- Program offline
  - Generate paths
  - Assign parameters
  - Export program
- Verify program in robot cell
  - Check / adjust according to reference points
  - Check for collisions
- Weld part
  - First weld test
  - Quality evaluation
  - Touch up
  - Second weld test
  - Etc.

First test welding without Touch-up

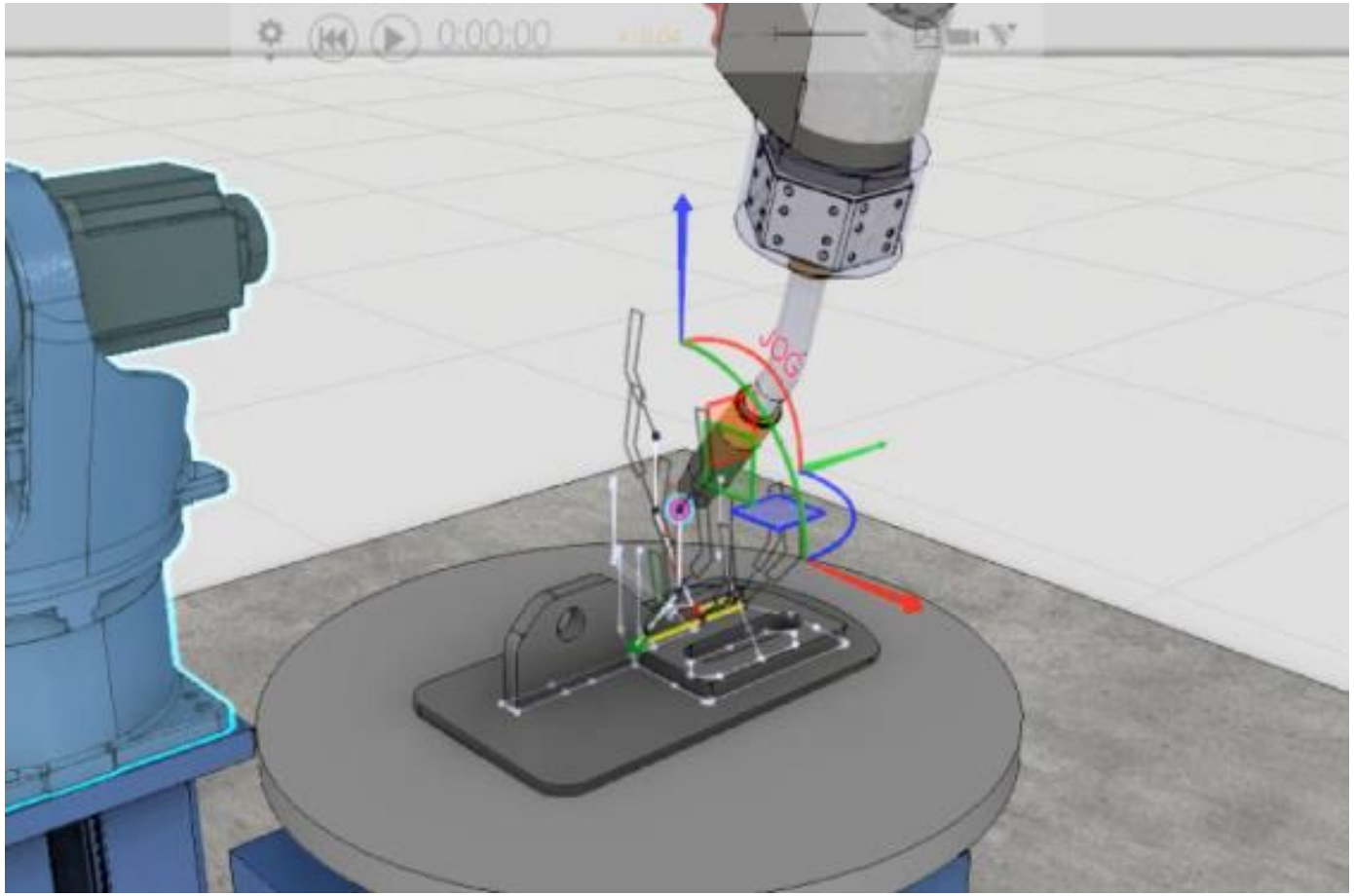
Fifth try with improvements
Done manually in the robot
- Still need for manual repairs

# Future state

- Creating a Creo-model with model based welds.
  - Inner/outer corners
  - Start stop
- Exporting XML- file

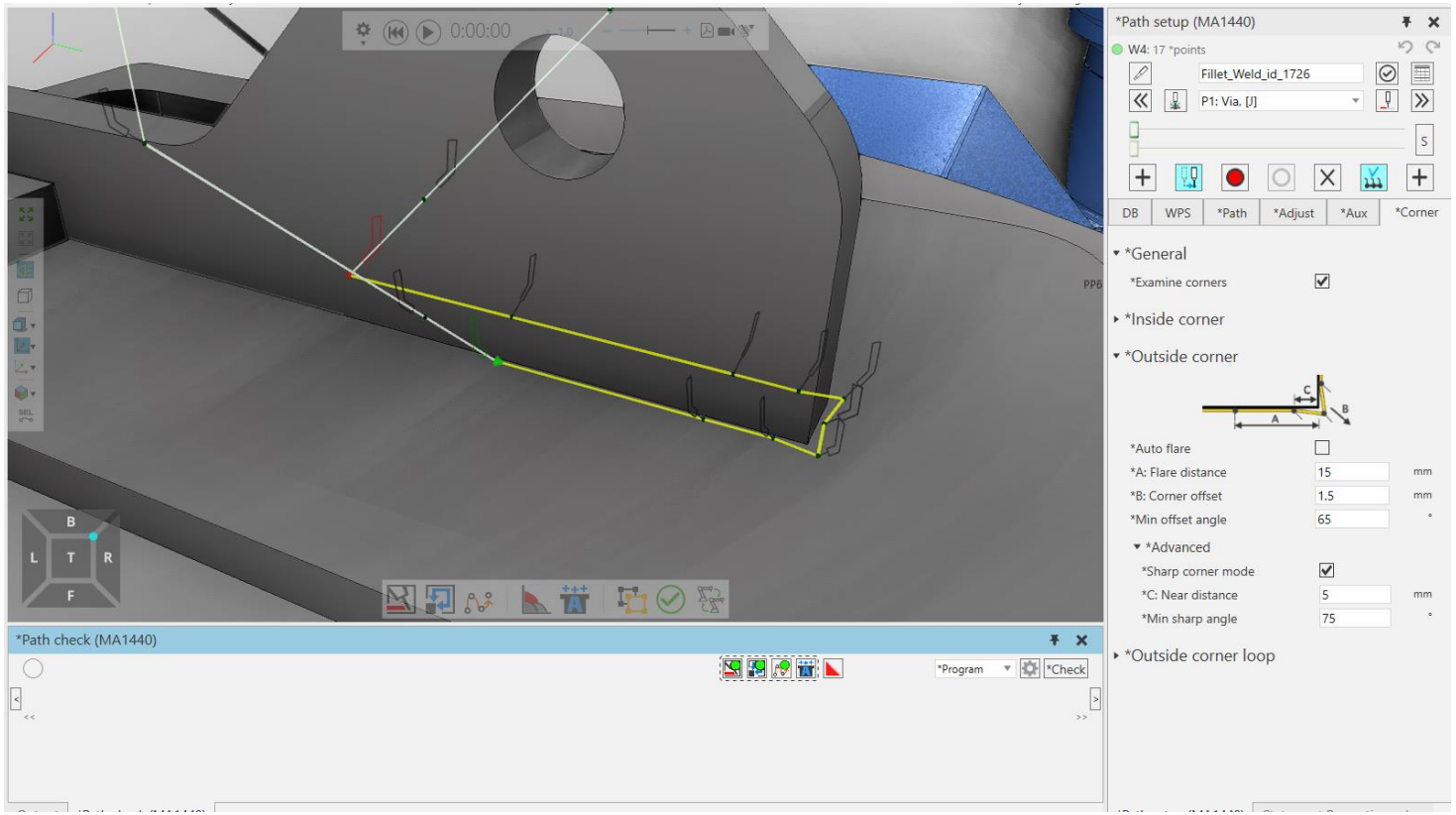


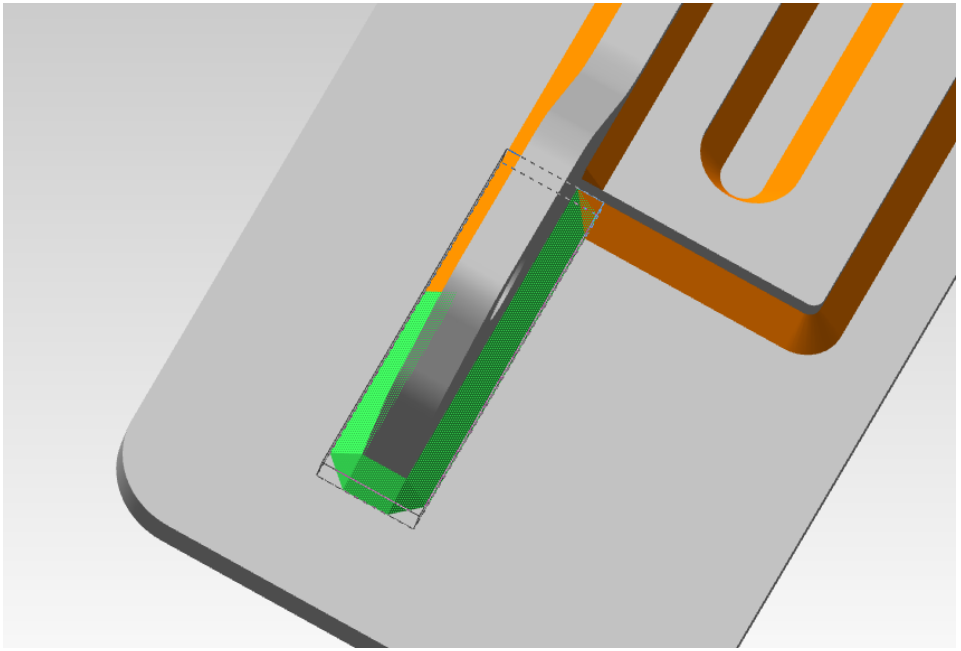
# Model based programming



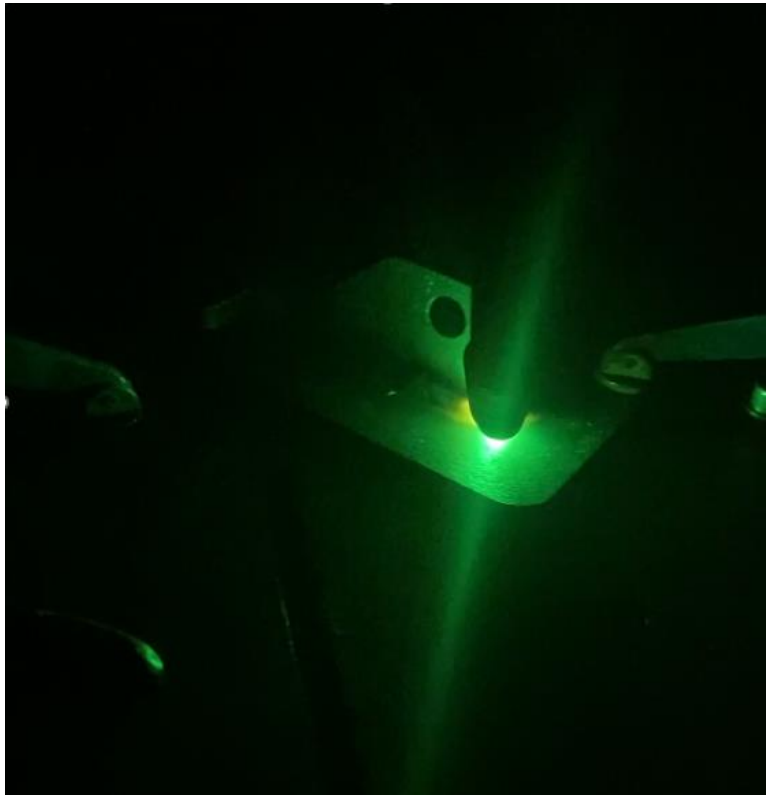
# Fine tuning

Weld path and procedure optimization – To be automated



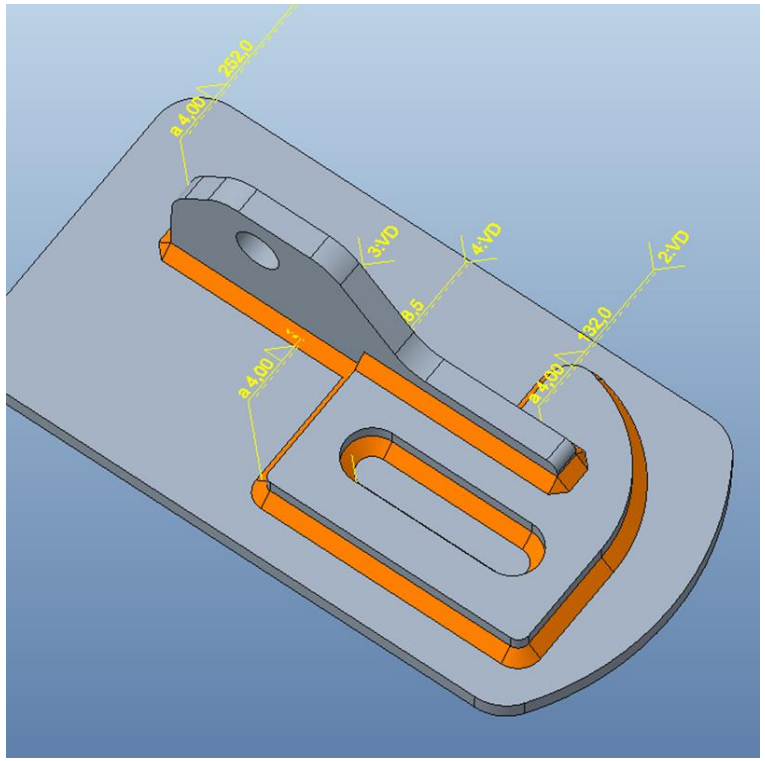



# Start and stopp point searches



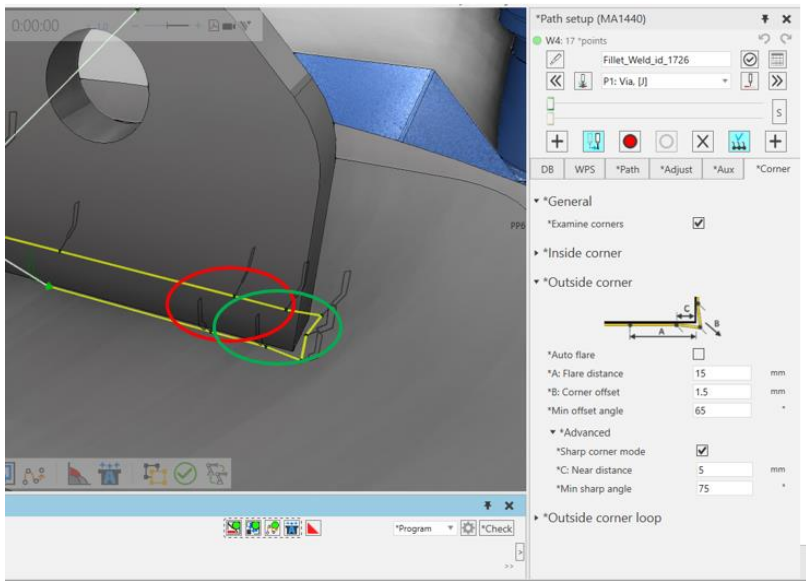
- To reach a high automation level with good/improved quality the robot need to check the exact position of the part
- This is typically done by touch sensing or laser sensors, images can also be used
- For automatic program creation and investment cost, touch sensing is to prefer
- To improve the robustness can controlled pulsed welding processes be used.

# Future process




Our small demonstrator
CAD part, with model-based requirements

Points marked red have push angle 10deg (manually copied from start point)
Points marked green, speed reduced to 5mm/sec ( From 7)




Learn how to handle corners
- create macros


First try to weld complete part.
- No manual adjustments of points in robot
- No need for manual repairs

# Demonstrator summary

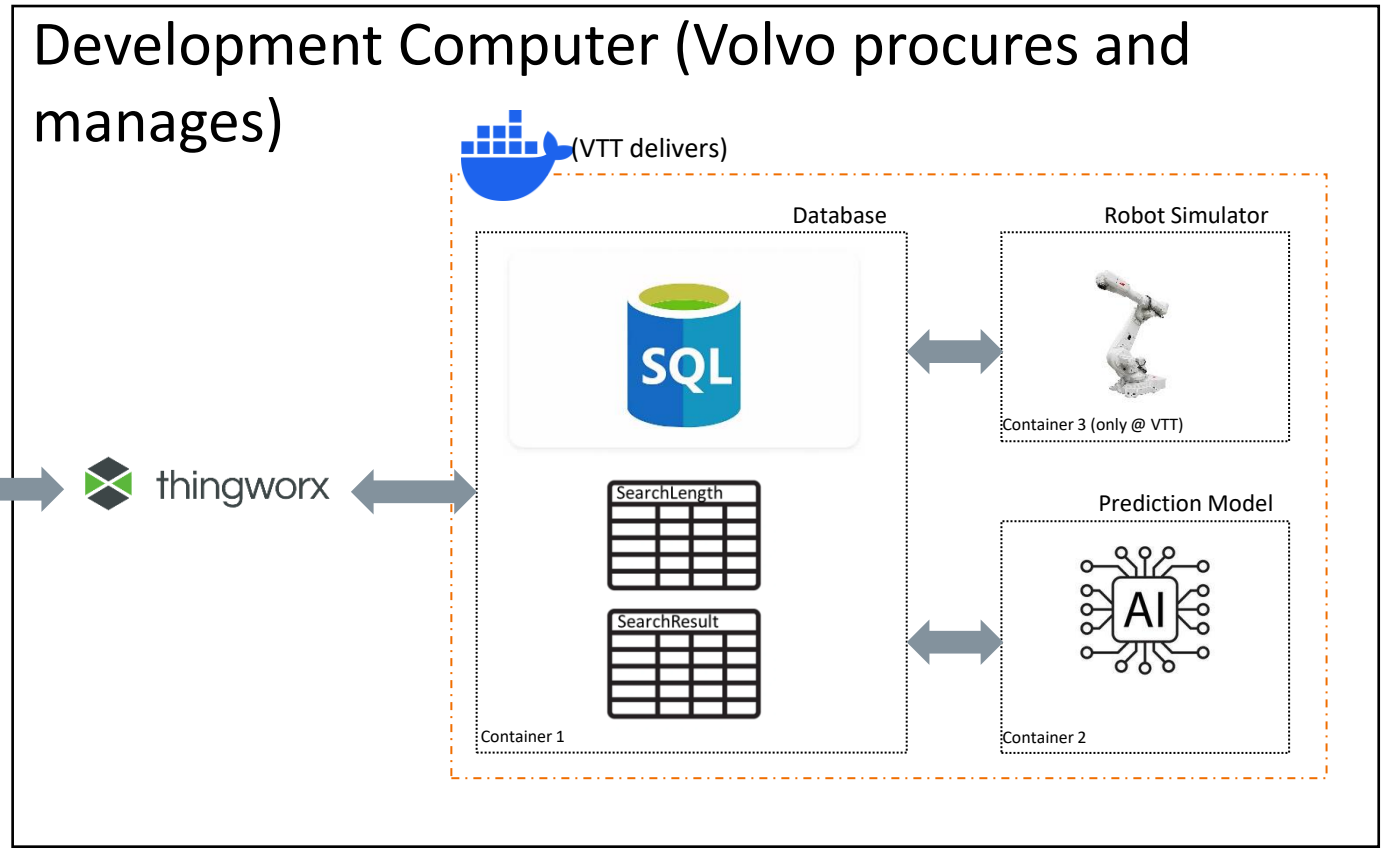


It is possible to produce high quality welds in tricky locations. Standardization of procedures from off-line programming and model based helps to achieve a good result.

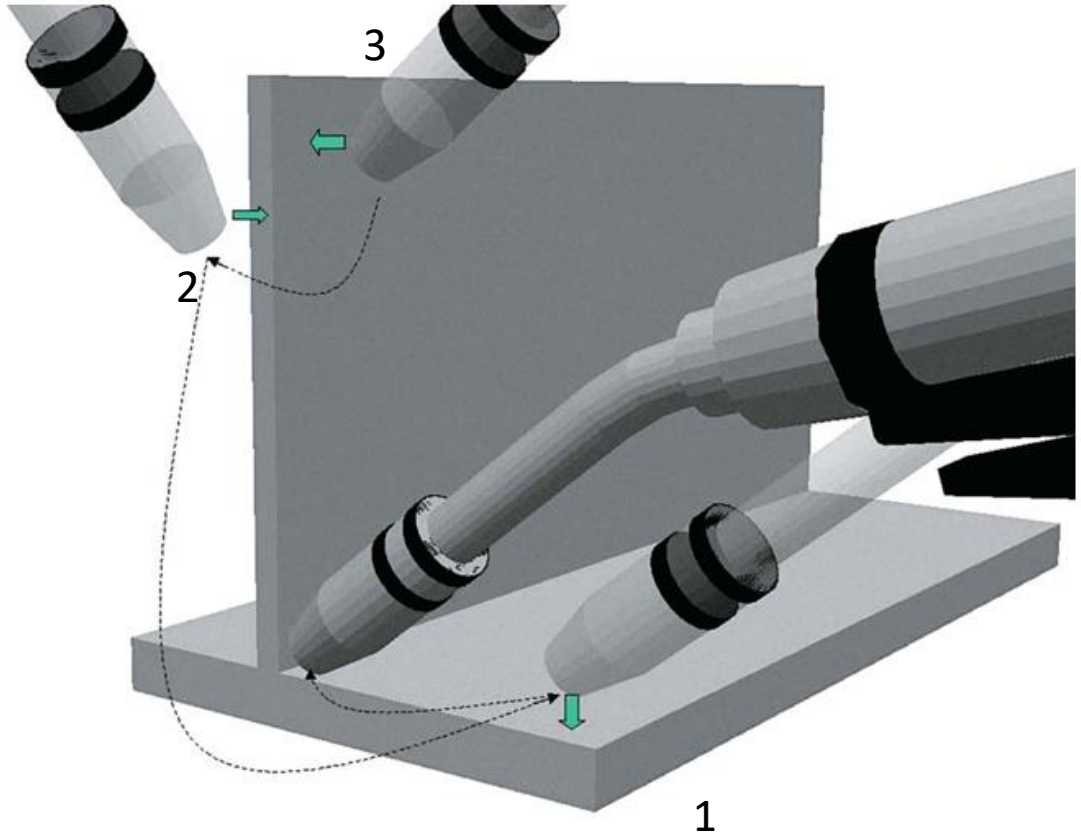
Standard procedures and positions around edges is a key

Feasible to automatically create optimized weld paths and choose weld parameters

# Deployment of AI model to shopfloor



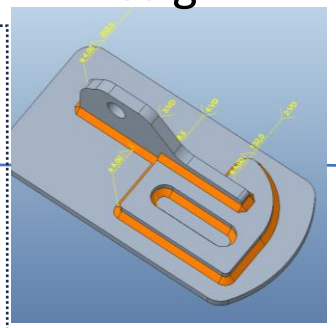

Containers can be pulled from VTT's external gitlab registry



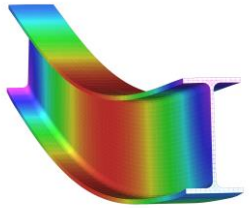

With AI and continious learning and adjustment can the total search length be redused with ~ 70 %

# Future vision

Design



Automatic FEA model generation

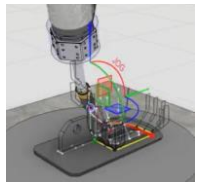


Optimized requirements

Optimization iterations
For product weight, weld size, weld quality level

Model based requirements

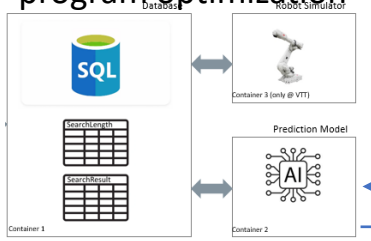
Outside of the scope for this project

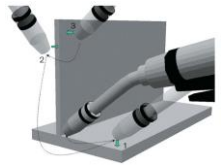


Generic robot program generation
- Path creations
- Part searches
- Welding parameters

Real product dimentions / variation

AI supported program optimization



Program server

Program processing
- Adotions to cell calibration
- Weld path creation
- Weld search
- Task sharing (Multi robot cells)

Robot cell A | Robot cell B | Robot cell c

Call for program

# Thank you!