

Cluster Conference 2023

Multi-Objective Optimization Platform of Worker Well-Being AND Productivity

UNIVERSITY OF SKÖVDE

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HELLO!

- Ph.D. in Multi-Objective Optimization of Worker Well-being and Productivity.
- Create a tool to enable multi-objective optimization of worker well-being and productivity.
- University of Skövde.
- Supervisors: Anna Syberfeldt, Dan Högberg and Erik Brolin.

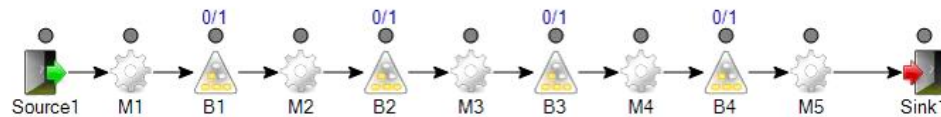
That's me!



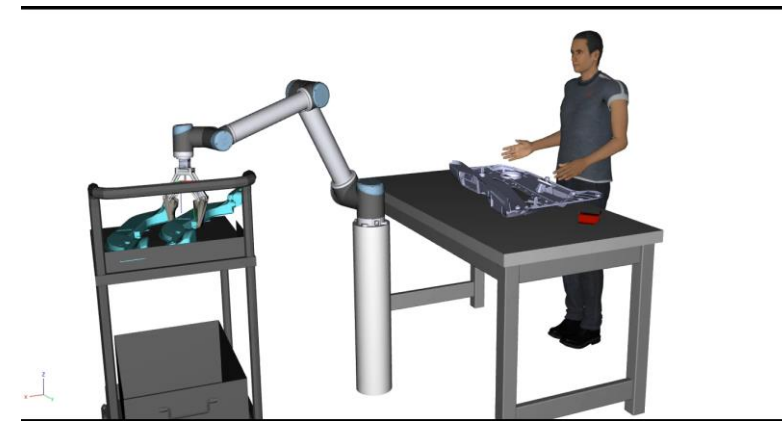
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BACKGROUND

- Simulation software is used in industry to simulate production as it allows predicting behaviors.
- Simulations performed to predict production are usually done separately from human simulations performed to evaluate ergonomics.



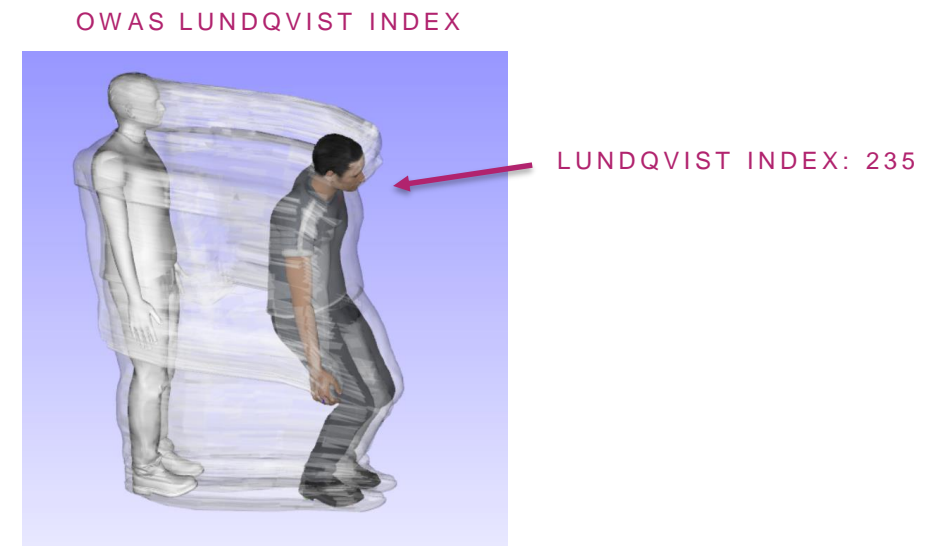
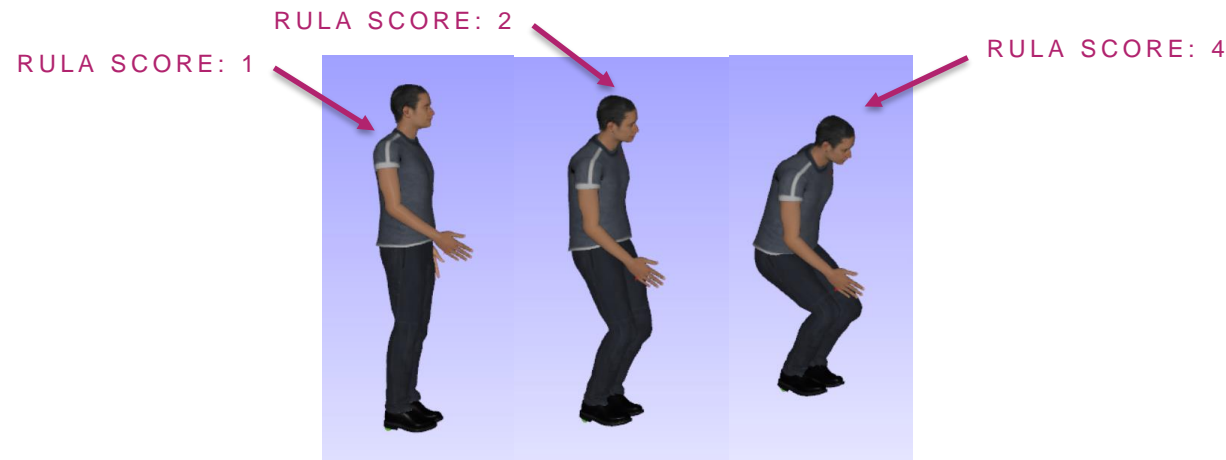
FACTS Analyzer - Production flow simulation software



IPS IMMA – Digital human modelling tool

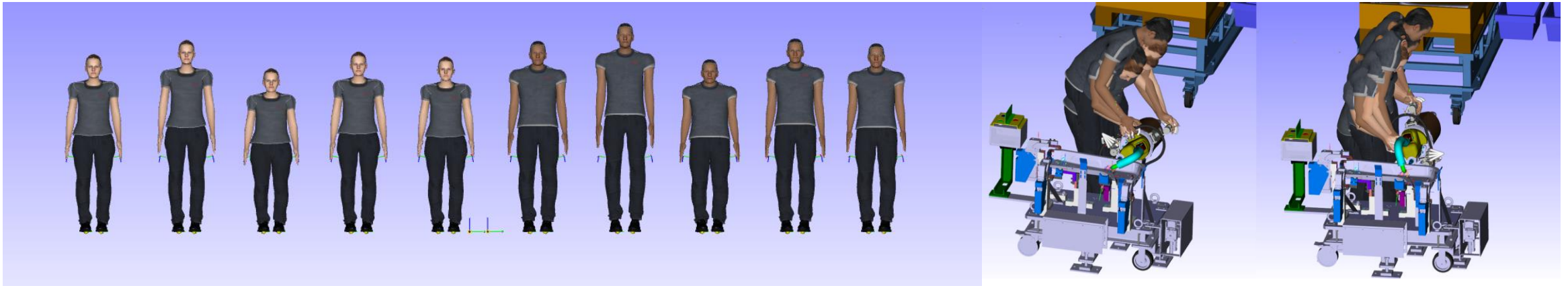
HOW DO WE EVALUATE WORKER WELL-BEING

- Static ergonomic evaluation methods like RULA [1-7].
- Time-based ergonomic evaluation method OWAS with Lundqvist index [100-400].
- The results always indicate risk: the lower the better!



CONSIDERATION OF ANTHROPOMETRIC DIVERSITY

- Simulations with a manikin family to consider body size related variety in the workforce.
- Optimizations must consider each manikin as an objective.

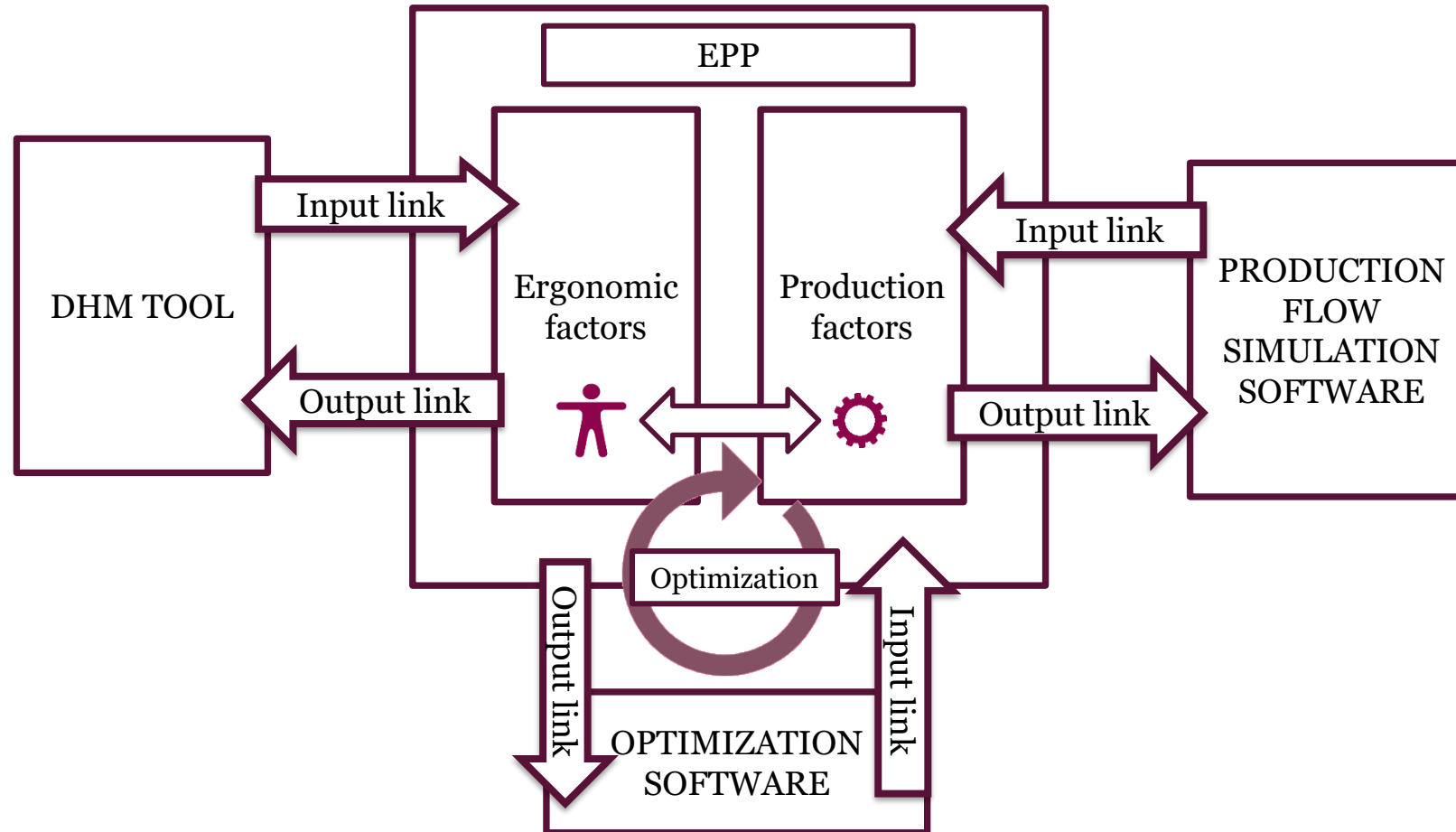


WORKSTATION/PRODUCT DESIGN OPTIMIZATION IN DHM TOOLS

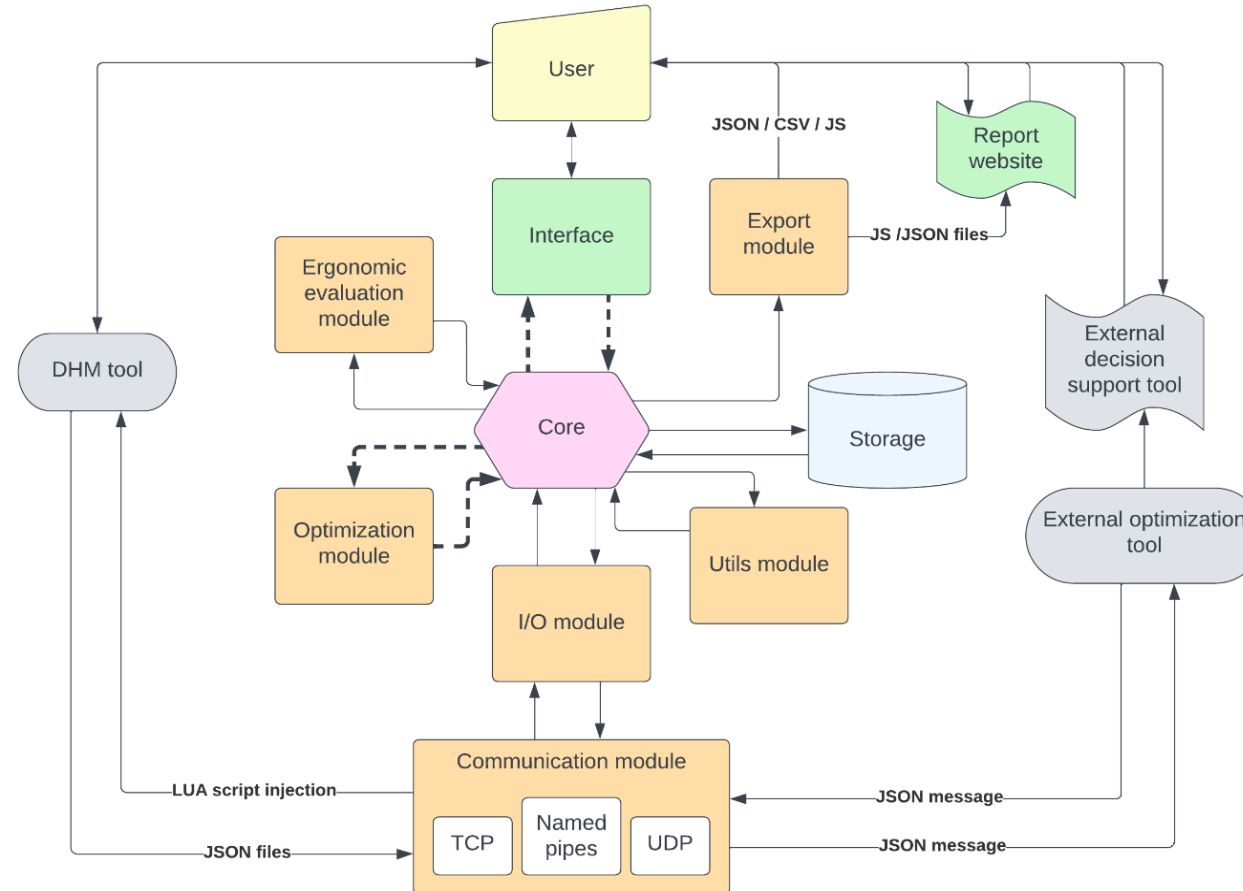
- Not available at the moment in the tools.
- We want to bring together ergonomists and production engineers in design processes.



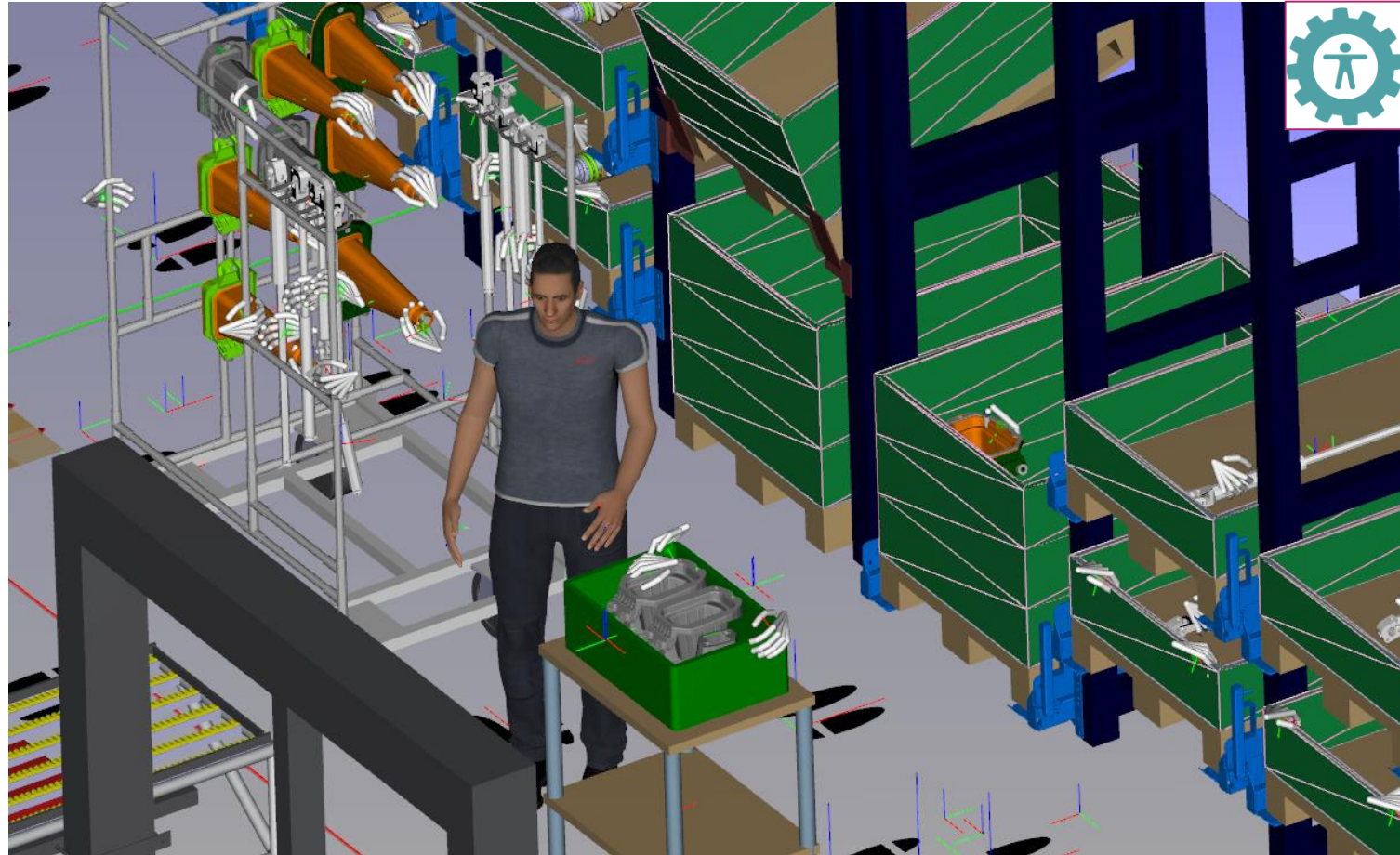
ERGONOMICS IN PRODUCTION PLATFORM



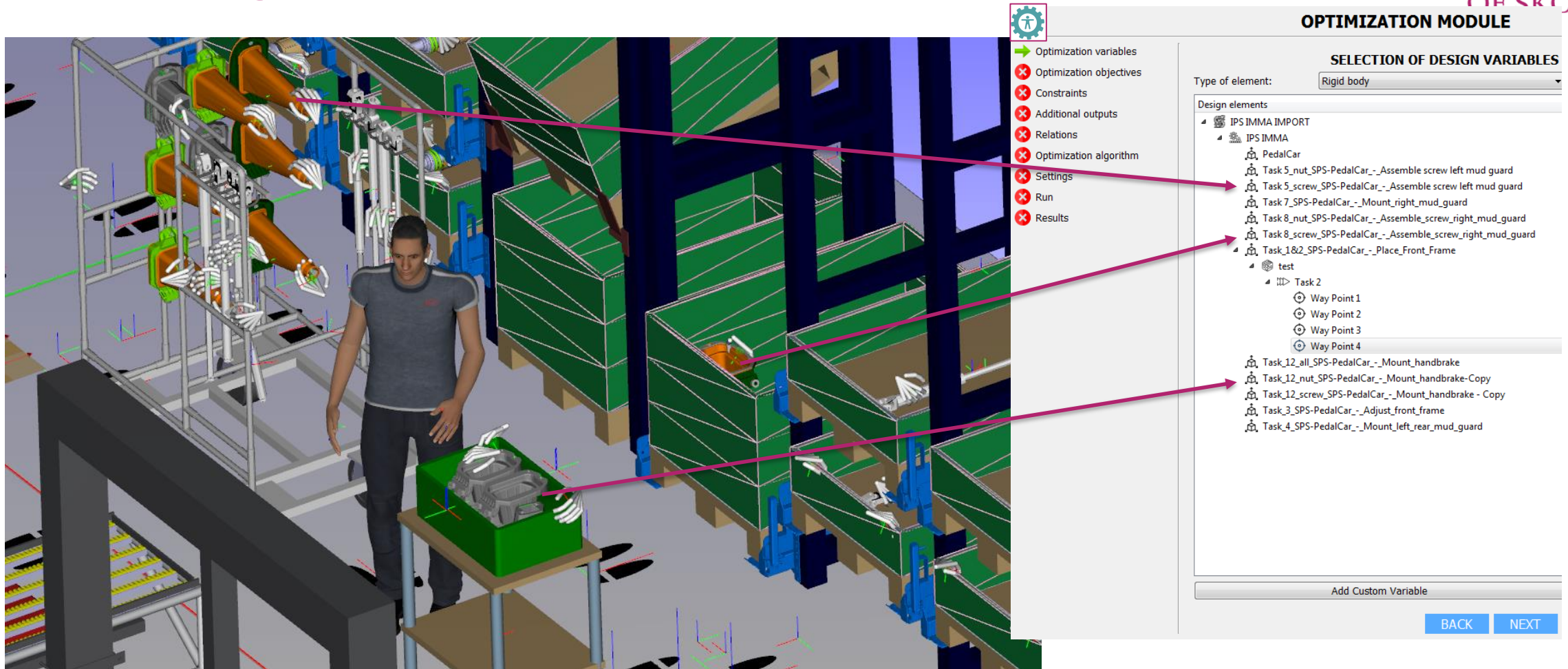
ERGONOMICS IN PRODUCTION PLATFORM



ERGONOMICS IN PRODUCTION PLATFORM



ERGONOMICS IN PRODUCTION PLATFORM



ERGONOMICS IN PRODUCTION PLATFORM

→ Optimization variables

✗ Optimization objectives

✗ Constraints

✗ Additional outputs

✗ Relations

✗ Optimization algorithm

✗ Settings

✗ Run

✗ Results

OPTIMIZATION MODULE

SELECTION OF DESIGN VARIABLES

Type of element: Rigid body

Design elements

- IPS IMMA IMPORT
 - IPS IMMA
 - PedalCar
 - Task 5_nut_SPS-PedalCar_-_Assemble screw left mud guard
 - Task 5_screw_SPS-PedalCar_-_Assemble screw left mud guard
 - Task 7_SPS-PedalCar_-_Mount_right_mud_guard
 - Task 8_nut_SPS-PedalCar_-_Assemble_screw_right_mud_guard
 - Task 8_screw_SPS-PedalCar_-_Assemble_screw_right_mud_guard
 - Task 1&2_SPS-PedalCar_-_Place_Front_Frame
 - test
 - Task 2
 - Way Point 1
 - Way Point 2
 - Way Point 3
 - Way Point 4
 - Task 12_all_SPS-PedalCar_-_Mount_handbrake
 - Task 12_nut_SPS-PedalCar_-_Mount_handbrake-Copy
 - Task 12_screw_SPS-PedalCar_-_Mount_handbrake - Copy
 - Task 3_SPS-PedalCar_-_Adjust_front_frame
 - Task 4_SPS-PedalCar_-_Mount_left_rear_mud_guard

Add Custom Variable

BACK NEXT

Initial absolute values

Translation (mm):
X: 10992.5
Y: -26978.6
Z: 755.2

Rotation (Euler deg.):
RX: 0
RY: 0
RZ: 90

Absolute parameters

Translation (mm):
☐ X: Min: Get Test
Max: Get Test
☐ Y: Min: Get Test
Max: Get Test
☒ Z: Min: 0 Get Test
Max: 2000 Get Test

Rotation (Euler deg.):
☐ RX: Min: Get Test
Max: Get Test
☐ RY: Min: Get Test
Max: Get Test
☐ RZ: Min: Get Test
Max: Get Test

NEXT

ERGONOMICS IN PRODUCTION PLATFORM

- ✓ Optimization variables
- ➔ Optimization objectives
- ✗ Constraints
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- ✗ Results

Factory browser

- IPS IMMA IMPORT
 - IPS IMMA
 - Operation Sequence 1
 - Family 2
 - Female_w=65_s=1674
 - Operation Sequence 2
 - Family 2
 - Female_w=65_s=1674
 - Operation Sequence 3
 - Family 2
 - Female_w=65_s=1674
 - Operation Sequence 4
 - Family 1
 - Male_w=78_s=1756

Add Custom Objective

SELECT OPTIMIZATION OBJECTIVES OF THE MANIKIN

Type of objective: RULA

☐ Group A: Arm and Wrist Analysis

☐ Left Upper Arm Position ☐ Right Upper Arm Position

☐ Lower Arm Position

☐ Left Wrist Position ☐ Right Wrist Position

☐ Left Wrist Twist ☐ Right Wrist Twist

☐ Group B: Neck, Trunk and Leg Analysis

☐ Neck Position ☐ Trunk Position

☒ Grand RULA Score

NEXT

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Factory browser

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 - Operation Sequence 3
 - Family 2
 - Female_w=65_s=1674
 - Operation Sequence 4
 - Family 1
 - Male_w=78_s=1756

Add Custom Objective

Rigid body

Elements

- Linde_Dolly_3D-Task3_p...
- Linde_Dolly_3D-Task4
- Linde_Dolly_3D-Task4 - ...
- MH-0476_B4_3D
- Motion Sweep - Tugger...
- P90_Base - P4237
- P90_Base - P4238
- P90_Base - P4239
- P90_Base - P4240
- P90_Base - P4241
- P90_Base - P4242
- P90_Base - P4243
- P90_Base - P4244
- P90_Base - P4245
- P90_Base - P4246
- P90_Base - P4247
- P90_Base - P4249
- P90_Base - P4250
- P90_Base - P4251
- P90_Base - P4252
- P90_angledshelf - P4242
- P90_flatshelf_1 - P4240
- P90_flatshelf_1 - P4237

Script:

Open EPP data tree

```
//Translations in meters
var P90_Base - P4245_tx = EPP.line.workstations[0].rigidBodies[50].tx;
var P90_Base - P4245_ty = EPP.line.workstations[0].rigidBodies[50].ty;
var P90_Base - P4245_tz = EPP.line.workstations[0].rigidBodies[50].tz;
//Rotations in Euler angles
var P90_Base - P4245_rx = EPP.line.workstations[0].rigidBodies[50].rx;
var P90_Base - P4245_ry = EPP.line.workstations[0].rigidBodies[50].ry;
var P90_Base - P4245_rz = EPP.line.workstations[0].rigidBodies[50].rz;
```

☒ Inputs ☒ EPP Objects ☐ Updated script ☐ Advanced libraries

☒ Real Number ☐ Integer

☒ Show debug ☐ Show result

TEST

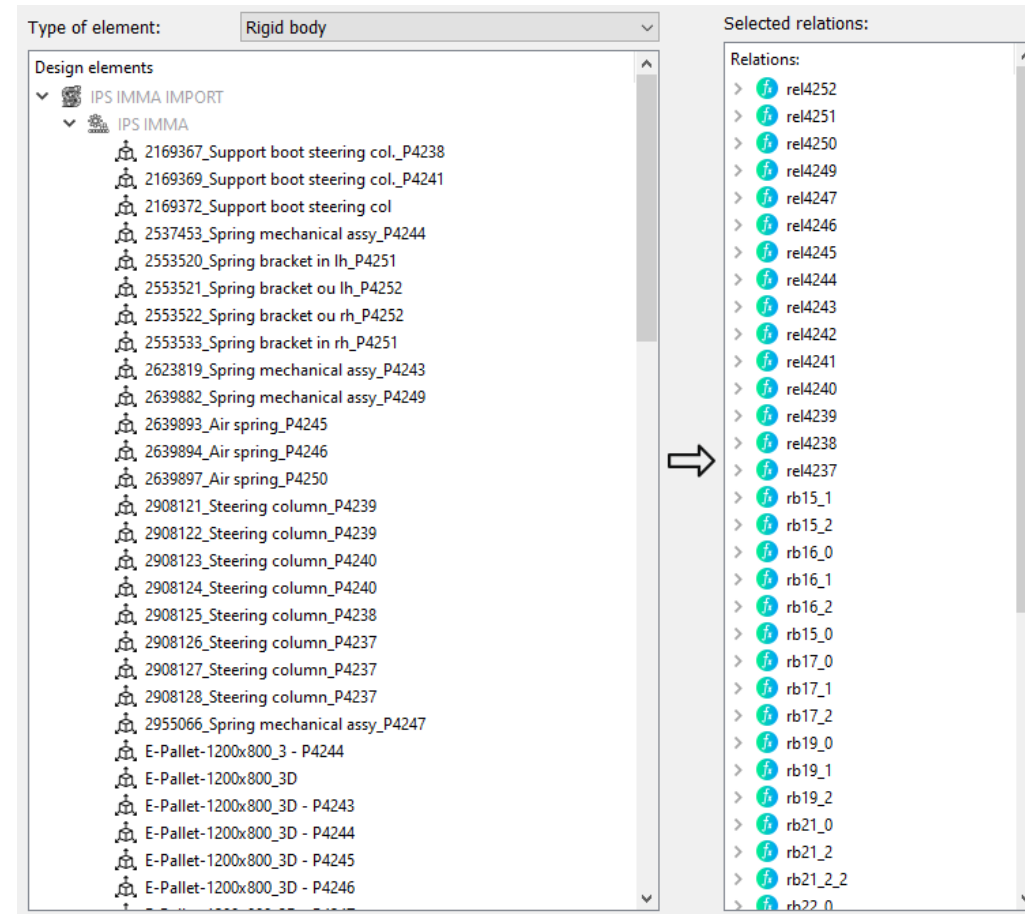
☒ Minimize ☐ Maximize

Name:

Save file Load file

ERGONOMICS IN PRODUCTION PLATFORM

- ✓ Optimization variables
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ERGONOMICS IN PRODUCTION PLATFORM

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CONFIGURATION OF OPTIMIZATION ALGORITHM

Iterations:

Simulation frames per second:

Get estimated time for optimization

Optimization algorithm:

Population size:

Child population size:

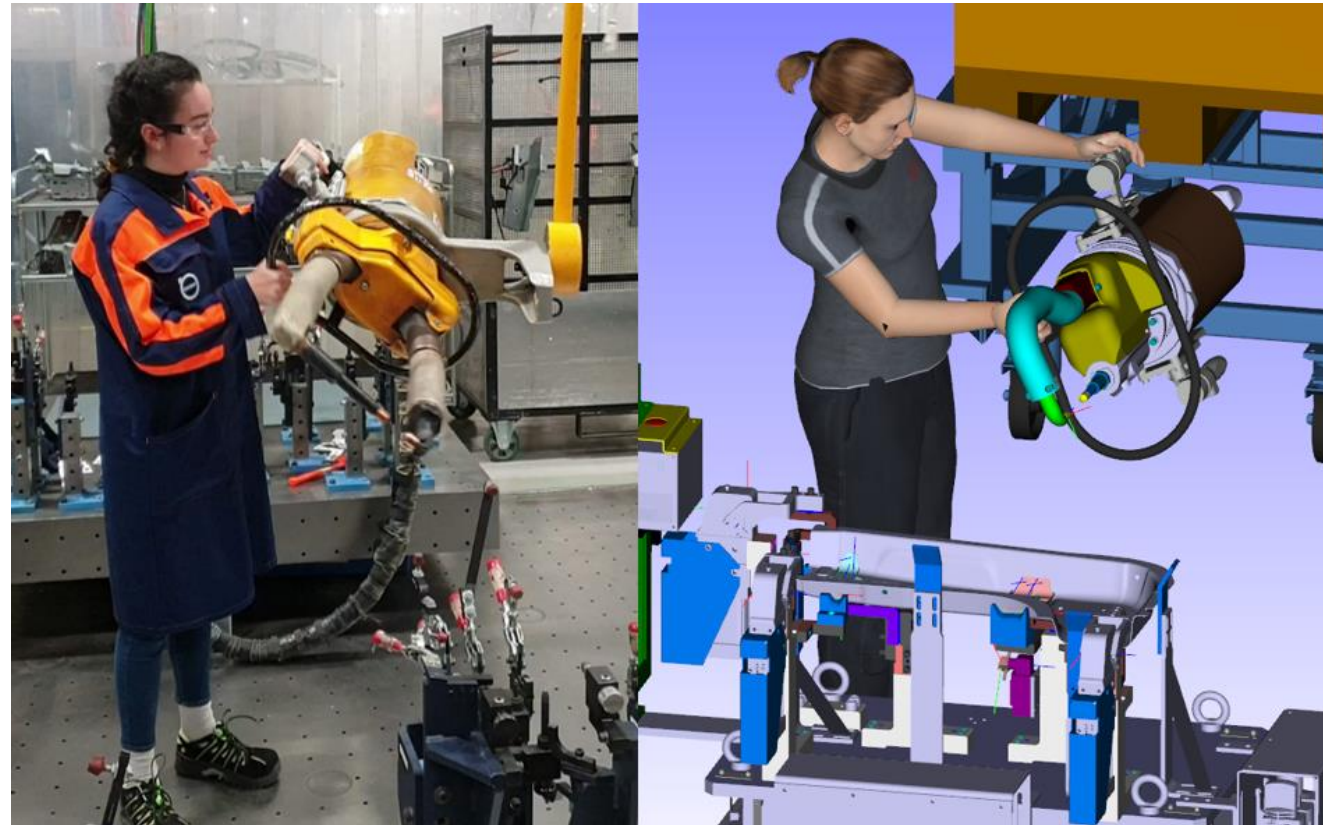
Mutation probability:

Crossover probability:

Tournament size:

USE CASE – WELDING GUNS

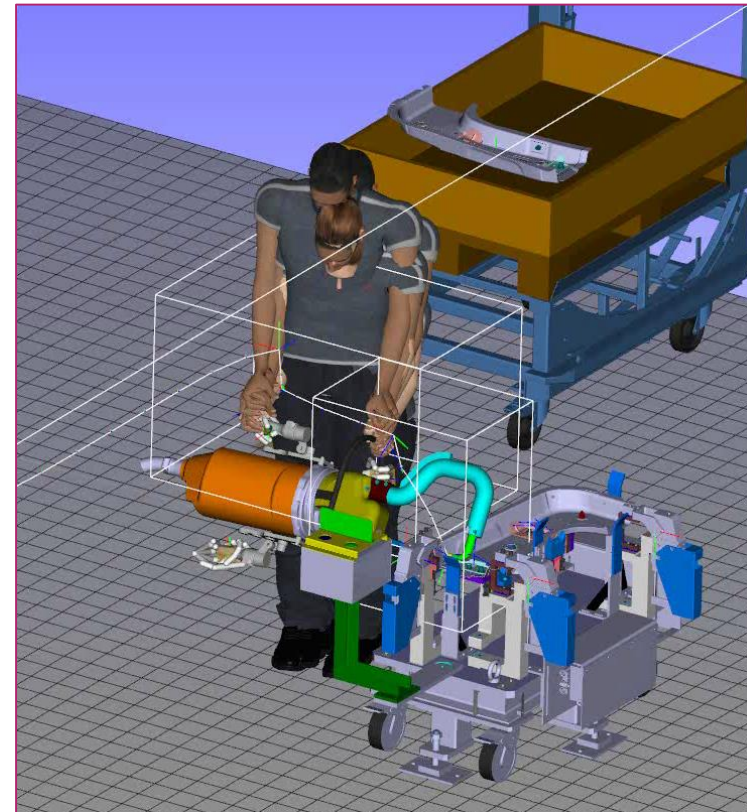
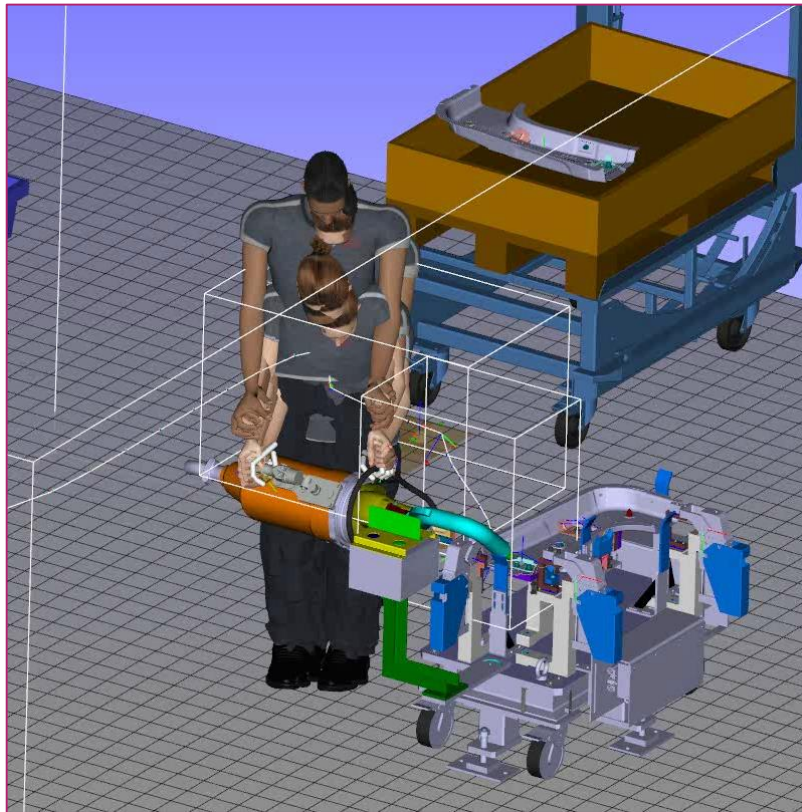
DESIGN OF WORKSTATION FOR MANUAL WELDING



USE CASE – WELDING GUNS

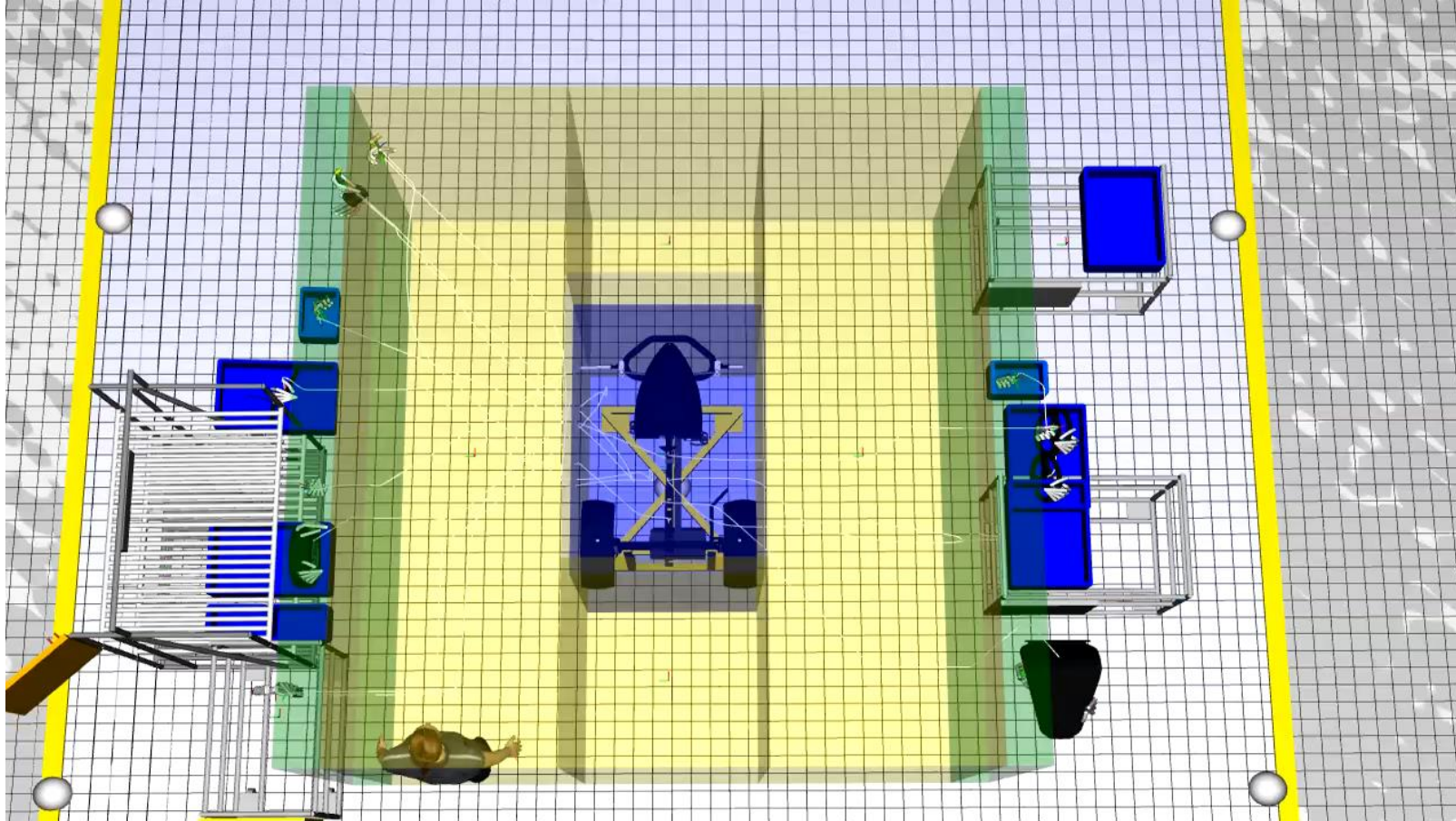
DESIGN OF WORKSTATION FOR MANUAL WELDING

- Welding angle optimization considering anthropometric diversity:



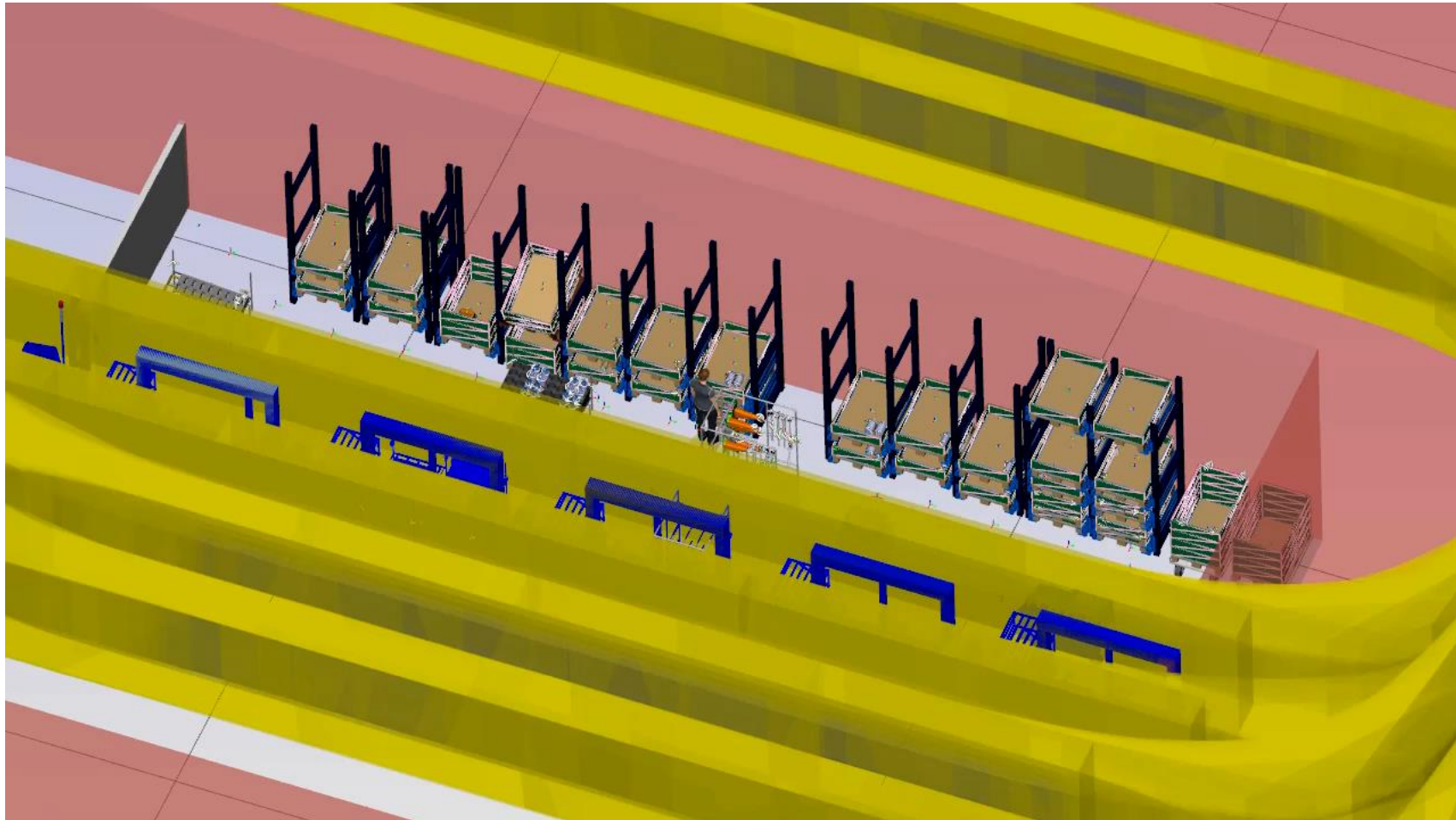
USE CASE – PEDAL CAR LAYOUT

DESIGN OF PEDAL CAR ASSEMBLY LAYOUT

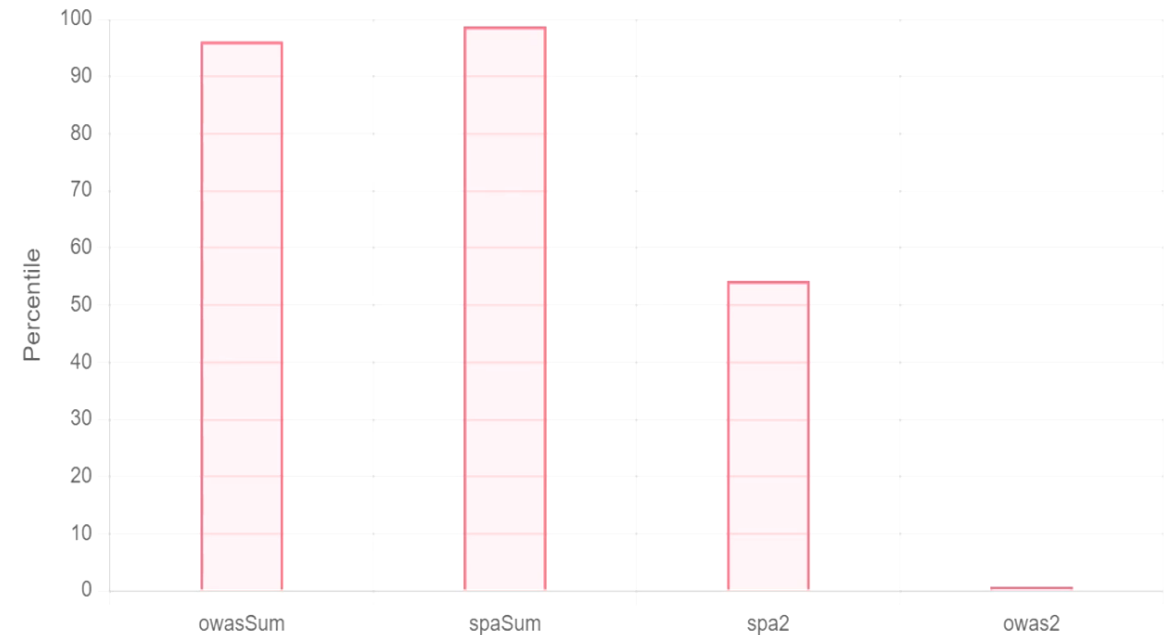
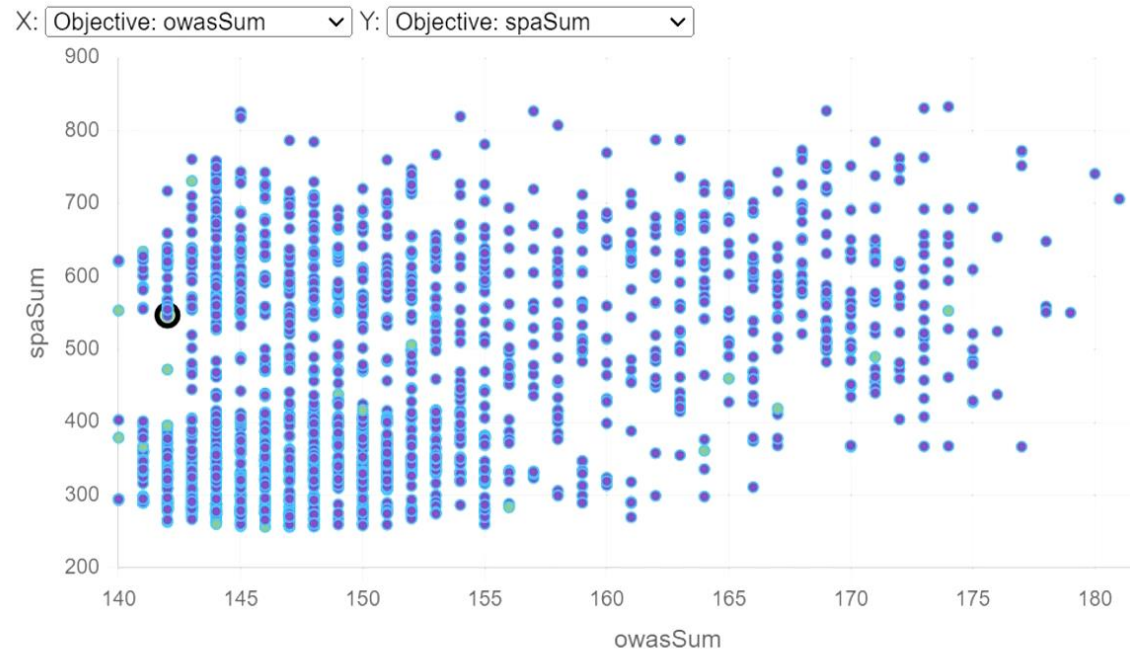


USE CASE – LOGISTICS PLATFORM

DESIGN OF LOGISTICS WORKSTATION LAYOUT



ERGONOMICS IN PRODUCTION PLATFORM



ERGONOMICS IN PRODUCTION PLATFORM

OPTIMIZATION MODULE Help

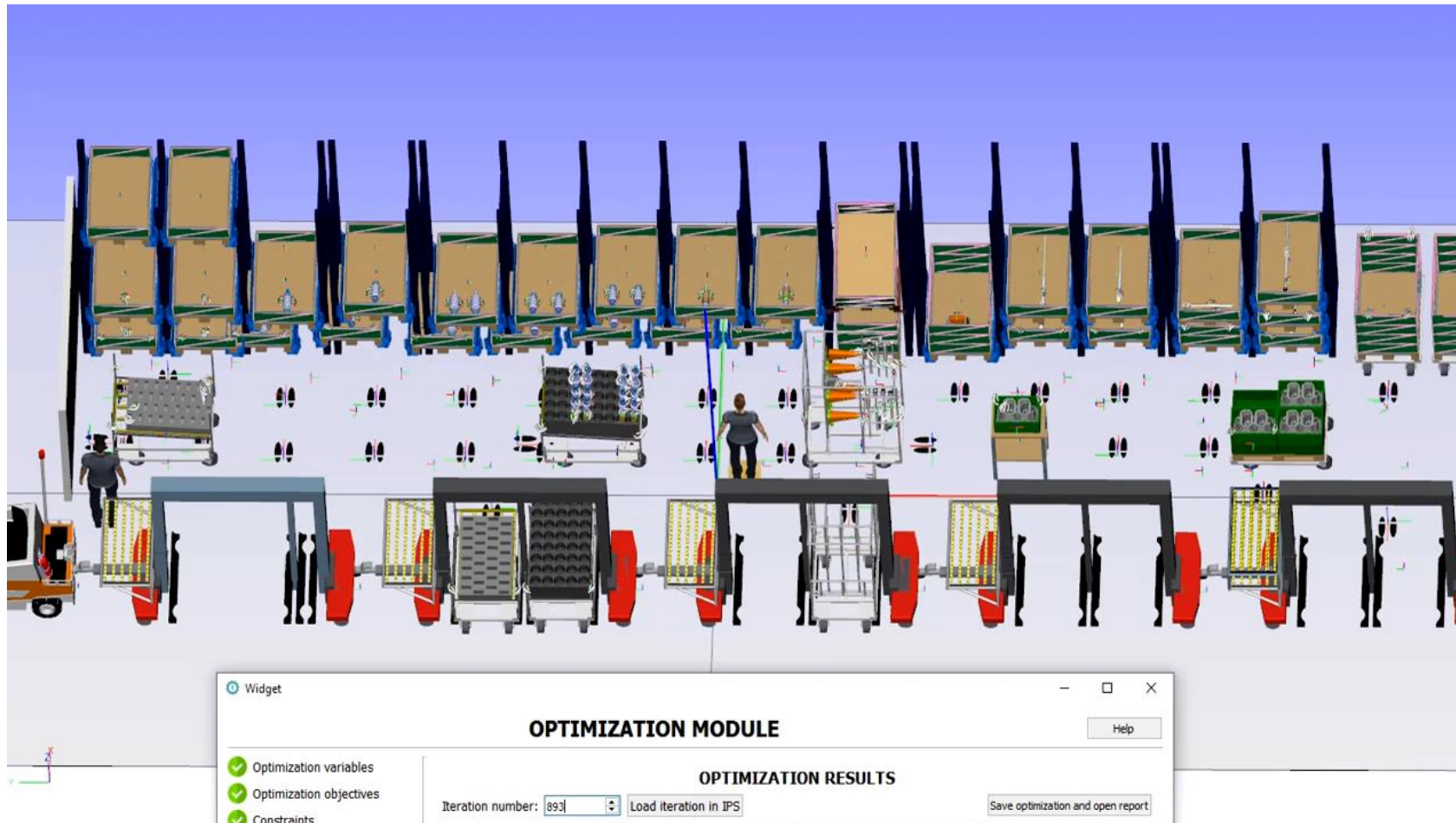
✓ Optimization variables
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➔ Results

OPTIMIZATION RESULTS

Iteration number: Load iteration in IPS Save optimization and open report

Variables:	Objectives:	Additional outputs:	Relations:
permu_node_0 Value: 6	owasSum Value: 143	owas1 Value: 136	rel4252 Object name: P90_B... Object type: RigidB...
permu_node_1 Value: 12	spaSum Value: 558.7	owas2 Value: 146	Relations Translation [y]: 7...
permu_node_2 Value: 11	spa2 Value: 59.9	owas3 Value: 159	Objects related to
permu_node_3 Value: 11	owas2 Value: 100	spa1 Value: 320.4	rel4251 Object name: P90_B... Object type: RigidB...
permu_node_4 Value: 10		spa2 Value: 170.1	Relations Translation [y]: 7...
permu_node_5 Value: 9		spa3 Value: 68.2	Objects related to
permu_node_6 Value: 8		time1 Value: 71	rel4250 Object name: P90_B... Object type: RigidB...
permu_node_7 Value: 7		time2 Value: 86	Relations Translation [y]: 7...
permu_node_8 Value: 6		time3 Value: 19	Objects related to
permu_node_9 Value: 5		P4252pos Value: 6	rel4249 Object name: P90_B... Object type: RigidB...
permu_node_10 Value: 4		P4251pos Value: 13	Relations Translation [y]: 7...
permu_node_11 Value: 3		P4250pos Value: 12	Objects related to
permu_node_12 Value: 0		P4249pos Value: 14	rel4247 Object name: P90_B... Object type: RigidB...
permu_node_13 Value: 1		P4247pos Value: 11	Relations Translation [y]: 7...
P4252_h Value: 273.779		P4246pos Value: 10	Objects related to
P4251_h Value: 257.151		P4245pos Value: 9	rel4246 Object name: P90_B... Object type: RigidB...
P4250_h		P4244pos	Relations Translation [y]: 7...

ERGONOMICS IN PRODUCTION PLATFORM



COME TO US!

- If you would like to test it yourselves.
- If you want to give feedback about Ergonomics in Production Platform.
- Possible additional use cases.

Thank you for your attention

Please contact me for any further questions: aitor.iriondo.pascual@his.se

