



AXIOM TECH



Digital Human Modelling and Simulation in Tecnomatix

Feb 15th, 2018, Slovenia, Ljubljana
Presenter: David Sámek

Solution
Partner

PLM

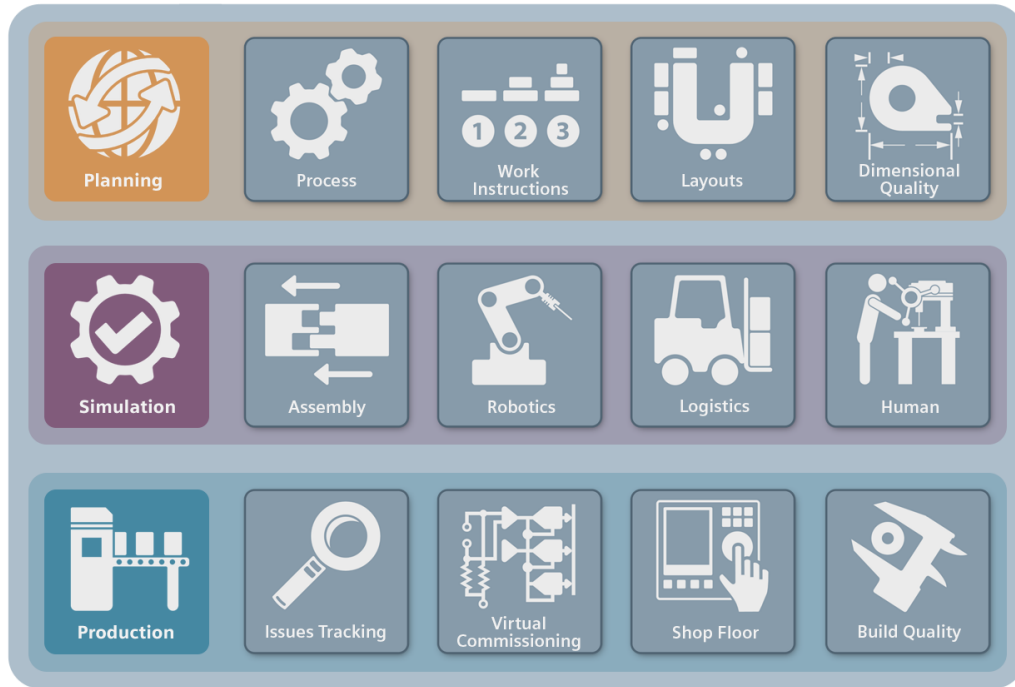
SIEMENS

Outline

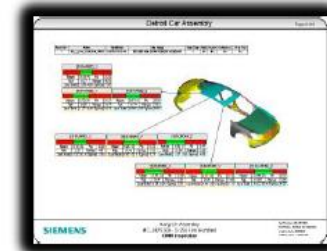
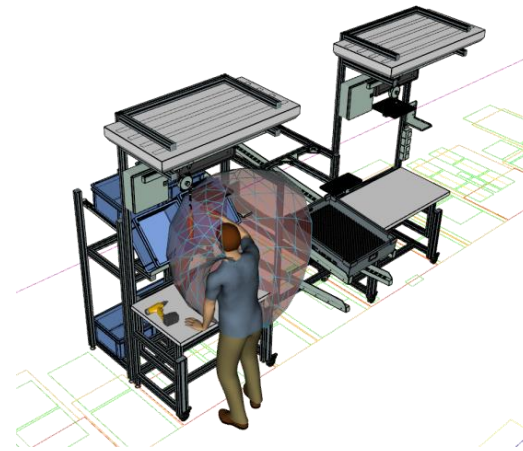
- Tecnomatix introduction
- Digital Human Modelling and Simulation
- Human performance tools
- Feasibility Tools
- Motion Capture & Virtual Reality
- Task Simulation Builder
- Human - Robot Collaboration
- Conclusion

Tecnomatix

TECNOMATIX



Solutions to cover manufacturing challenges



TOP 16 CAR PRODUCERS

TOP 16 PRODUCERS	DESIGN	PLM	PRODUCTION
BMW		TEAMCENTER	TECNOMATIX
Daimler	NX	TEAMCENTER	TECNOMATIX
Fiat	NX	TEAMCENTER	TECNOMATIX
Ford		TEAMCENTER	TECNOMATIX
General Motors	NX	TEAMCENTER	TECNOMATIX
Hyundai			TECNOMATIX
Honda		TEAMCENTER	TECNOMATIX
Chana	NX		
Chrysler	NX	TEAMCENTER	TECNOMATIX
Mazda	NX	TEAMCENTER	TECNOMATIX
Nissan	NX	TEAMCENTER	TECNOMATIX
PSA			
Renault			TECNOMATIX
Suzuki	NX	TEAMCENTER	TECNOMATIX
Toyota			TECNOMATIX
VW/Audi		TEAMCENTER	TECNOMATIX

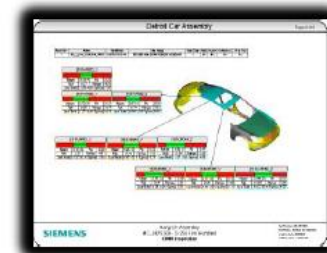
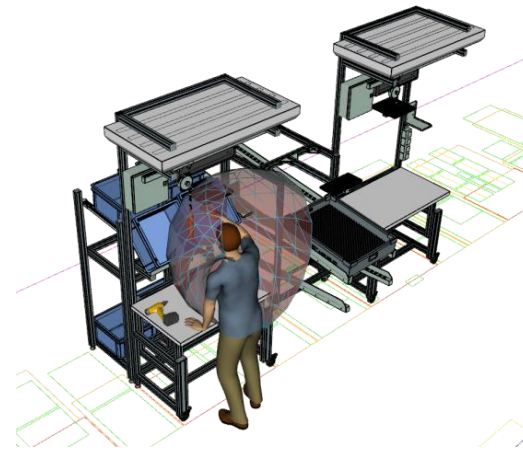


Tecnomatix Assembly

TECNOMATIX



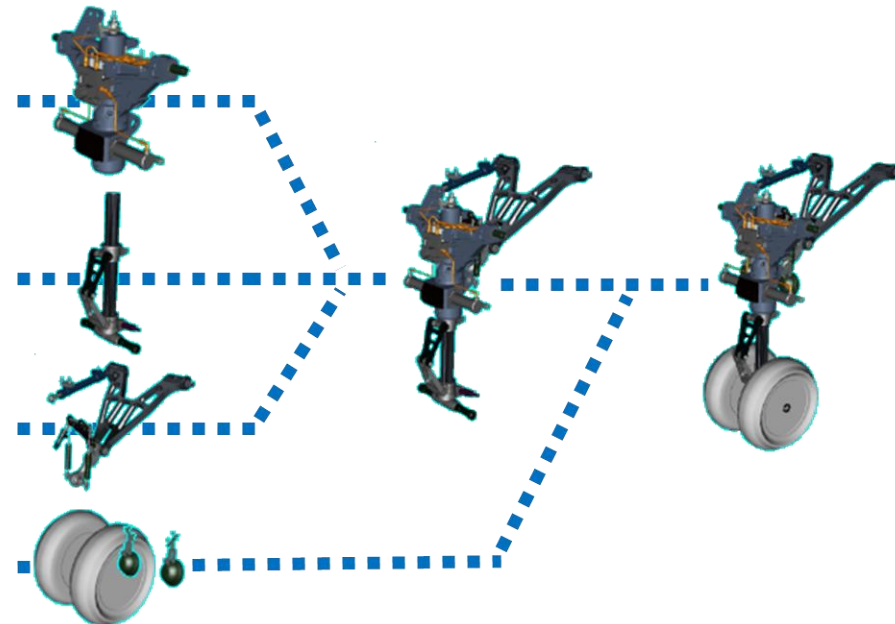
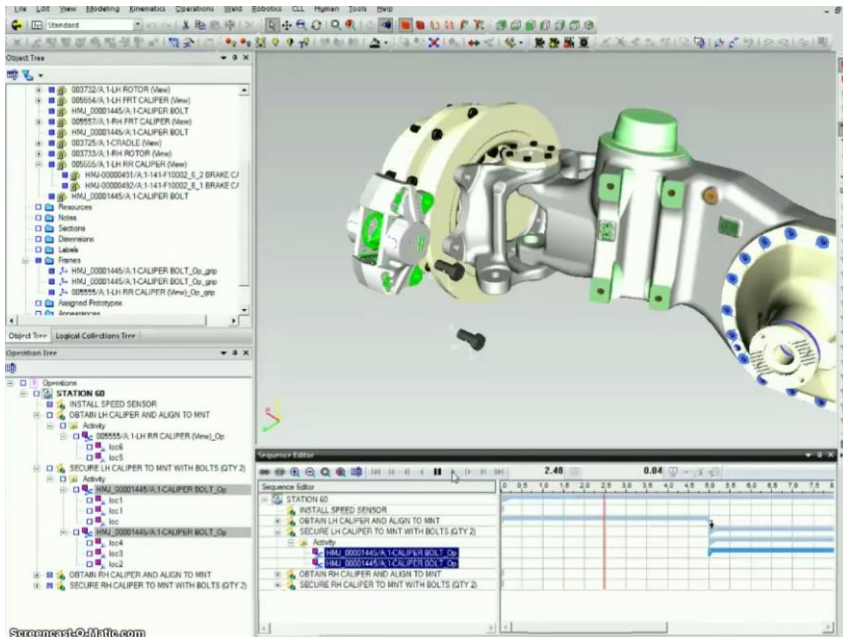
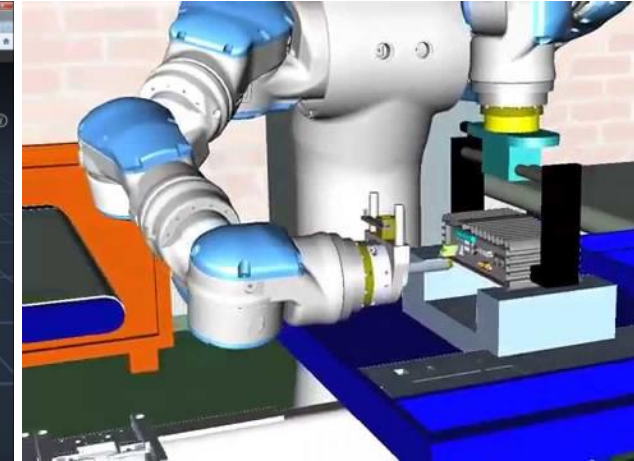
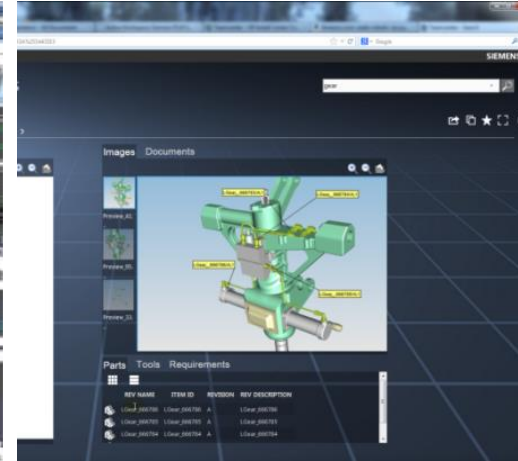
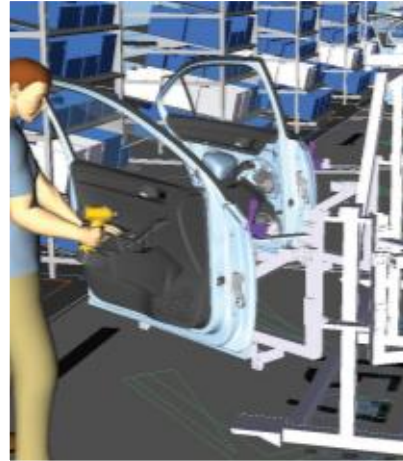
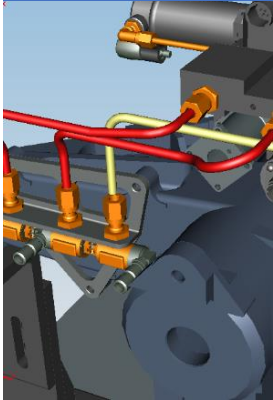
Solutions to cover
manufacturing challenges



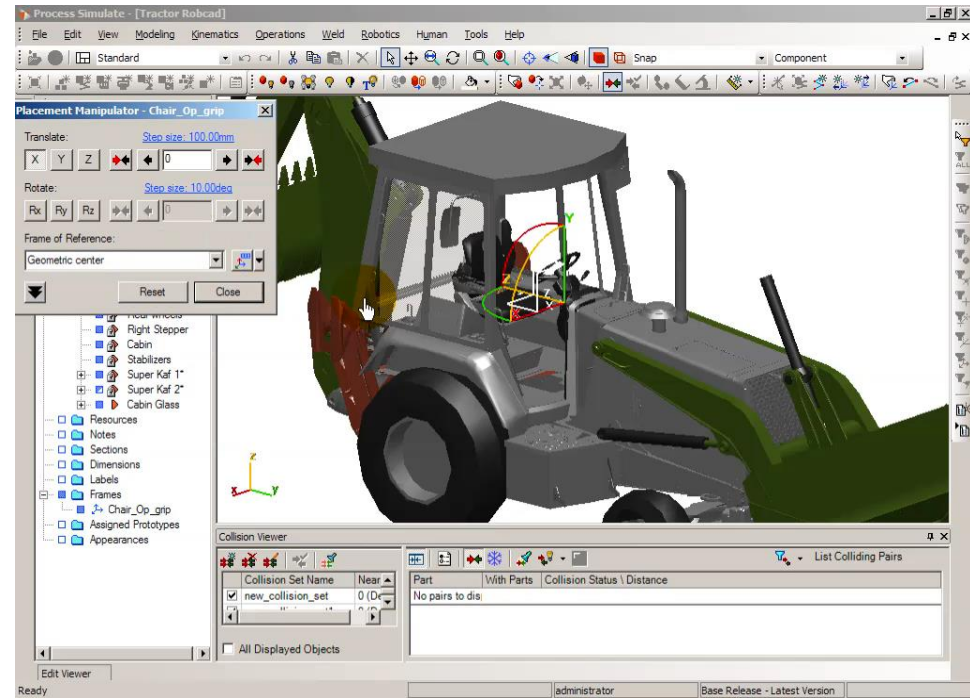
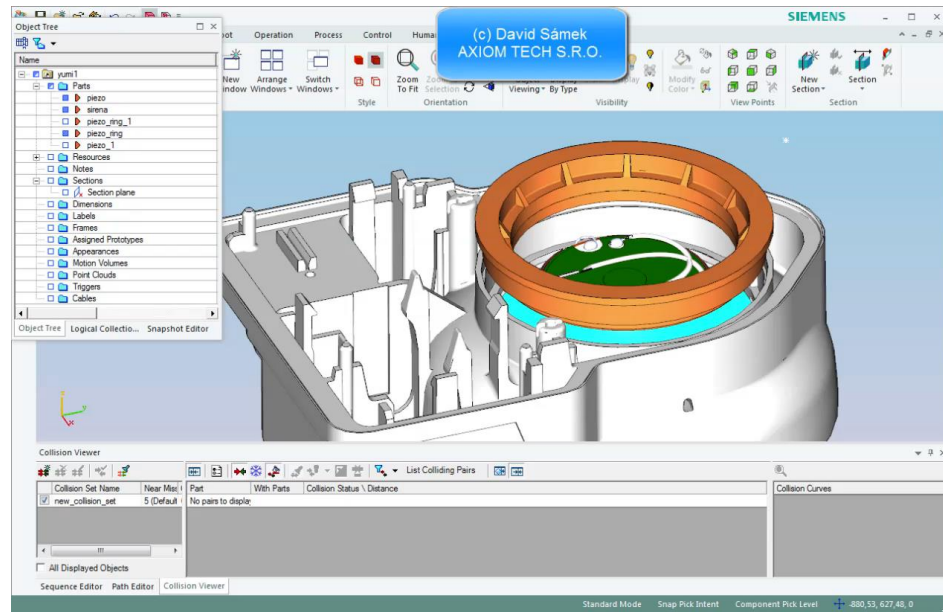
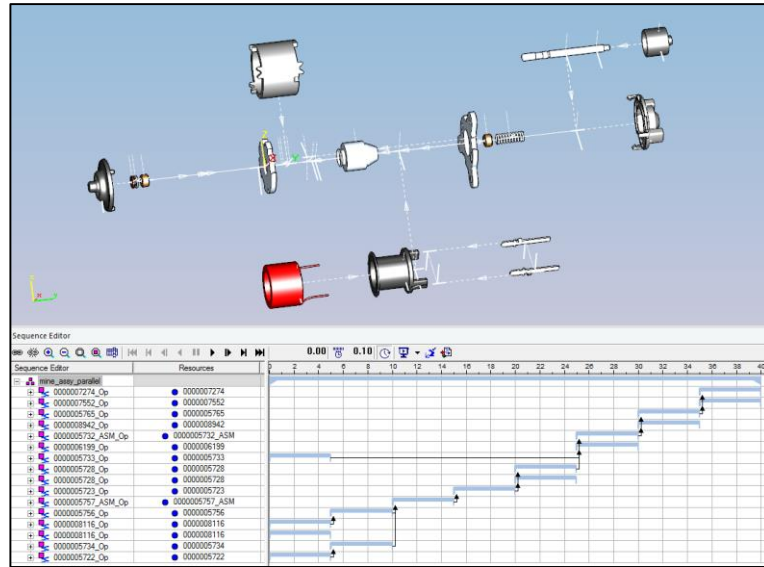
Assembly Planning

Assembly / Disassembly

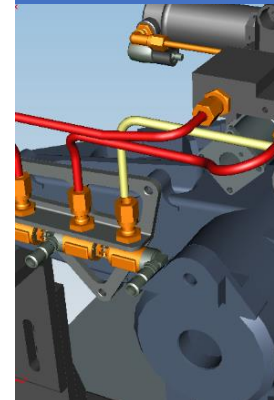
- Feasibility study
- Automatic path planner and operations order
- 3D kinematic simulation
- Operation sequence
- Dynamic collision detection



Assembly Planning



Assembly / Disassembly



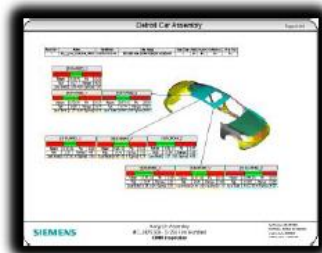
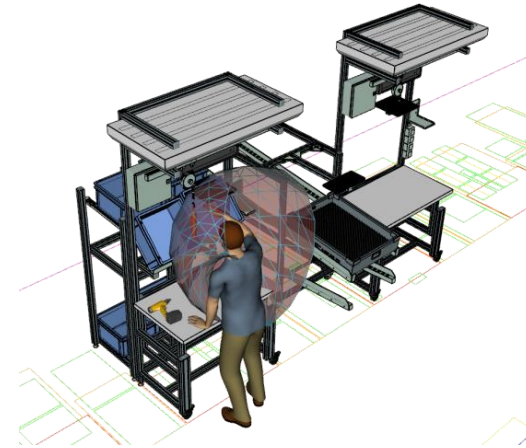
- Gantt chart
- Automatic Path Planner
- Collision detection

Tecnomatix Human

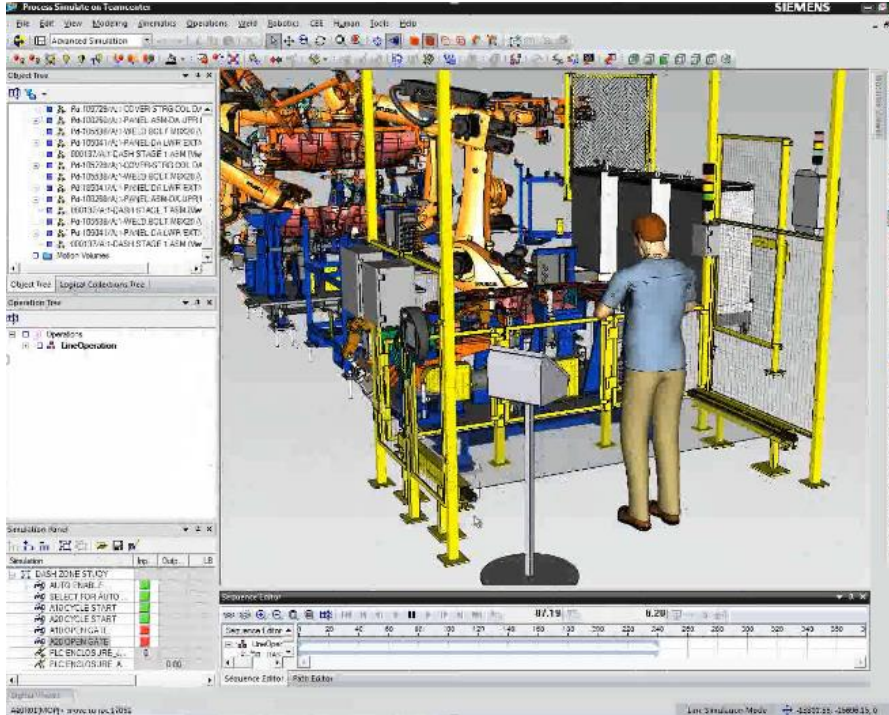
TECNOMATIX



Solutions to cover manufacturing challenges



Tecnomatix Robotics



Line layout

- Design and optimization

3D environment

- intuitive work

Off-line robots programming

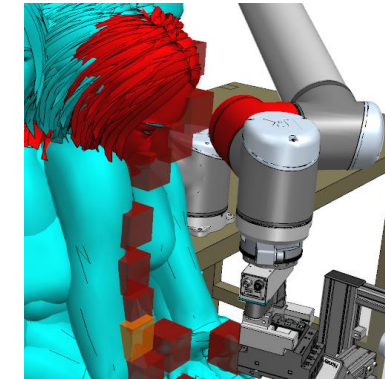
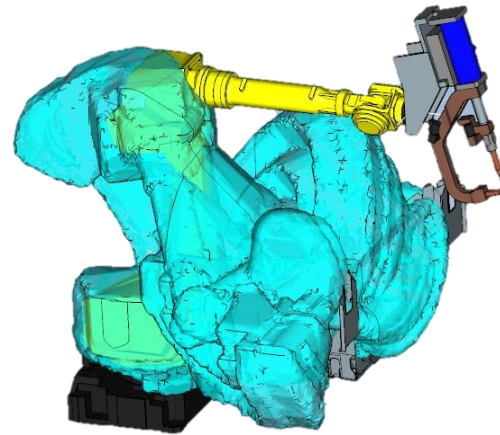
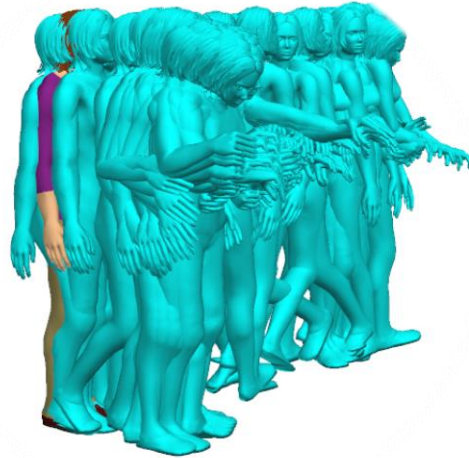
- resulting code could be directly loaded and run in the robot

Simulation

- optimization of robot program / line design, including conveyors, safety equipment, tooling, fixtures, PLC control, sensors



Tecnomatix Robotics: Human - Robot Collaboration



Dynamic Collision Report

Time	Object A	Object B	Violation Status	Violation Value
2.4	Device	Weld gun	Near Miss	14.95
2.6	000241/	Weld gun	Near Miss	6.04
2.6	Device	Weld gun	Collision	149.06
2.8	000243/	Weld gun	Near Miss	9.34

Minimal Distance Report

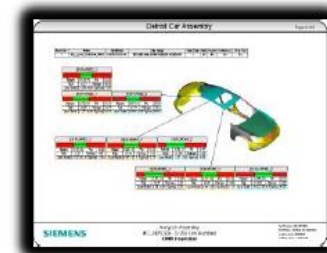
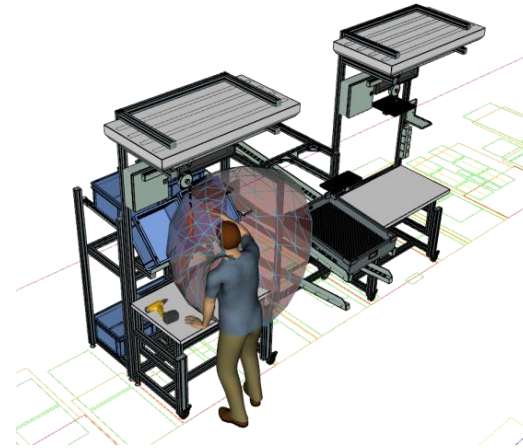
Time	Collision Set	Object A	Object B	Minimal Distance
0.00	new_collision_set	Jill	Workbench3	173.80
0.10	new_collision_set	Jill	Workbench3	179.21
0.20	new_collision_set	Jill	Workbench3	187.55
0.30	new_collision_set	Jill	Workbench3	196.12
0.40	new_collision_set	Jill	Workbench3	204.90
0.50	new_collision_set	Jill	Workbench3	213.53
0.60	new_collision_set	Jill	Workbench3	217.30
0.70	new_collision_set	Jill	Workbench3	212.22
0.80	new_collision_set	Jill	Workbench3	207.54
0.90	new_collision_set	Jill	Workbench3	203.48
1.00	new_collision_set	Jill	Workbench3	199.76
1.10	new_collision_set	Jill	Workbench3	198.60
1.20	new_collision_set	Jill	Workbench3	193.13
1.30	new_collision_set	Jill	Workbench3	184.56
1.40	new_collision_set	Jill	Workbench3	174.27
1.50	new_collision_set	Jill	Workbench3	166.99

Tecnomatix Plant Simulation

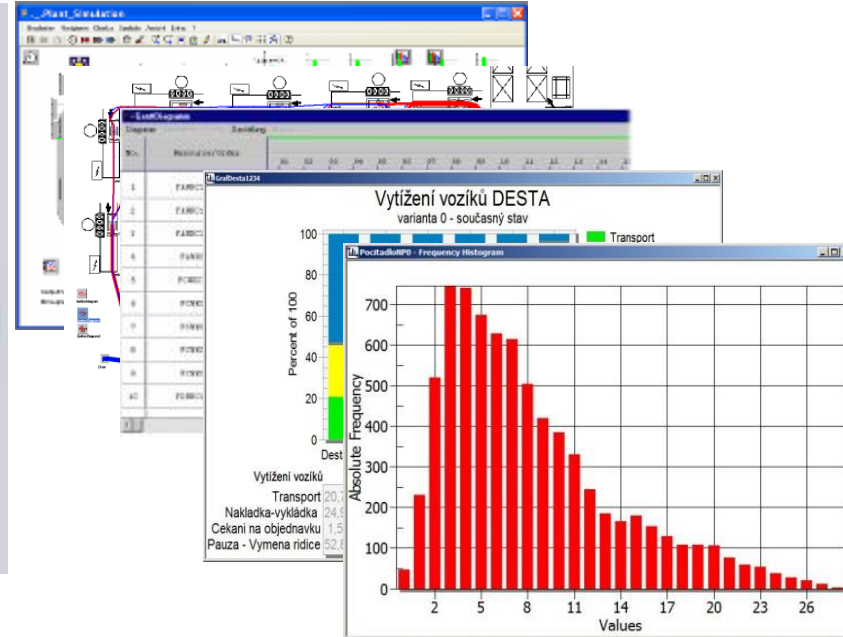
TECNOMATIX



Solutions to cover manufacturing challenges



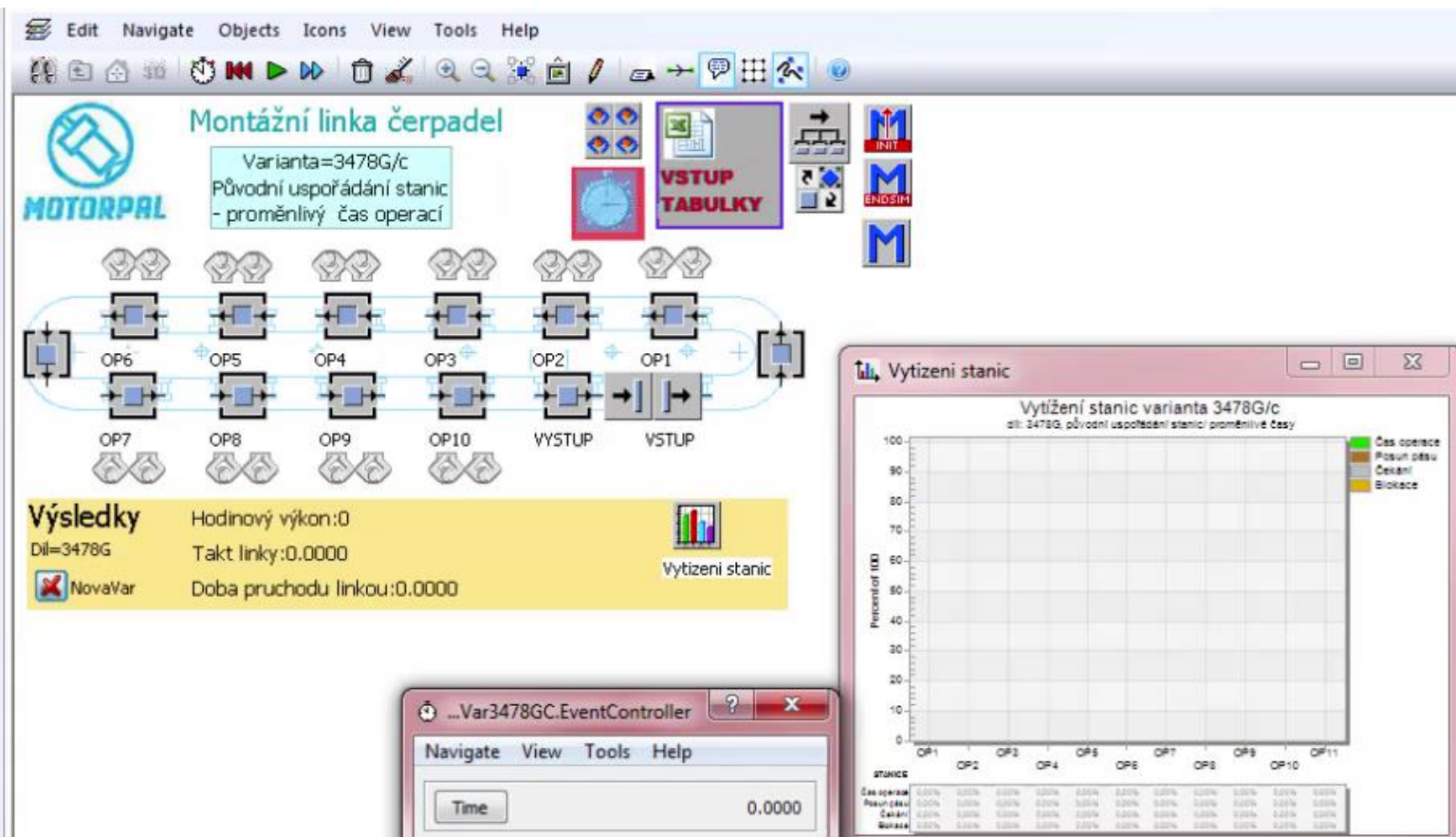
Tecnomatix Plant Simulation



- Improve productivity of existing facilities
- Reduce investment in planning new facilities
- Cut inventory and throughput time
- Optimize system dimensions, including buffer sizes
- Reduce investment risks through early proof of concept
- Maximize use of manufacturing resources
- Improve production line design and schedule



Tecnomatix Plant Simulation

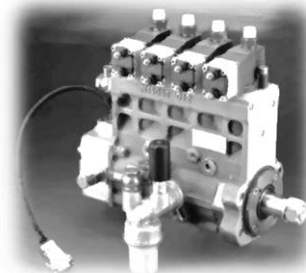
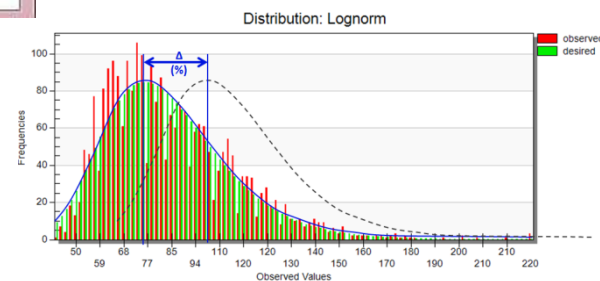


Benefits:

- Validation of designed measures in assembly process
- Identification of the bottle-necks.
- Statistic evaluation of the operation times and workloads
- Suggestion of final measures with clear ROI

Směrodatné odchytky	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10	φ
Statistiky 3478G - směrod. odch.	26,44	29,96	24,58	24,26	20,73	23,55	22,71	26,74	27,65	19,82	24,64
Statistiky 3492 - směrod. odch.	27,99	37,74	27,07	26,47	23,07	26,34	27,01	26,32	29,16	23,67	27,48
Statistiky 3522 - směrod. odch.	28,40	26,68	27,11	27,37	17,40	23,76	20,70	26,14	32,44	34,40	26,44
Statistiky 3707 - směrod. odch.	22,44	64,08	54,06	59,24	61,38	43,74	27,98	27,51	28,99	17,63	40,70
Statistiky 3748 - směrod. odch.	21,66	34,24	23,43	30,89	19,35	25,54	30,57	27,93	24,74	30,14	26,85

Legenda:
■ - nejvyšší SO
■ - druhá nejvyšší SO
■ - nadprůměrná SO
■ - podprůměrná SO

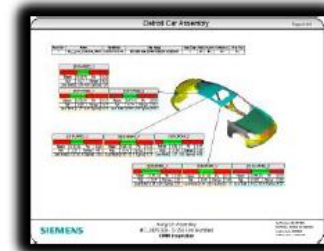
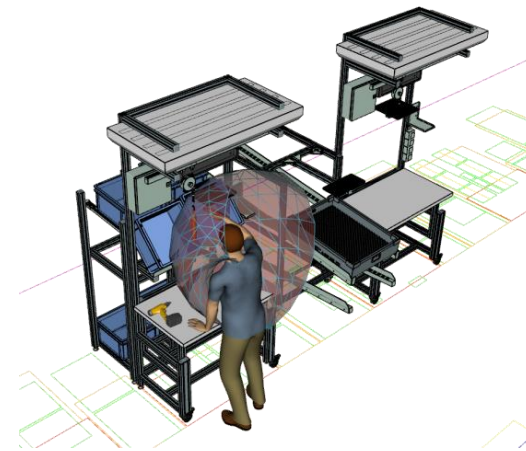


Tecnomatix Human

TECNOMATIX



Solutions to cover manufacturing challenges



Digital Human Modelling

- Reduce cost of change with early detection (digital twin)
- Reduce cost & eliminate human factor issues upfront
- Increase productivity of new or existing production facilities
- Optimize ROI for capital equipment investments
- Increase efficiency of manual operations
- Validate workspace configurations and protect worker safety
- Utilize Anthropomorphic models that represent the workforce



Tecnomatix Human



Force Solver - 30_2

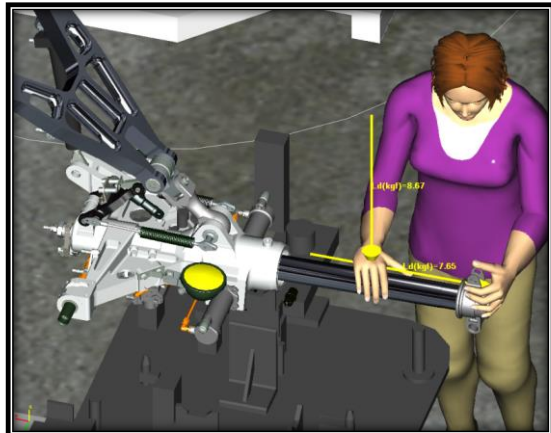
Ergonomic analysis

Left hand: Site: (palm-polynomial) 75 N, 7.6 kg

Right hand: Site: (palm-polynomial) 85 N, 8.7 kg

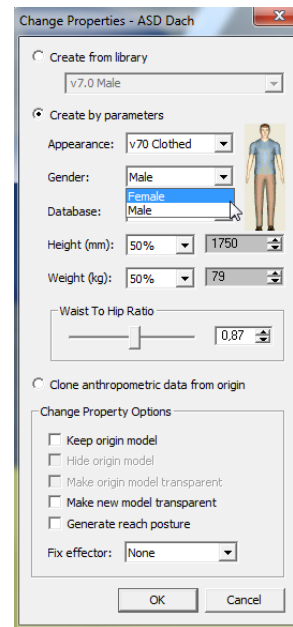
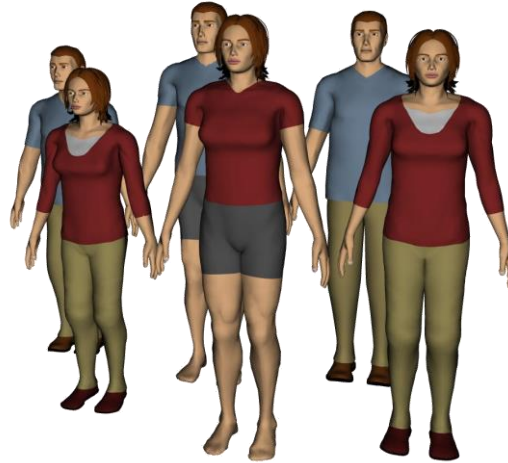
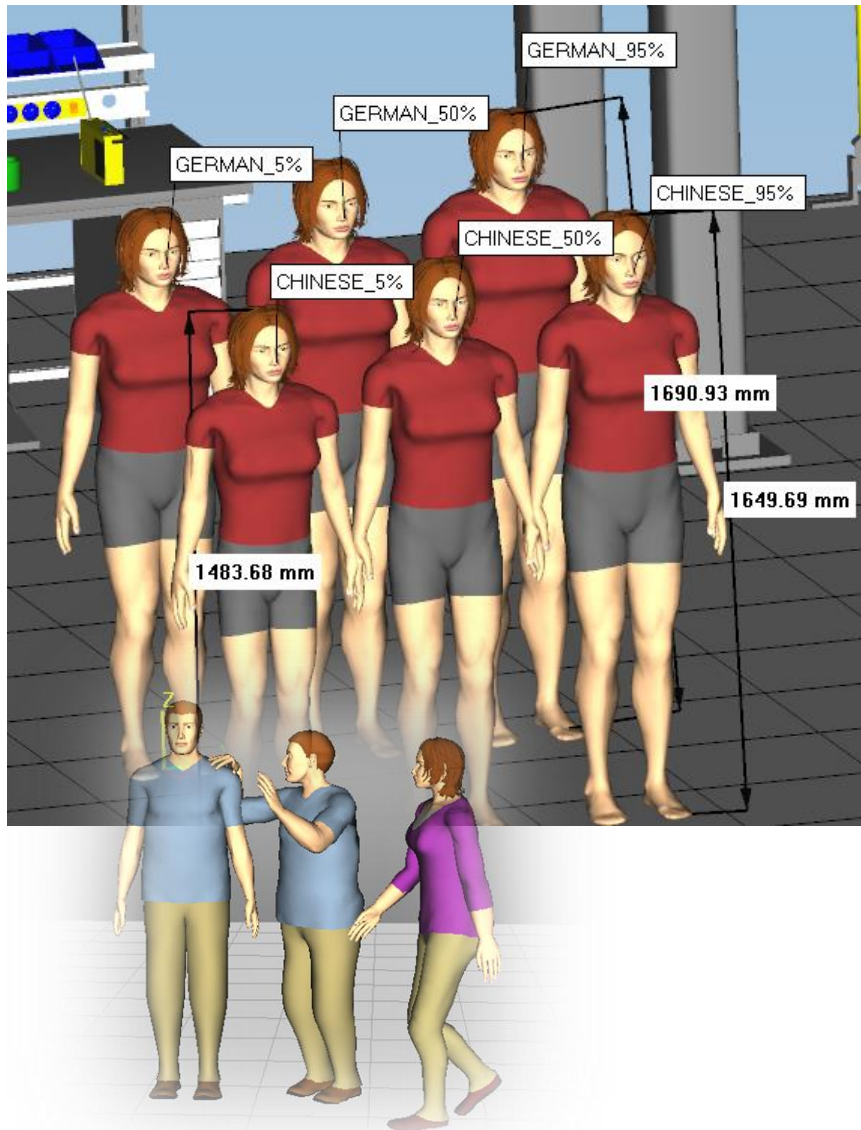
Joint/Ax	Coordi	Upr	Moment	Muscl	Angle	Strength	Strength
(N)	(m)	(deg)	(Nm)	(deg)	(deg)	(N)	(N)
R Wrist Flex	75.1	4.6	EXTN	6.3	5.9	1.9	
R Wrist Dev	99.9	0.1	-	9.3	-		
R Wrist Sup	99.7	0.0	-	-70.2	-		
R Elbow	75.7	-24.1	FLEX	64.5	38.0	10.2	
R Shoulder	89.9	28.2	ABDN	0.0	38.2	10.3	
R Shoulder	96.8	-17.7	PWID	0.0	48.8	16.6	
R Shoulder	99.4	-7.6	LAT	0.0	22.4	5.8	
R Hip	99.1	-11.2	EXTN	-3.7	103.6	38.2	
R Knee	99.1	-19.3	FLEX	16.2	80.8	25.9	
R Ankle	94.6	-27.0	EXTN	20.9	101.9	27.9	
L Wrist Flex	89.8	-4.0	FLEX	10.3	6.8	2.2	
L Wrist Dev	99.9	-0.1	-	4.2	-		
L Wrist Sup	99.7	0.0	-	17.5	-		
L Elbow	99.9	-7.9	FLEX	64.9	38.3	9.5	
L Shoulder	87.3	18.4	ABDN	0.0	38.7	14.7	
L Shoulder	88.7	-26.7	PWID	0.0	45.3	15.4	
L Shoulder	75.9	18.3	MEDU	0.0	24.5	9.1	
L Hip	99.1	-11.5	EXTN	-4.0	103.6	38.2	
L Knee	99.0	-20.6	FLEX	15.9	80.9	26.0	
L Ankle	94.4	-27.0	EXTN	21.4	102.4	28.1	
Trunk Flex	97.8	-44.4	FLEX	0.0	145.6	50.3	
Trunk Dev	100.0	4.7	LEFT	0.0	82.6	28.2	
Trunk Twst	90.9	38.1	CCW	0.0	50.5	15.3	
L4/L5 Com	105.2	-	-	-	-	-	
L4/L5 AP	131.6	-	-	-	-	-	
L4/L5 Lat	24.3	-	-	-	-	-	

Maximum supporting right hand force: 85.0%
Maximum left hand force: 79.8%



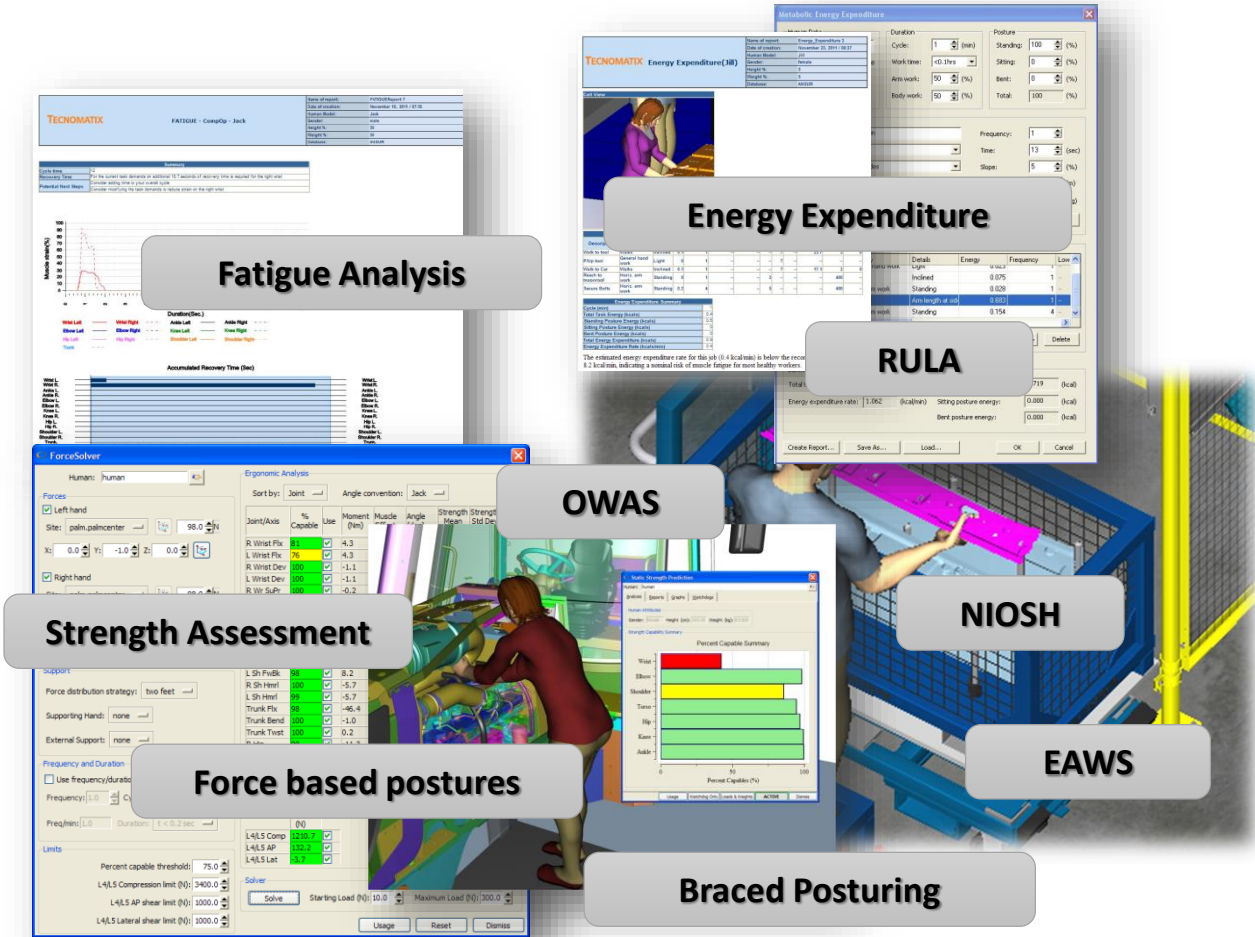
- Human Centered Design Process (1st person perspective)
- Relevant physical human factors assessments throughout the product lifecycle in most industries
- Broad ergonomic tools for comprehensive ergonomic assessment
- Accurate figure models for fit, reach, vision
- Powerful posture prediction for automated and repeatable prediction of task postures
- Easy to use Task Simulation Builder for process simulation
- Virtual Reality support for accelerated exploration of new product, workstation and process designs.

Tecnomatix Human: Figure Anthropometry



- Anthropomorphic models that represent the workforce
- Accurate Human figures to represent workers from around the World
- Fully articulated spine and hands
- Independently articulated eyes
- Deformable skin on the human manikin surface provides realistic simulation
- Detailed hand models based on scans

Tecnomatix Human: Human Performance Tools



- Comprehensive human performance capability assessment
- Strength, low back injury risk, posture analysis and fatigue assessment
- Quantitative numbers for engineering decisions
- Industrial standards integrated
- Reports with figures and tables

Tecnomatix Human: Human Performance Tools

Human Reports

Human Model: All

A. Arm and Wrist Analysis - Right Arm

Step 1: Locate Upper Arm Position

-20 to 20	less than -20	20 to 45	45 to 90	more than 90
1	2	2	3	4

UpperArm Angle: 10

Step 1a: Adjust...

- If shoulder is raised +1
- If upper arm is abducted +1
- If arm is supported or person is leaning -1

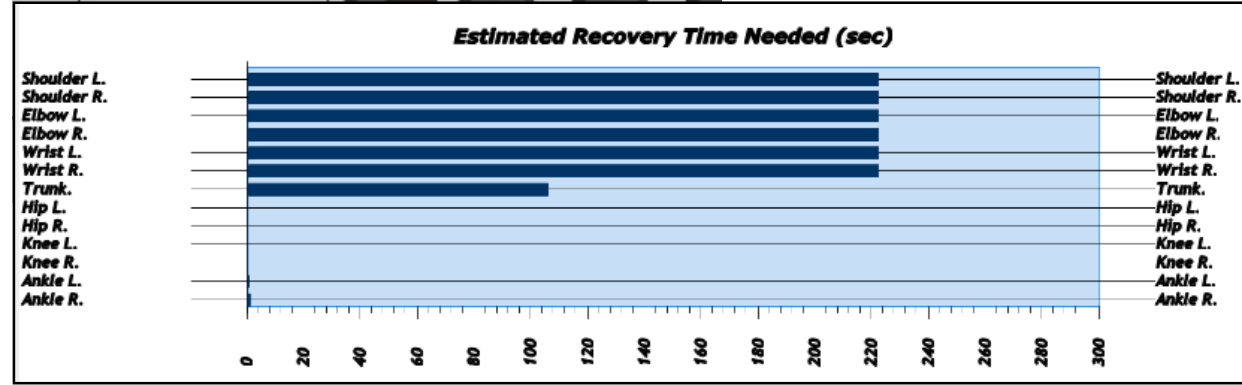
Final Upper Arm Score:

Step 2: Locate Lower Arm Position

60 to 100	more than 100 or less than 60



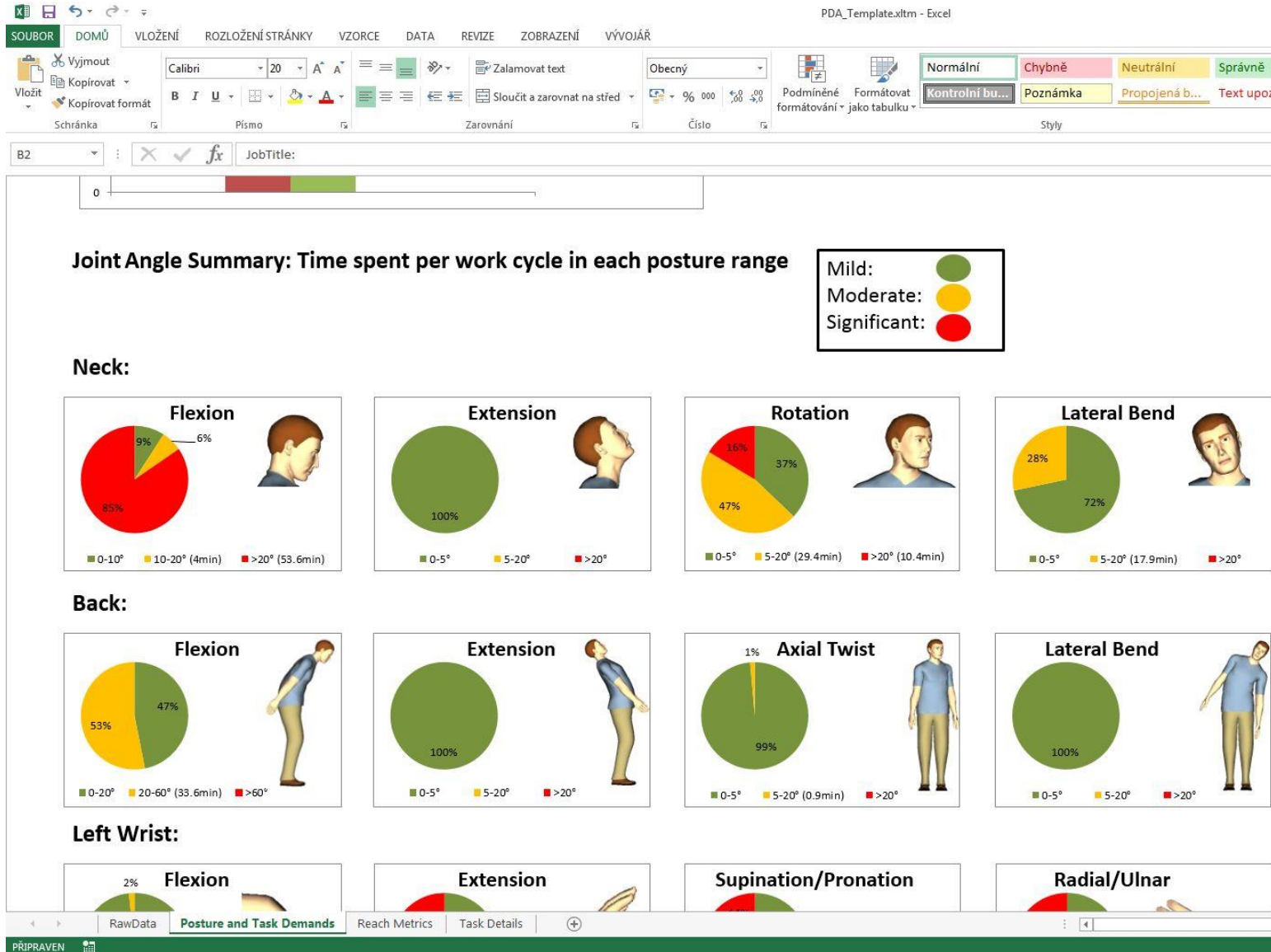
- Reports with figures and tables
- Report Viewer
- Reports are printable files, that can be sent by email



Tecnomatix Human: Human Performance Tools



Tecnomatix Human: Human Performance Tools



- Ergonomics Metrics Report
- XLS file
- Time evaluation of work postures during a shift

Tecnomatix Human: Human Performance Tools

OWAS

-Ovako Working posture Analyzing System

Postura della schiena					1 - Schiena dritta 2 - Schiena curva 3 - Schiena curva 4 - Schiena curva ed in torsione
Postura delle braccia					1 - Braccia sotto il livello delle spalle 2 - Un braccio sopra le spalle 3 - Entrambe le braccia sopra le spalle
Posizione della gamba					1 - Seduto 2 - In piedi, gambe distese 3 - In piedi, peso su una gamba sola 4 - In piedi, gambe piegate 5 - In piedi, peso su una gamba sola, piegata 6 - In ginocchio, su una o due ginocchia 7 - In piedi, in movimento
Peso sollevato					1 - Peso sollevato inferiore a 10 kg 2 - Peso sollevato: 10x20 kg 3 - Peso sollevato superiore a 20 kg

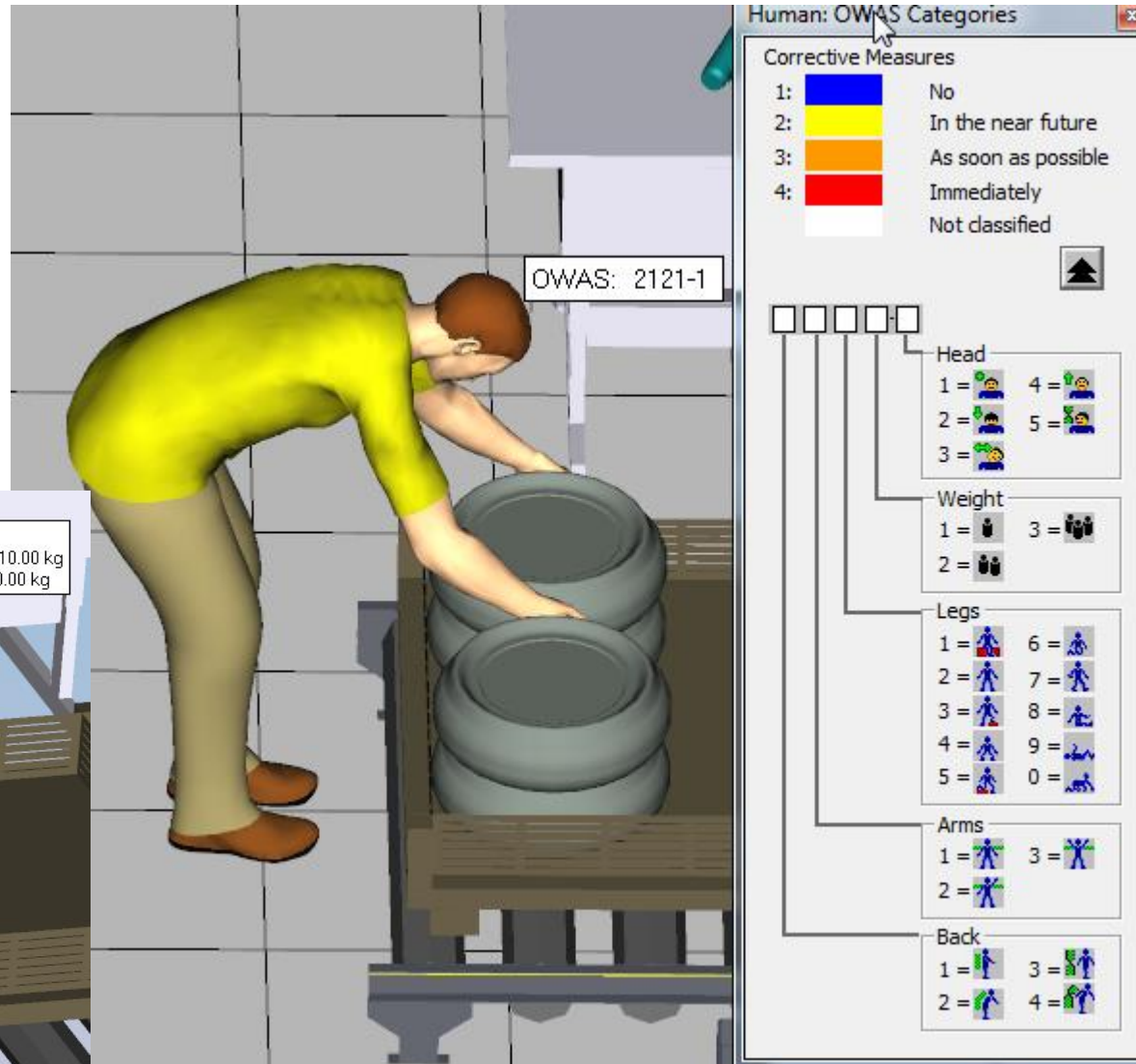
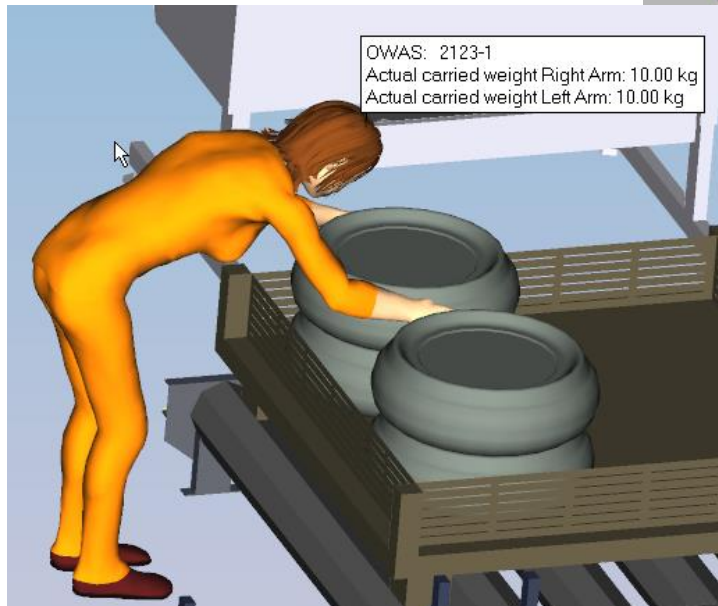
PUNTAZ	1			2			3			4			5			6			7			
	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	MENOS DE 10 KGS	ENTRE 11 Y 20 KGS	MAS DE 20 KGS	
ESPALDA		BRACCIO																				
1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
3	1	1	1	1	1	1	1	1	1	2	3	2	2	2	3	1	1	1	1	1	2	
4	2	2	3	2	2	3	2	2	2	3	3	3	3	3	2	2	2	2	2	3	3	
5	2	2	3	2	2	3	2	2	3	3	3	4	3	4	4	3	3	4	2	3	4	
6	3	3	4	2	2	3	3	3	3	3	3	4	4	4	4	4	4	4	2	3	4	
7	1	1	1	1	1	1	1	1	1	2	3	3	4	4	4	1	1	1	1	1	1	
8	2	2	3	1	1	1	1	1	1	2	4	4	4	4	4	3	3	3	1	1	1	
9	2	2	3	1	1	1	2	2	3	3	4	4	4	4	4	4	4	4	1	1	1	
10	2	3	3	2	2	3	2	2	2	3	4	4	4	4	4	4	4	4	2	3	4	
11	3	3	4	2	3	4	3	3	3	4	4	4	4	4	4	4	4	4	2	3	4	
12	4	4	4	2	3	4	3	3	3	4	4	4	4	4	4	4	4	4	2	3	4	

FUENTE: ESPECIALISTA YAJAIRA CÁRDENAS A. 2011.
ELABORACIÓN PROPIA PARA UN MEJOR ENTENDIMIENTO.

Tecnomatix Human: Human Performance Tools

OWAS

-Ovako Working posture Analyzing System



Tecnomatix Human: Human Performance Tools

NIOSH
(National
Institute for
Occupational
Safety and
Health)

-manual
lifting
operations

1. THE REVISED LIFTING EQUATION

This section provides the technical information for using the revised lifting equation to evaluate a variety of two-handed manual restrictions/limitations, revised lifting equation.

1.1 Definition of Terms

1.1.1 Recommended Weight

The RWL is the principal equation. The RWL is defined as the weight of the load that a *healthy worker*, we mean conditions that would increase

The RWL is defined by the

$$RWL = LC \times HM$$

A detailed description of the variables are provided in Section 1.1.2.

1.1.2. Lifting Index (LI)

The LI is a term that provides an estimate of the level of physical stress associated with a lift. The estimate of the level of physical stress is based on the relationship of the weight of the load to the weight limit.

The LI is defined by the following equation:

$$LI = \frac{\text{Load Weight}}{\text{Recommended Weight}}$$

1.1.2. Terminology and Data Definitions

The following list of brief definitions is provided for the revised NIOSH lifting equation. For detailed definitions, refer to the individual sections which describe the methods for measuring these variables as shown in Sections 1 and 2.

Lifting Task Defined as the act of manually moving an object of definable size and mass vertically moving the object without assistance.

Load Weight (L) Weight of the object to be lifted, in kilograms, including the weight of the container.

Horizontal Location (H) Distance of the hands away from the ankles, in inches (measure at the origin and destination of lift). See Figure 1.

Vertical Location (V) Distance of the hands above the ankles, in inches or centimeters (measure at the destination of lift). See Figure 1.

Vertical Travel Distance (D) Absolute value of the difference between the vertical heights at the destination and origin of the lift, in inches or centimeters.

Asymmetry Angle (A) Angular measure of how far the *object* is displaced from the front (mid-sagittal plane) of the worker's body at the beginning or ending of the lift. See Figure 1.

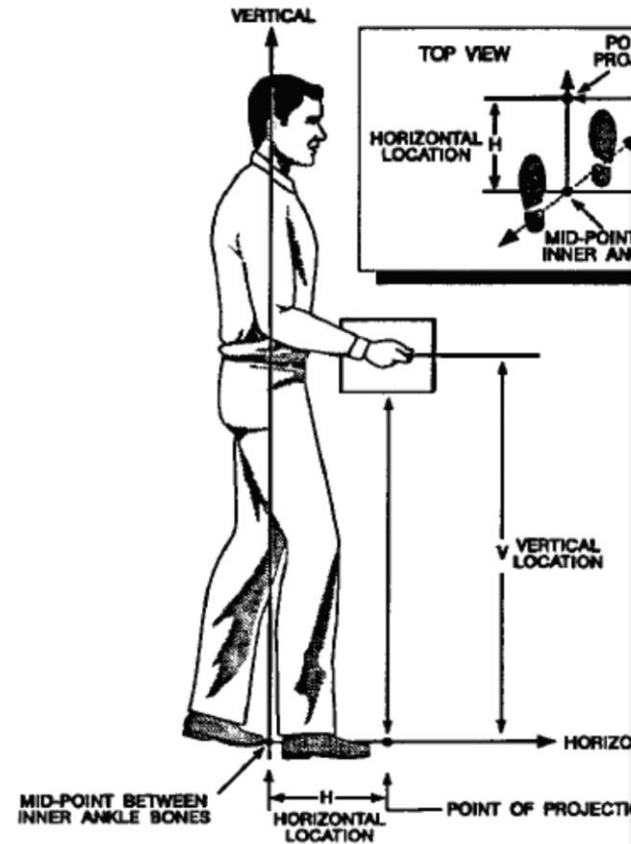


Figure 1 Graphic Representation of Hand Location

APPLICATIONS MANUAL FOR THE REVISED NIOSH LIFTING EQUATION

Thomas R. Waters, Ph.D.
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Tecnomatix Human: Human Performance Tools

NIOSH
(National
Institute for
Occupational
Safety and
Health)
-manual
lifting
operations

The screenshot displays the Tecnomatix Human software interface for a NIOSH lifting analysis. The main 3D view shows a human figure standing next to a workbench with a yellow container. A blue box labeled "NIOSH lifting analysis" is overlaid on the scene. The interface includes a menu bar (File, Home, View, Modeling, Robot, Operation, Process, Control, Human, Tools, AT, New Tab), a toolbar with various icons, and several panels:

- Object Tree:** Lists the simulation components, including "Robotics Example", "Parts", "Resources", "Jack2", "OP10 user0", "desk_contents", "Workbench3", "toolcrib", "Jack", "kontejner_e2_training_500kg", "kontejner_e2_training_10kg", "sikma_podlozka", "Notes", "Sections", "Dimensions", "Labels", "Frames", "Assigned Prototypes", "Appearances", and "Mplinn Vnl imier".
- Operation Tree:** Lists the simulation operations, including "Operations", "NIOSH_demo", "Walk to WalkLoc", "Grasp kontejner_e2_training_10kg", "Place kontejner_e2_training_10kg", "polozit", "narovnat_se", "Walk to WalkLoc2", "Grasp kontejner_e2_training_500kg", "Place kontejner_e2_training_500kg", and "CompOp".
- Sequence Editor:** A timeline view showing the sequence of operations over time, with a time scale from 0.00 to 11.5 seconds.

The bottom right corner of the interface shows the status bar with the text "Standard Mode Snap Pick Intent Component Pick Level 6886,37, -9169,48, 0".

Tecnomatix Human: Human Performance Tools

RULA - Rapid Upper Limb Assessment

RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...

If shoulder is raised: +1;
If upper arm is abducted: +1;
If arm is supported or person is leaning: -1

Final Upper Arm Score =

Step 2: Locate Lower Arm Position

Step 2a: Adjust...

If arm is working across midline of the body: +1;
If arm out to side of body: +1

Final Lower Arm Score =

Step 3: Locate Wrist Position

Step 3a: Adjust...

If wrist is bent from the midline: +1

Final Wrist Score =

Step 4: Wrist Twist

If wrist is twisted mainly in mid-range = 1;
If twist at or near end of twisting range = 2

Wrist Twist Score =

Step 5: Look-up Posture Score in Table A

Use values from steps 1, 2, 3 & 4 to locate Posture Score in table A.

Posture Score A =

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or;
If action repeatedly occurs 4 times per minute or more: +1

Muscle Use Score =

Step 7: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

Step 8: Find Row in Table C

The completed score from the Arm/Wrist analysis is used to find the row on Table C

Final Wrist & Arm Score =

SCORES

Table A

Upper Arm	Lower Arm	Wrist			
		1	2	3	4
1	1	1	2	3	4
2	1	2	3	4	5
3	1	3	4	5	6
4	1	4	5	6	7
5	1	5	6	7	8
6	1	6	7	8	9
1	2	2	3	4	5
2	2	3	4	5	6
3	2	4	5	6	7
4	2	5	6	7	8
5	2	6	7	8	9
6	2	7	8	9	10
1	3	3	4	5	6
2	3	4	5	6	7
3	3	5	6	7	8
4	3	6	7	8	9
5	3	7	8	9	10
6	3	8	9	10	11
1	4	4	5	6	7
2	4	5	6	7	8
3	4	6	7	8	9
4	4	7	8	9	10
5	4	8	9	10	11
6	4	9	10	11	12

Table B

Neck	Legs		Legs		Legs	
	1	2	1	2	1	2
1	1	2	3	4	5	6
2	2	3	4	5	6	7
3	3	4	5	6	7	8
4	4	5	6	7	8	9
5	5	6	7	8	9	10
6	6	7	8	9	10	11
7	7	8	9	10	11	12
8	8	9	10	11	12	13

Table C

1	2	3	4	5	6	7
1	1	2	3	4	5	6
2	2	3	4	5	6	7
3	3	4	5	6	7	8
4	4	5	6	7	8	9
5	5	6	7	8	9	10
6	6	7	8	9	10	11
7	7	8	9	10	11	12
8	8	9	10	11	12	13

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...

If neck is twisted: +1; If neck is side-bending: +1

Final Neck Score =

Step 10: Locate Trunk Position

Step 10a: Adjust...

If trunk is twisted: +1; If trunk is side-bending: +1

Final Trunk Score =

Step 11: Legs

If legs & feet supported and balanced: +1;
If not: +2

Final Leg Score =

Trunk Posture Score

Step 12: Look-up Posture Score in Table B

Use values from steps 9, 9.a, 10 to locate Posture Score in Table B

Posture B Score =

Step 13: Add Muscle Use Score

If posture mainly static or;
If action 4/minute or more: +1

Muscle Use Score =

Step 14: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

Step 15: Find Column in Table C

The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Final Neck, Trunk & Leg Score =

Final Score =

Subject: _____ Date: / / _____

Company: _____ Department: _____ Scorer: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

Tecnomatix Human: Human Performance Tools

RULA - Rapid
Upper Limb
Assessment

The screenshot displays the Siemens Tecnomatix Human software interface. The main window shows a 3D simulation of a worker in a purple shirt and green pants performing a task. The worker is standing next to a table with two tires on it. A callout box above the worker displays the RULA assessment results: "RULA Final Right Code:6 Final Left Code:7". The interface includes a menu bar with options like File, Home, View, Modeling, Robot, Operation, Process, Control, Human, Tools, AT, and New Tab. Below the menu bar are several toolbars with icons for various functions. On the left side, there are panels for Snapshot Editor, Object Tree, Logical Collections Tr..., and Operation Tree. The Operation Tree shows a list of operations, including "TSB_Simulation_1". At the bottom, there is a Sequence Editor panel with a timeline and a list of tasks: "T TSB_Simulation_1", "T Attach_Tire_1_To_i", "T Attach_Tire_2_To_i", "T Attach_Tire_3_To_i", "T Attach_Tire_4_To_i", "T Move_Bin", and "T Get_Tire_1_Jack". The bottom status bar shows "Standard Mode", "Snap Pick Intent", "Component Pick Level", and coordinates "-697, 234, 54, 0". A blue callout box in the top right corner contains the text "AXIOM TECH s.r.o. David Šámek".

Methods Time Measurement (MTM)

Distance Moved (inches)	TIME (TMU)				WEIGHT ALLOWANCE		
	A	B	C	Hand in Motion B	Weight (pounds) up to:	Dynamic Factor	Static Constant TMU
3/4 or less	2.0	2.0	2.0	1.7			
1	2.5	2.9	3.4	2.3	2.5	1.00	
2	3.6	4.6	5.2	2.9			
3	4.9	5.7	6.7	3.6	7.5	1.06	
4	6.1	6.9	8.0	4.3			
5	7.3	8.0	9.2	5.0	12.5	1.11	
6	8.1	8.9	10.3	5.7			
7	8.9	9.7	11.1	6.5	17.5	1.17	
8	9.7	10.6	11.8	7.2			
9	10.5	11.5	12.7	7.9	22.5	1.22	
10	11.3	12.2	13.5	8.6			
12	12.9	13.4	15.2	10.0	27.5	1.28	
14	14.4	14.6	16.9	11.4			
16	16.0	15.8	18.7	12.8	32.5	1.33	
18	17.6	17.0	20.4	14.2			
20	19.2	18.2	22.1	15.6	37.5	1.39	
22	20.8	19.4	23.8	17.0			
24	22.4	20.6	25.5	18.4	42.5	1.44	
26	24.0	21.8	27.3	19.8			
28	25.5	23.1	29.0	21.2	47.5	1.50	
30	27.1	24.3	30.7	22.7			
Additional	0.8	0.6	0.85			TMU per inch o	

Unit Number	Unit Time	70%		75%		80%				
		Total Time	Unit Time	Total Time	Unit Time	Total Time	Unit Time			
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
2	.700	1.700	.750	1.750	.800	1.800				
3	.568	2.268	.634	2.384	.702	2.502				
4	.490	2.758	.562	2.946	.640	3.142				
5	.437	3.195	.513	3.459	.596	3.738				
6	.398	3.593	.475	3.934	.562	4.299				
7	.367	3.960	.446	4.380	.534	4.834				
8	.343	4.303	.422	4.802	.512	5.346				
9	.323	4.626	.402	5.204	.493	5.839				
10	.306	4.932	.385	5.589	.477	6.315				
11	.291	5.223	.370	5.958	.462	6.777				
12	.278	5.501	.357	6.315	.449	7.227				
13	.267	5.769	.345	6.660	.438	7.665				
14	.257	6.026	.334	6.994	.428	8.092				
15	.248	6.274	.325	7.319	.418	8.511				
16	.240	6.514	.316	7.635	.410	8.920				
17	.233	6.747	.309	7.944	.402	9.322				
18	.226	6.973	.301	8.245	.394	9.716				
19	.220	7.192	.295	8.540	.388	10.104				
20	.214	7.407	.288	8.828	.381	10.485	.495	12.402	.634	14.608
21	.209	7.615	.283	9.111	.375	10.860	.490	12.892	.630	15.237
22	.204	7.819	.277	9.388	.370	11.230	.484	13.376	.625	15.862
23	.199	8.018	.272	9.660	.364	11.594	.479	13.856	.621	16.483
24	.195	8.213	.267	9.928	.359	11.954	.475	14.331	.617	17.100
25	.191	8.404	.263	10.191	.355	12.309	.470	14.801	.613	17.713
26	.187	8.591	.259	10.449	.350	12.659	.466	15.267	.609	18.323
27	.183	8.774	.255	10.704	.346	13.005	.462	15.728	.606	18.929
28	.180	8.954	.251	10.955	.342	13.347	.458	16.186	.603	19.531
29	.177	9.131	.247	11.202	.338	13.685	.454	16.640	.599	20.131
30	.174	9.305	.244	11.446	.335	14.020	.450	17.091	.596	20.727

NO	ELEMENTS	FEET/FEET	UPPER LIMB - DISTANCES										LOWER LIMB - REACHS										NO. FIN	AS TIME	STD. DEVI.	MIS. PER. (L/IN)	CORRECT. FACTOR	WEIGHT TIME																		
			1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10																								
1	PICK UP TP PRICE AT VISE		14.94	52.89	16.56							95.35	100.51																															1	90	
2	PUT POINT IN VISE TP RL VISE HANDLE		42.63	80.91	45.84							92.34	98.80																															1	90	
3	MILL SLOT TP POWER FEED DISCHARGE		78.20	135.75	160.77							80	100	95	100																													1	100	
4	ASIDE PART TO PAN TP RL PART		108.78	165.29	29							80	90	85	88	88																													1	95
5	BRUSH CHIPS TP RL BRUSH		20.11	75	42	53						21	96	37	76																													2	80	

FORM NO. 500-01-01
 OPERATOR: WATCHED MARIA
 TOOL, JOB, GAUGE, MATERIAL, ETC.:
VISE 407
 BEG. ELAPSED ENDS
 1: 1:45 B 10
 .135
 .137

Methods Time Measurement (MTM)

The image displays the Siemens Process Simulate software interface for a Methods Time Measurement (MTM) simulation. The main window shows a 3D model of a worker (Jill) at a workstation with a blue cabinet and a shelving unit containing orange and blue bins. A blue callout box in the top-left corner identifies the user as "AXIOM TECH s.r.o. David Sámek".

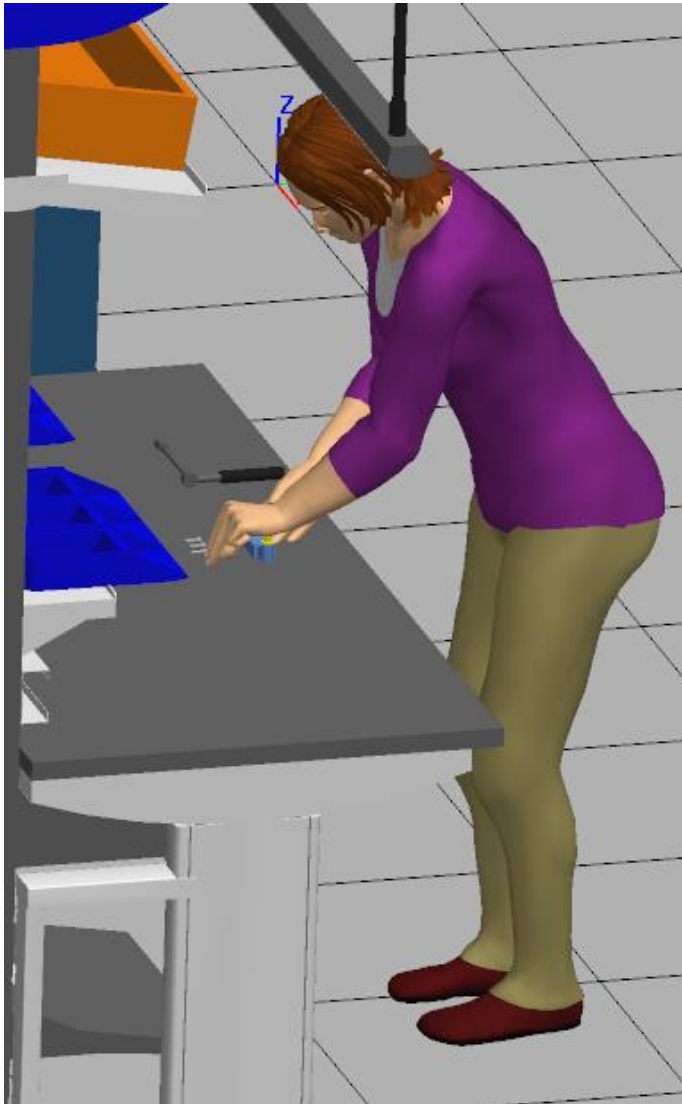
The software interface includes a top menu bar with options like Robot, Operation, Process, Control, Human, Tools, AT, and New Tab. Below this is a toolbar with various simulation tools such as Posture, Task Simulation Builder, Simulate, Vision Window, Grasp Envelope, Vision Envelope, Analysis Tools, Ergonomics, Tracking Setup, Server Setup, Motion Capture, and Active Human.

On the right side, the "Task Simulation Builder - demo" window is open, showing a list of simulation tasks under the "Human" tab. The tasks include: Go, Get, Put, Position, Pose, Regrasp, Stand, Sit, Wait, Touch, and Apply force.

The bottom of the interface features a "Sequence Editor" window with a timeline and a list of tasks. The timeline shows a sequence of tasks starting at 0.00 and ending at 0.03. The task list includes: demo, Pose_Jill, Get_28300-nl, Put_28300-nl, Put_28300-nl, Get_r7160_0, Put_r7160_0l, Get_r7160_0, Put_r7160_0l, Pose_Jill_1, Get_ratchet_wrench, Position_ratchet_wr, Position_ratchet_wr, Put_ratchet_wrench, Pose_Jill_1, Get_ratchet_wrench, Position_ratchet_wr, Position_ratchet_wr, Put_ratchet_wrench, Pose_Jill_2, Get_ratchet_wrench, Position_ratchet_wr, Position_ratchet_wr, Put_ratchet_wrench, Pose_Jill_2.

The bottom status bar shows "Standard Mode", "Snap Pick Intent", "Component Pick Level", and "0, 0, 0".

Tecnomatix Human: Timing Report, MTM codes



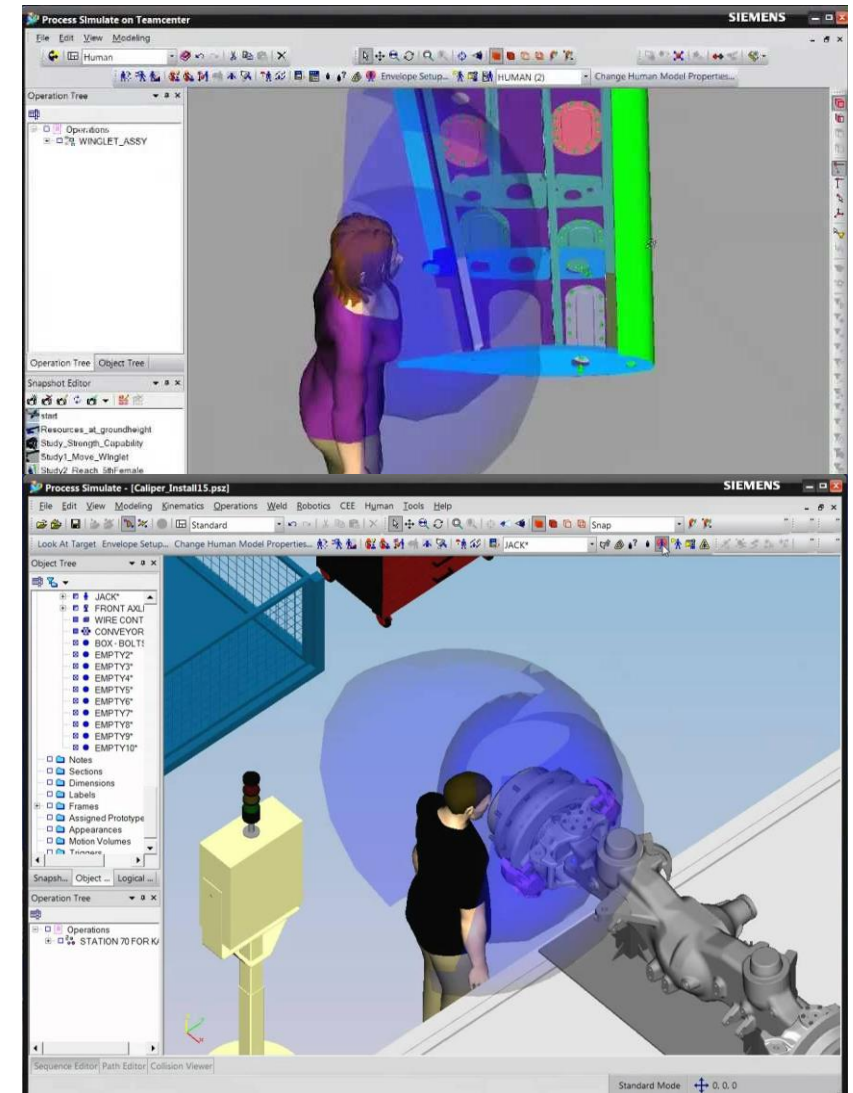
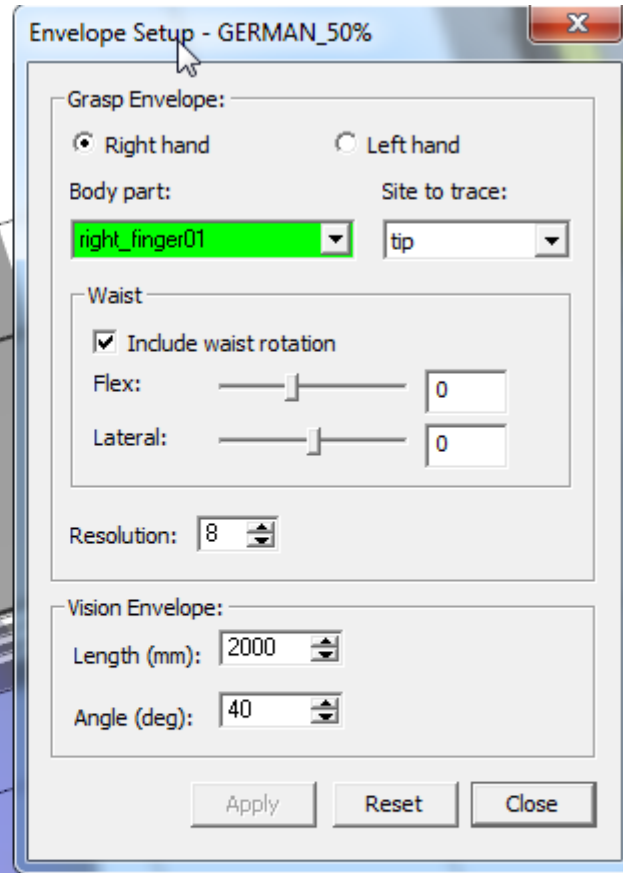
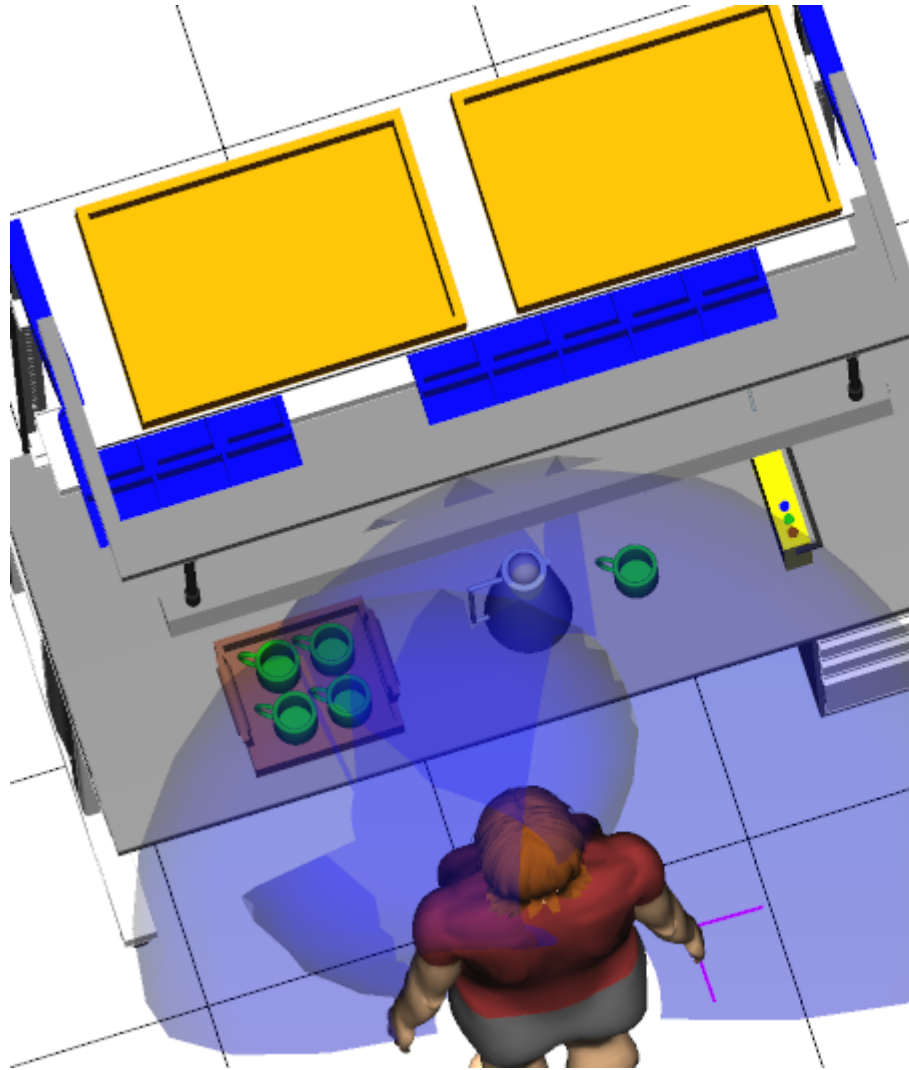
Jill			
Task	Action	Duration (s)	Code
Get_28300_nlg_act_623_Jill		0.9	
	Reach	0.86	R18.213A(l)
Put_28300_nlg_act_623_Jill	Grasp	0.072	G1A(l)
		0.6	
Get_28300_nlg_act_1157_Jill	Reach	0.569	R10.175A(b)
	Release	0.072	RL1(l)
Put_28300_nlg_act_1157_Jill		0.6	
	Reach	0.569	R9.645A(l)
Pose_Jill	Grasp	0.072	G1A(l)
		0.6	
Get_r7160_06x18_4_Jill	Reach	0.504	R8.602A(b)
	Release	0.072	RL1(l)
Pose_Jill_1		1	
	Pose	1	Pose
Get_r7160_06x18_4_Jill		0.4	
	Reach	0.346	R4.097A(l)
Put_r7160_06x18_4_Jill	Grasp	0.072	G1A(l)
		0.3	
Get_r7160_06x18_1_Jill	Reach	0.266	R2.378A(b)
	Release	0.072	RL1(l)
Put_r7160_06x18_1_Jill		0.4	
	Reach	0.299	R3.502A(l)
Pose_Jill_1	Grasp	0.072	G1A(l)
		0.3	
Get_ratchet_wrench1_Jill	Reach	0.252	R2.331A(b)
	Release	0.072	RL1(l)
Position_ratchet_wrench1_Jill		1	
	Pose	1	Pose
Position_ratchet_wrench1_Jill_1		0.5	
	Reach	0.472	R7.493A(r)
Put_ratchet_wrench1_Jill	Grasp		
	Reach		
Pose_Jill_2	Reach		
	Release		
	Pose		

- Simulated time of human tasks
- Suboperations duration
- Gantt chart

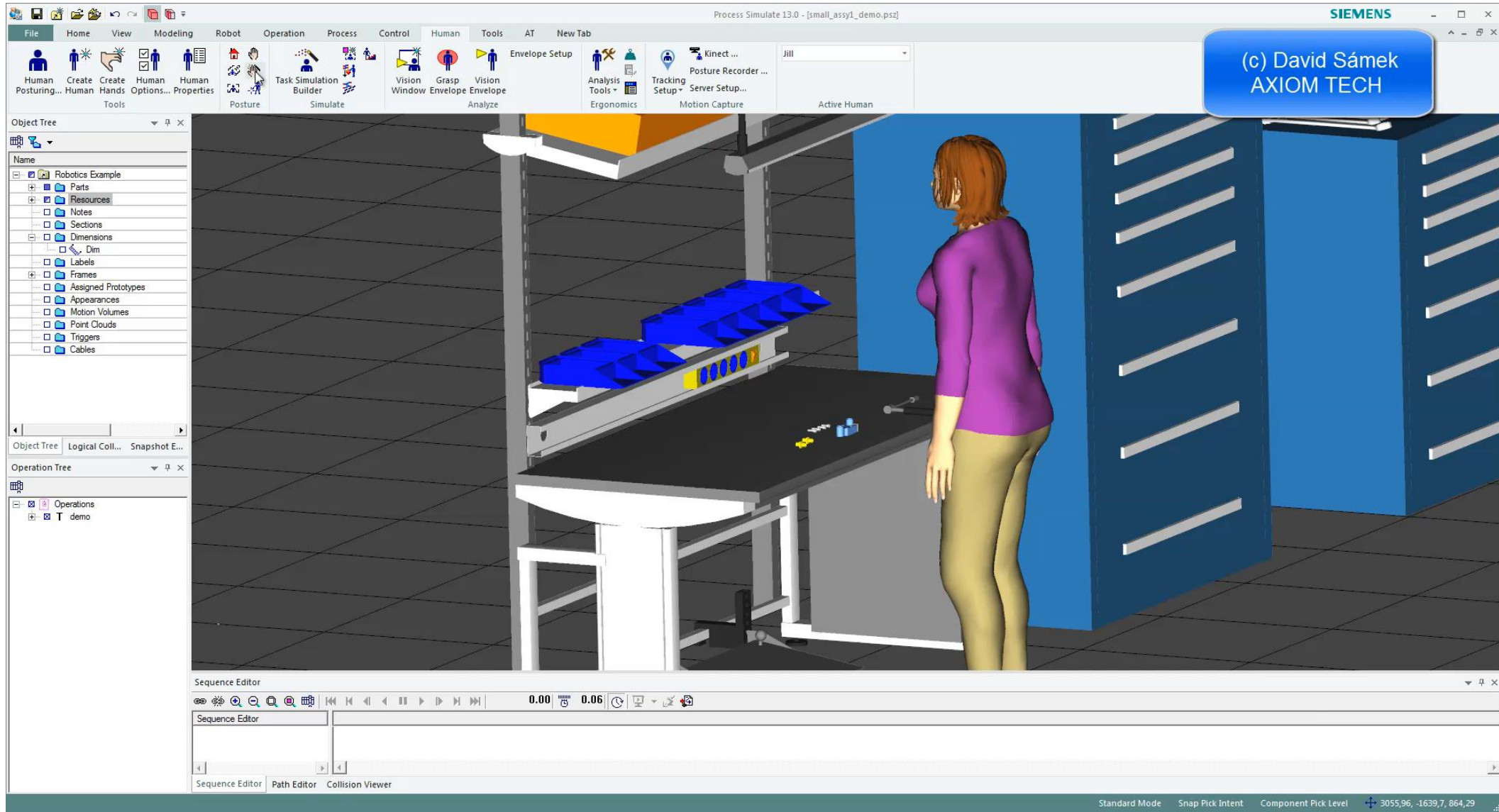
Tecnomatix Human: Feasibility Tools



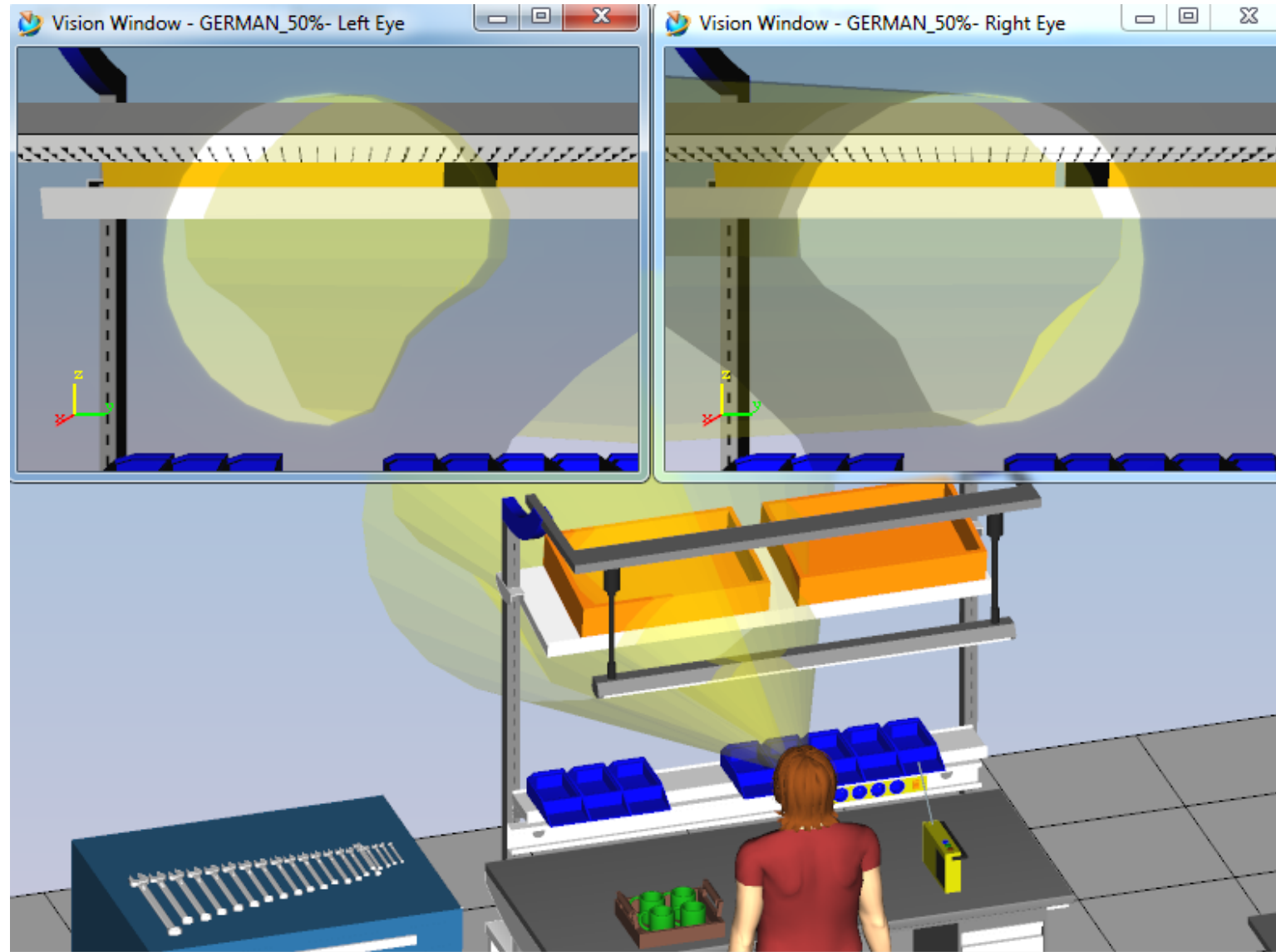
Human reach



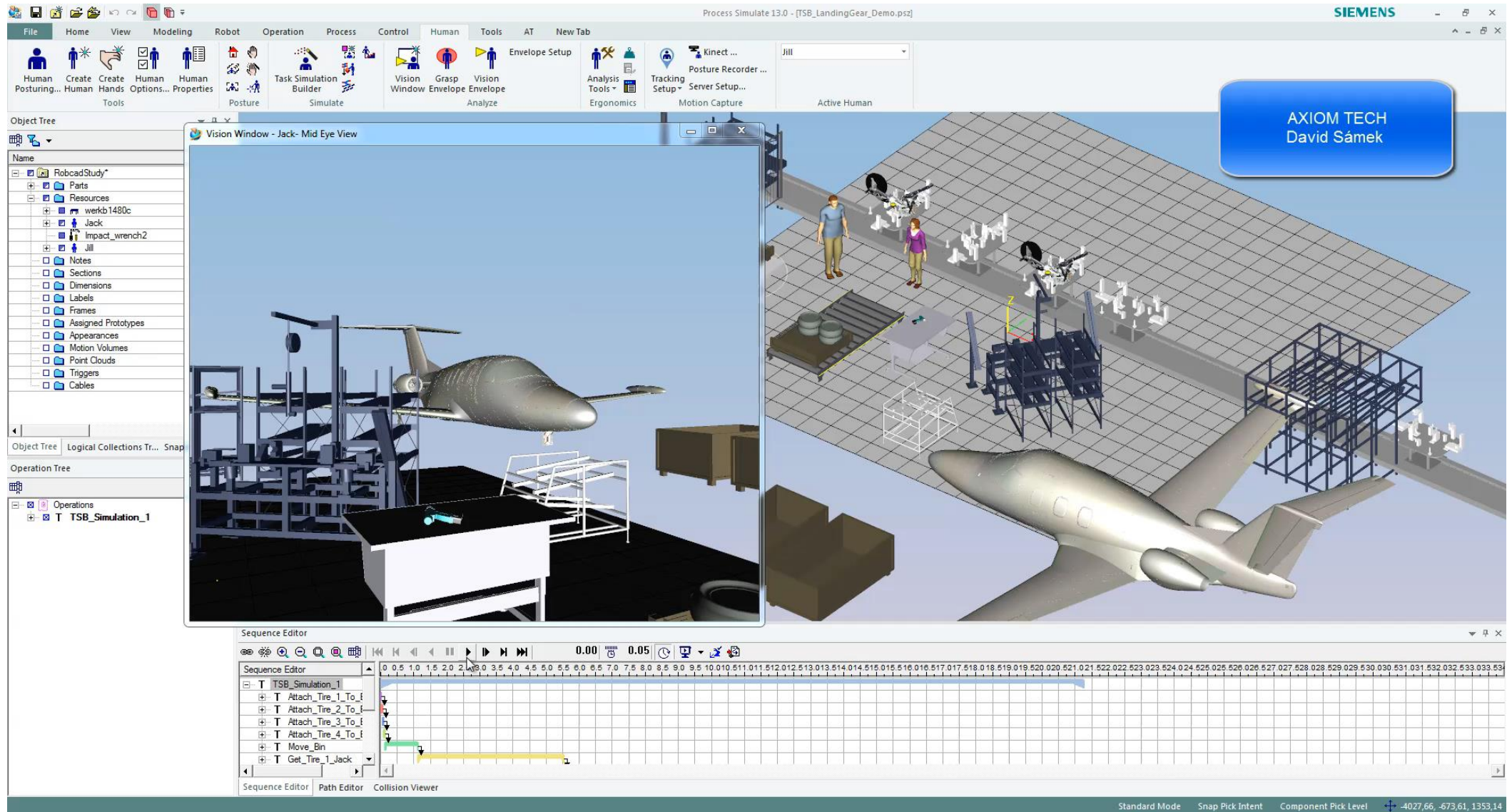
Human reach



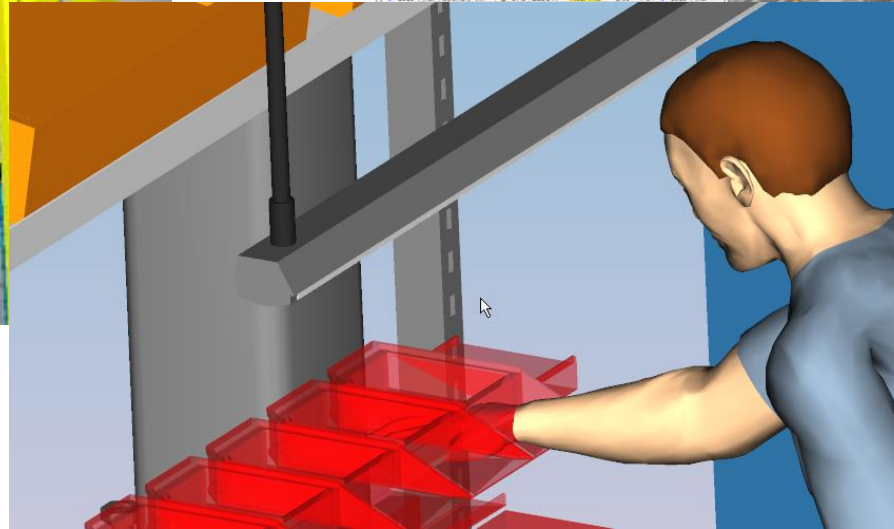
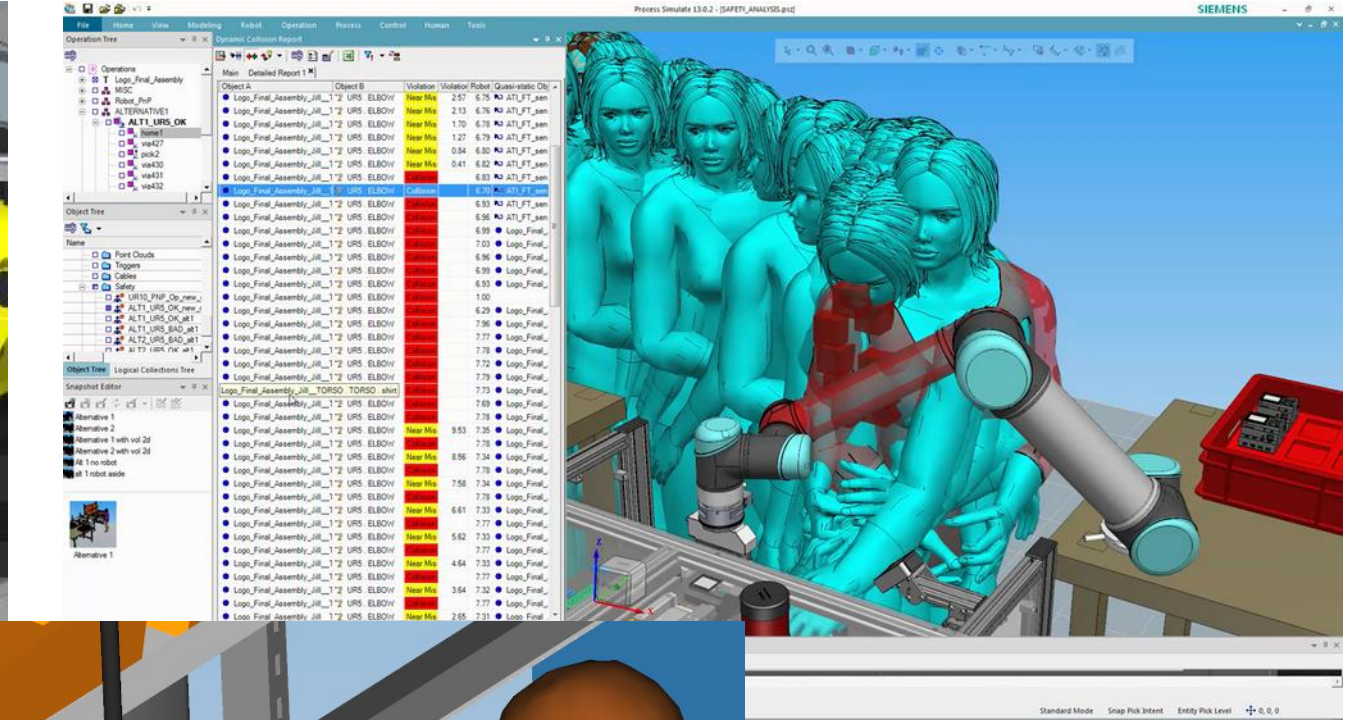
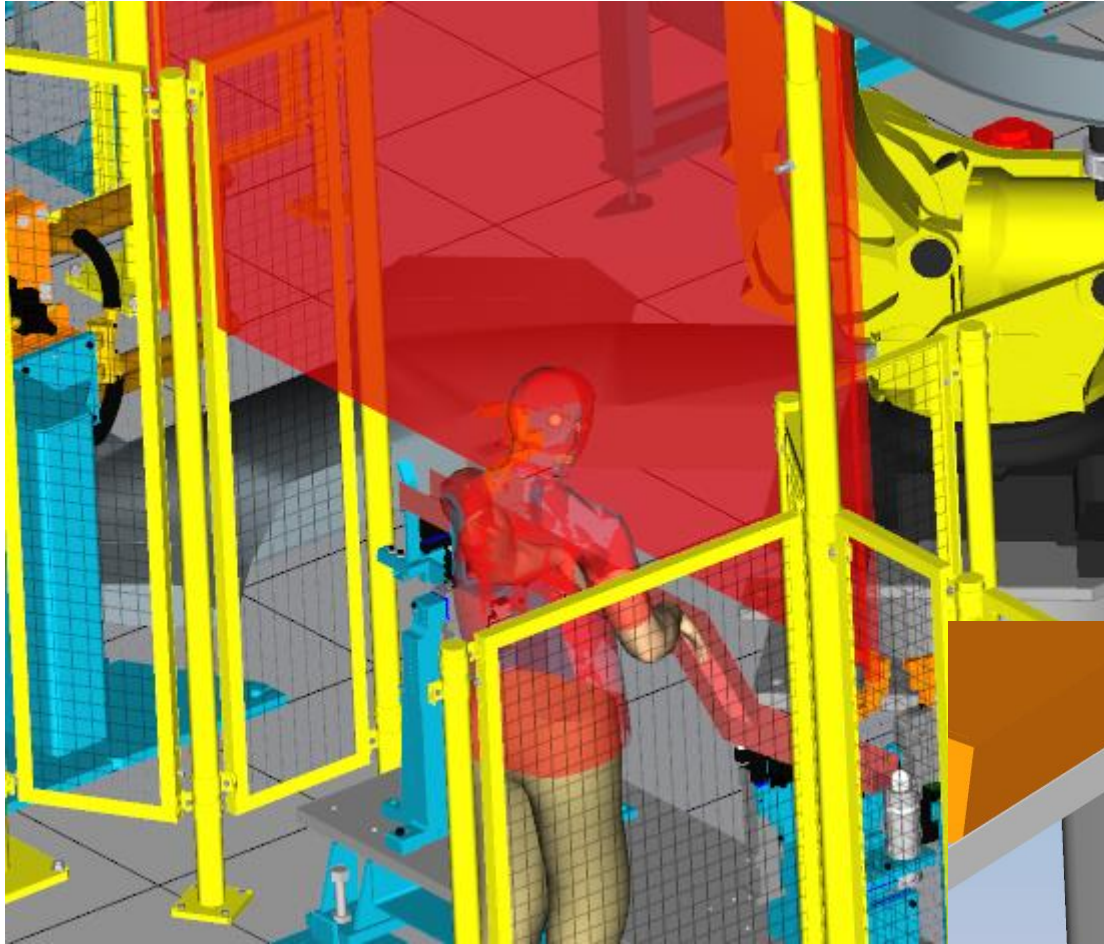
Vision view



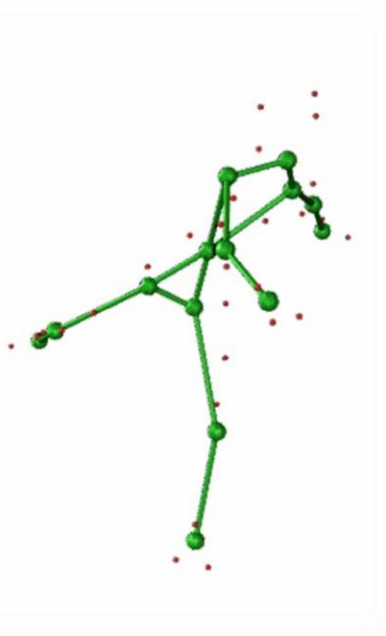
Vision view



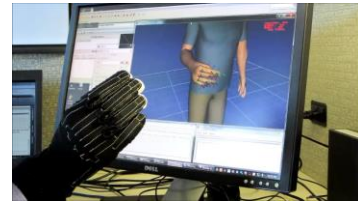
Collisions



Tecnomatix Human: Motion Capture & VR

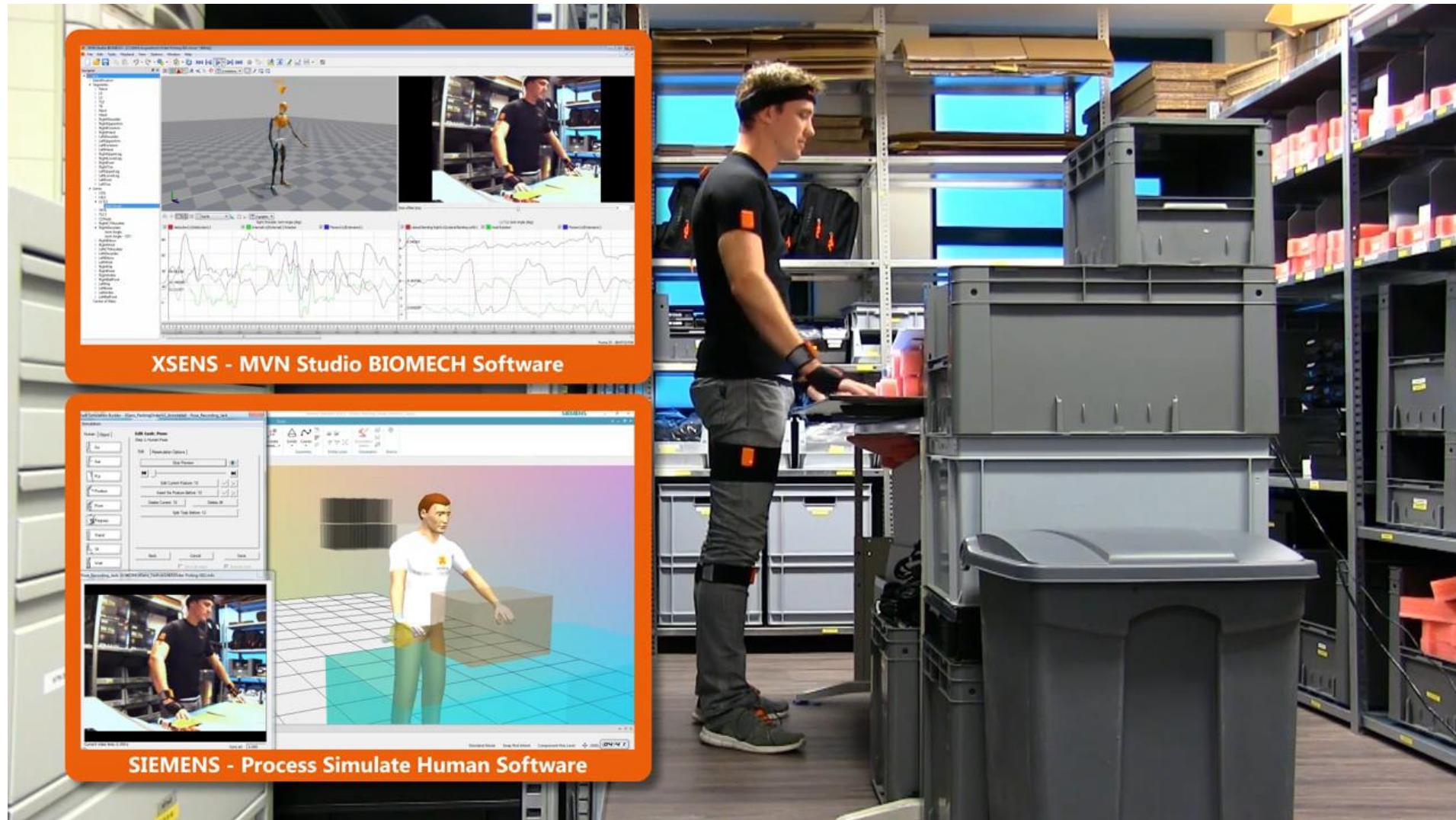


Tecnomatix Human: Motion Capture

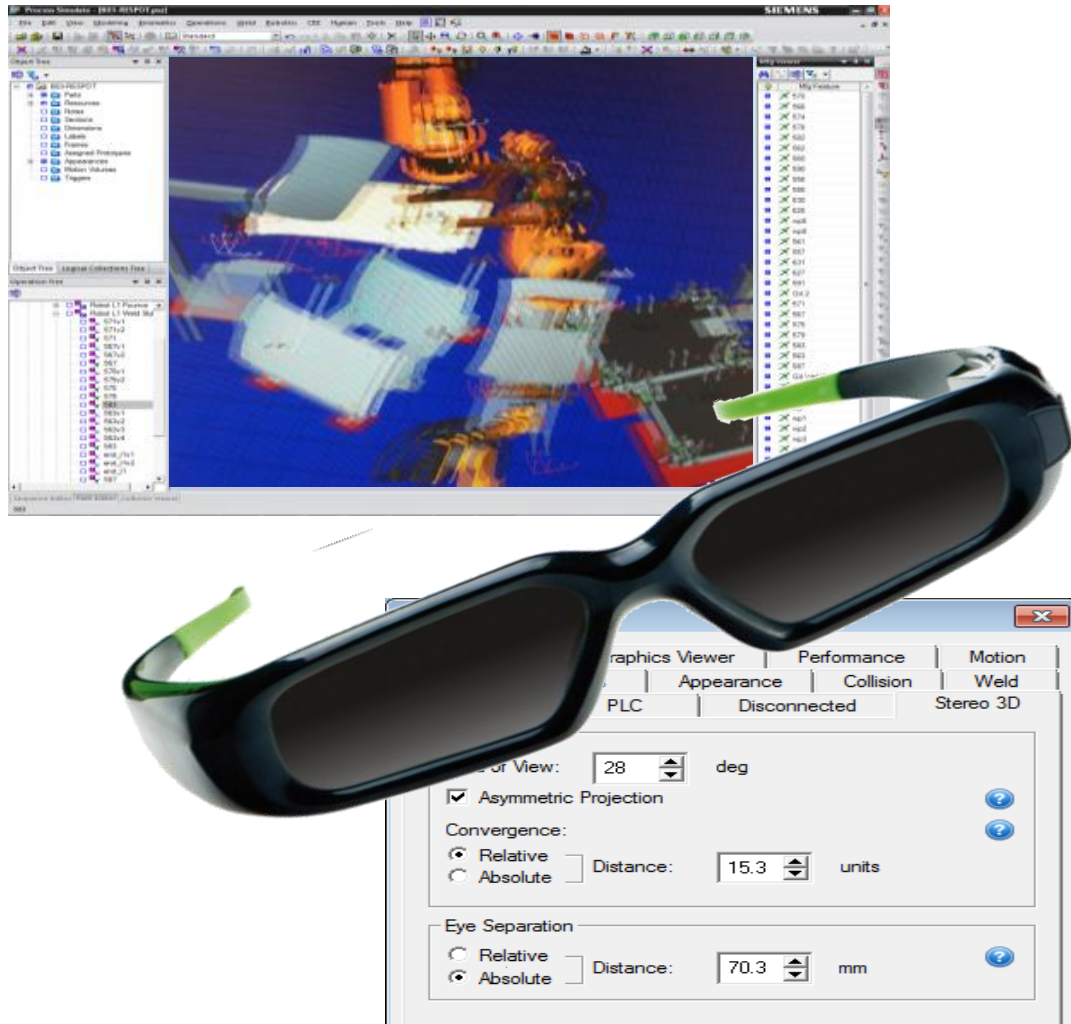


- Wide range of supported hardware
- Optical and gyroskopic systems
- Whole body, partial body, disembodied hands (data gloves)
- Open protocol for third party applications

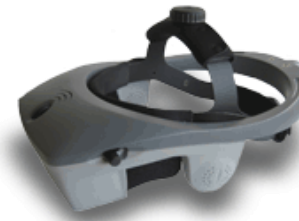
Tecnomatix Human: Motion Capture



Tecnomatix Human: Virtual Reality



- Head Mounted Displays (HMDs)
- 3D Stereoscopic mode of the Graphics Viewer and Human Visibility Viewer
- Enable realistic 3D view for intuitive understanding of the layout and process
- Active Stereo (Shutter Glasses) support, HTC Vive
- Third party API support



Tecnomatix Human: Virtual Reality

- HTC Vive



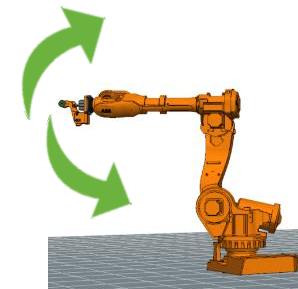
Teleport

Measure

Flashlight

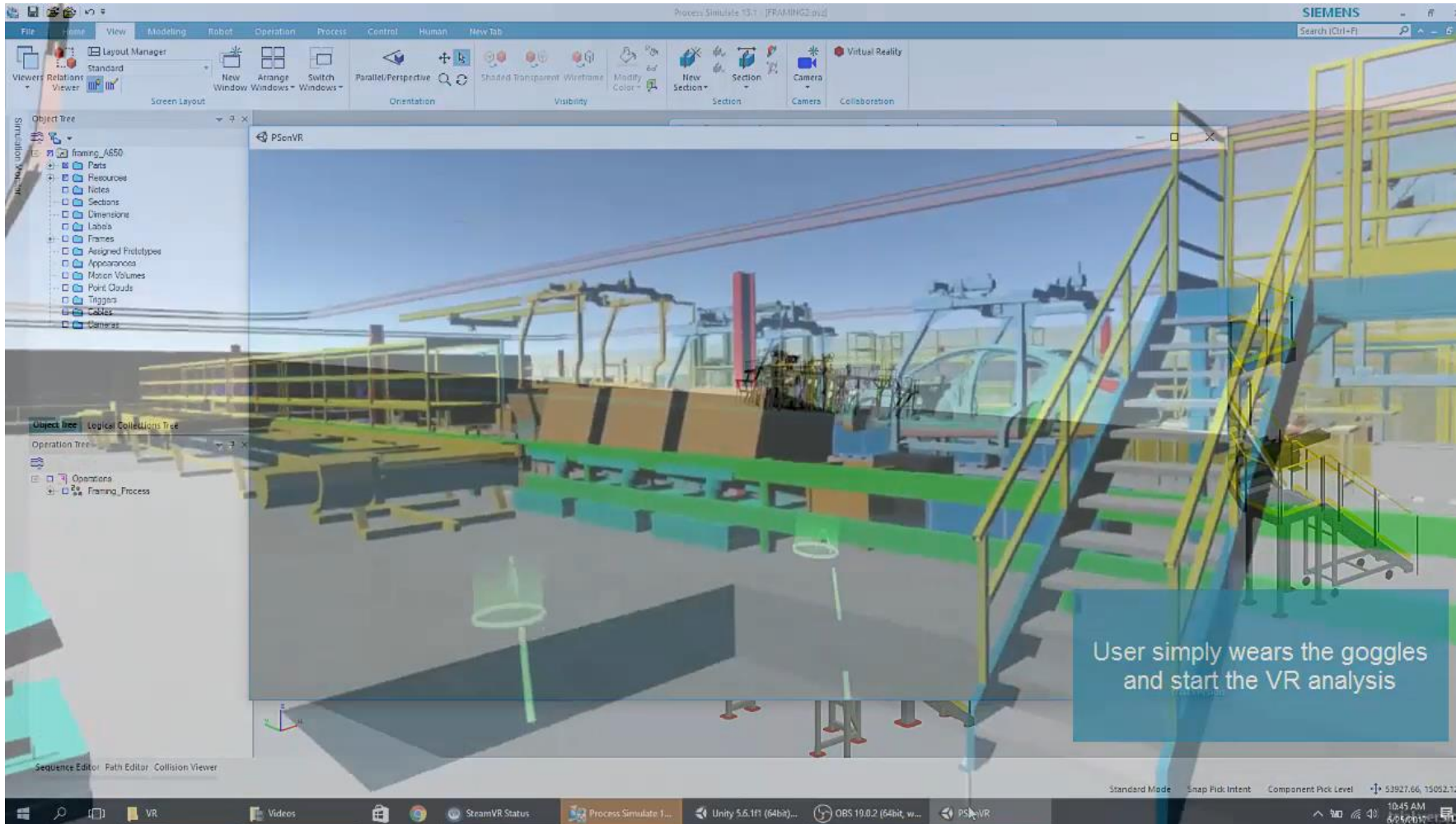
Play
Simulation

Laser
Pointer



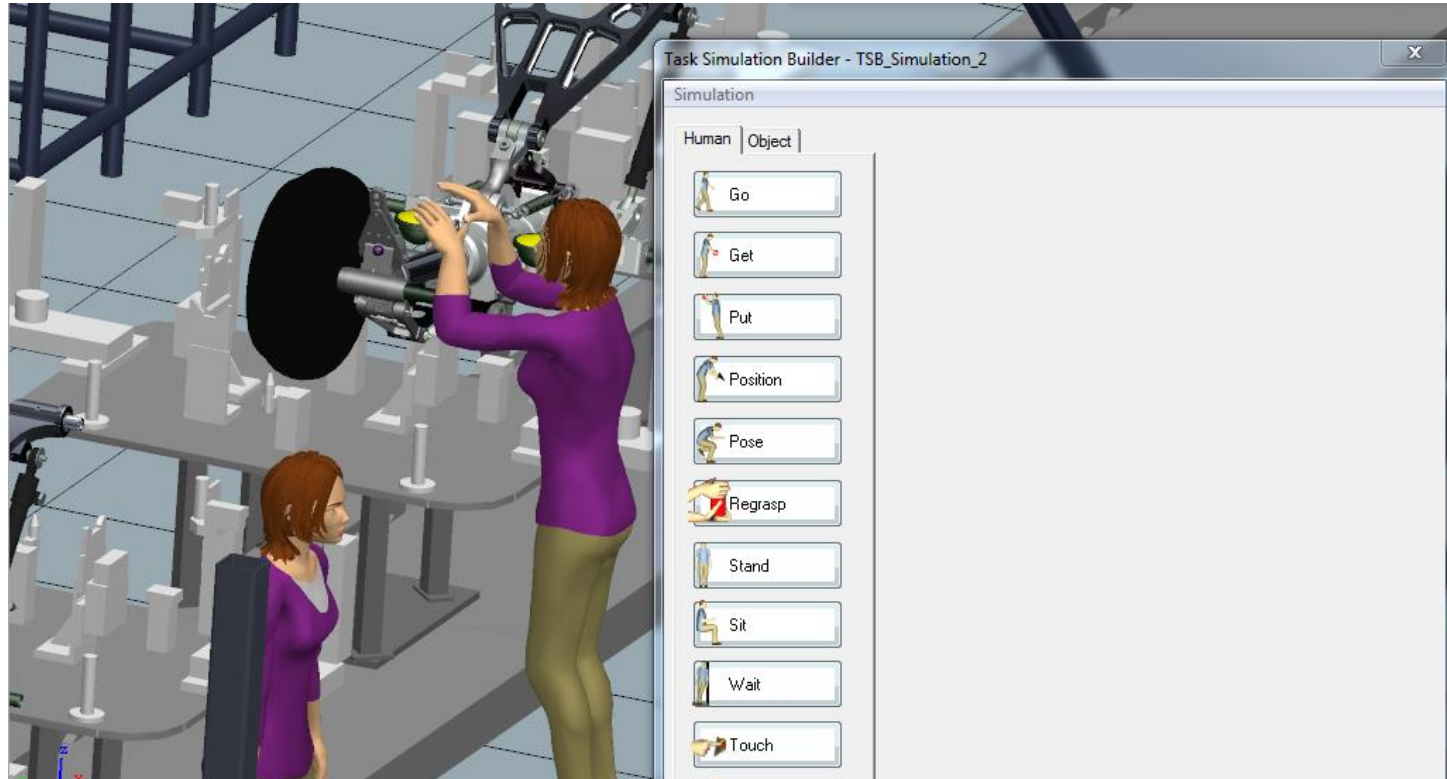
Tecnomatix Human: Virtual Reality

- HTC Vive

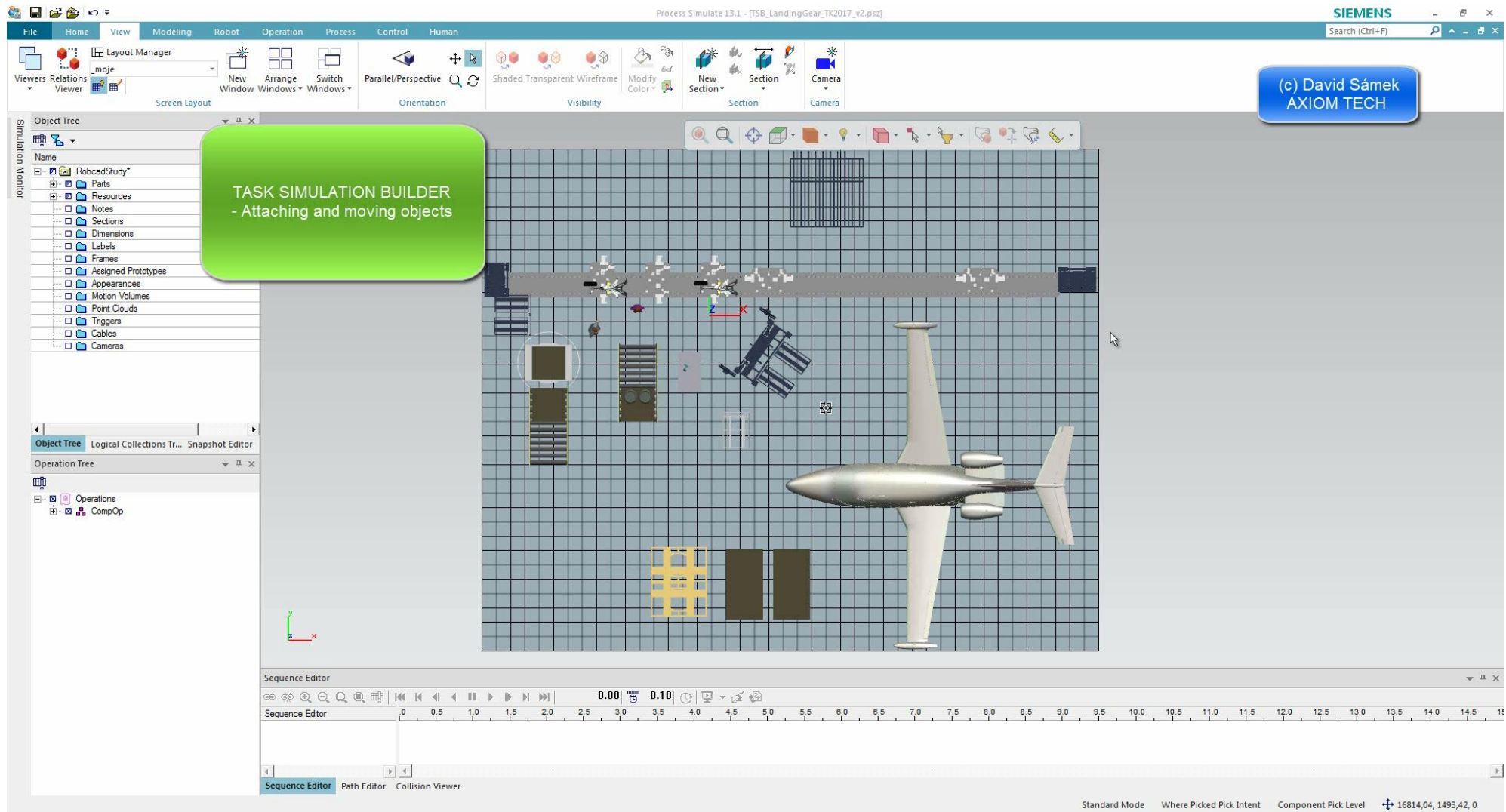


Task Simulation Builder

- Easy way how to simulate human tasks



Task Simulation Builder



Task Simulation Builder

Process Simulate 13.1 - [TSB_LandingGear_TK2017_v2.psz] SIEMENS

File Home View Modeling Robot Operation Process Control Human

Human Posturing... Create Human Create Hands Human Options... Properties Tools Posture Task Simulation Builder Simulate Vision Window Grasp Envelope Vision Envelope Analyze Envelope Setup Analysis Tools Ergonomics Tracking Setup Server Setup... Kinect ... Posture Recorder ... Motion Capture Active Human

Simulation Monitor

Object Tree

Name

- RobcadStudy
- Parts
- Resources
- Notes
- Sections
- Dimension
- Labels
- Frames
- Assigned Prototypes
- Appearances
- Motion Volumes
- Point Clouds
- Triggers
- Cables
- Cameras

Object Tree Logical Collections Tr... Snapshot Editor

Operation Tree

- Operations
- CompOp
- TSB_Simulation_2
 - Attach_Tire_2_To_Bin
 - Attach
 - Attach_Tire_4_To_Bin
 - Attach
 - Attach_Tire_1_To_Bin
 - Attach
 - Detach_Tire_1
 - Detach
 - Attach_Tire_3_To_Bin
 - Attach
 - Move_Bin
 - Slide

Sequence Editor

0.00 0.10

Sequence Editor

- TSB_Simulation_2
 - Attach_Tire_2_To_!
 - Attach_Tire_4_To_!
 - Attach_Tire_1_To_!

Simulation

Human Object

- Move
- Wait
- Attach
- Detach

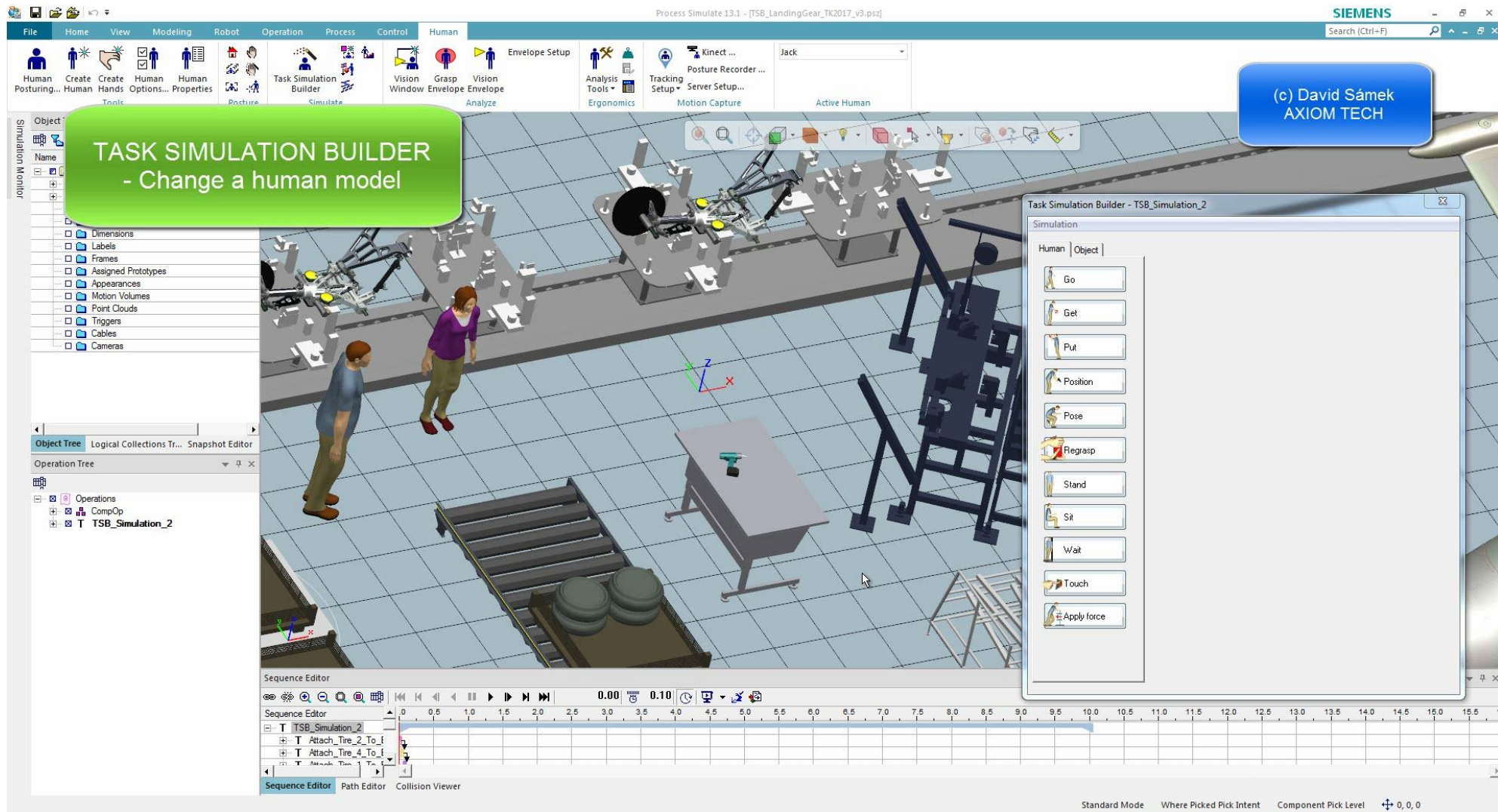
Sequence Editor Path Editor Collision Viewer

Standard Mode Where Picked Pick.Intent Component Pick.Level 0,0,0

(c) David Sámek AXIOM TECH

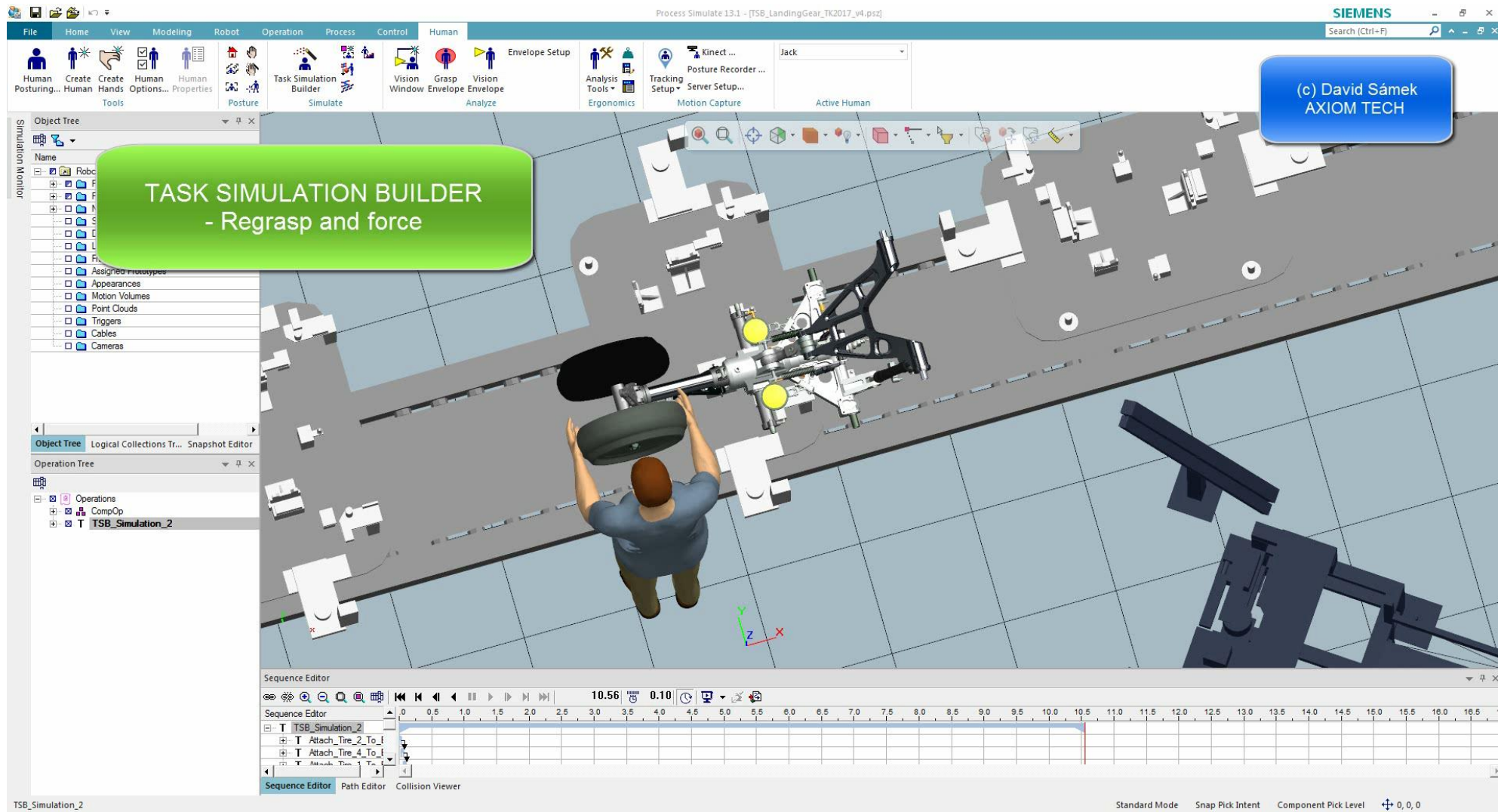
TASK SIMULATION BUILDER - Get and position

Task Simulation Builder



(c) David Sámek
AXIOM TECH

Task Simulation Builder



Task Simulation Builder

Process Simulate 13.1 - [TSB_LandingGear_TK2017_v5.psz]

SIEMENS

Search (Ctrl-F)

Human Posturing... Create Human... Create Hands... Human Options... Human Properties... Posture... Task Simulation Builder... Simulate... Vision Window... Grasp Envelope... Vision Envelope... Analyze... Envelope Setup... Analysis Tools... Ergonomics... Tracking Setup... Kinect... Posture Recorder... Server Setup... Motion Capture... Active Human

Object Tree

Simulation Monitor

Labels
Frames
Assigned Prototypes
Appearances
Motion Volumes
Point Clouds
Triggers
Cables
Cameras

Object Tree Logical Collections Tr... Snapshot Editor

Operation Tree

Operations
CompOp
TSB_Simulation_2

Task Simulation Builder - TSB_Simulation_2

Simulation

Human | Object

Go
Get
Put
Position
Pose
Regrasp
Stand
Sit
Wait
Touch
Apply force

Sequence Editor

12.83 0.10

Sequence Editor

TSB_Simulation_2
Attach_Tire_2_To_I
Attach_Tire_4_To_I

Sequence Editor Path Editor Collision Viewer

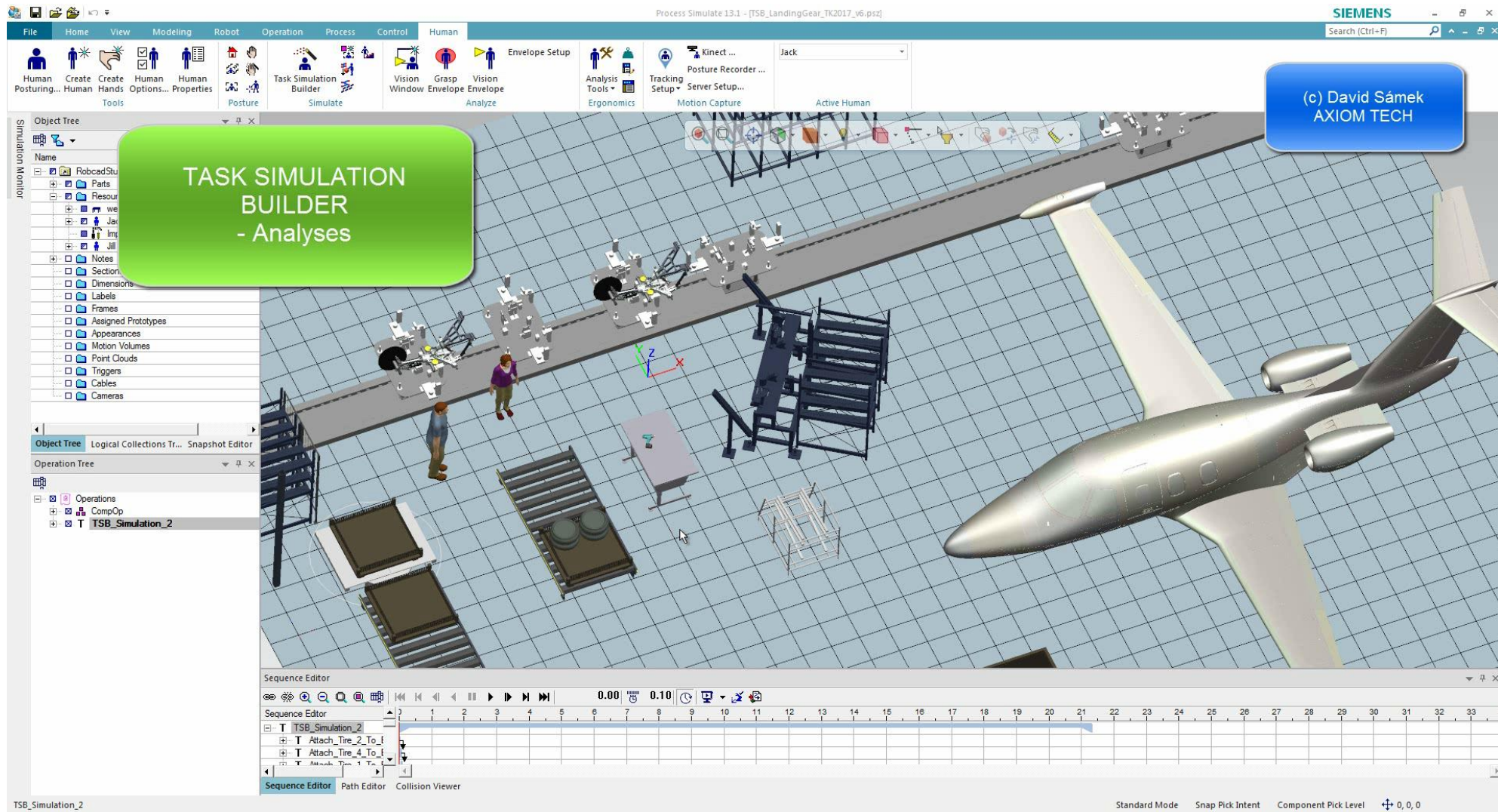
TSB_Simulation_2

Standard Mode Where Picked Pick.Intent Component Pick.Level + 0,0,0

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TASK SIMULATION BUILDER
- Hand tool grasp and usage

Task Simulation Builder



Task Simulation Builder

Change Properties - 95p_European_male

Create by parameters

Gender:

Appearance:

Database:

Height (mm):

Weight (kg):

Waist to Hip Ratio:

Boots & Gloves

Sole height: (cm)

Glove thickness: (mm)

Load parameters from .fig file

Clone anthropometric data from origin

Change Property Options

Keep original mode

Hide original mode

Make original model transparent

Make new model transparent

Generate reach posture

Fix effector:



95 percentil ANSUR



50 percentil GERMAN



5 percentil CHINESE



Human - Robot Collaboration



Human - Robot Collaboration



Cobots Safety Challenges

**Safety Measurements
Devices**

Certification Procedures

**Protection
Equipment**

Acceptance and Training

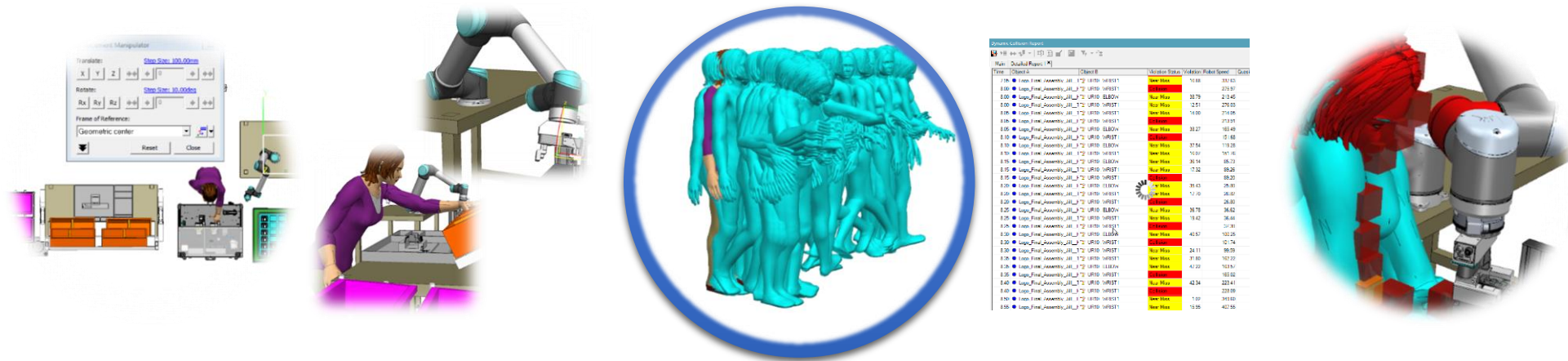
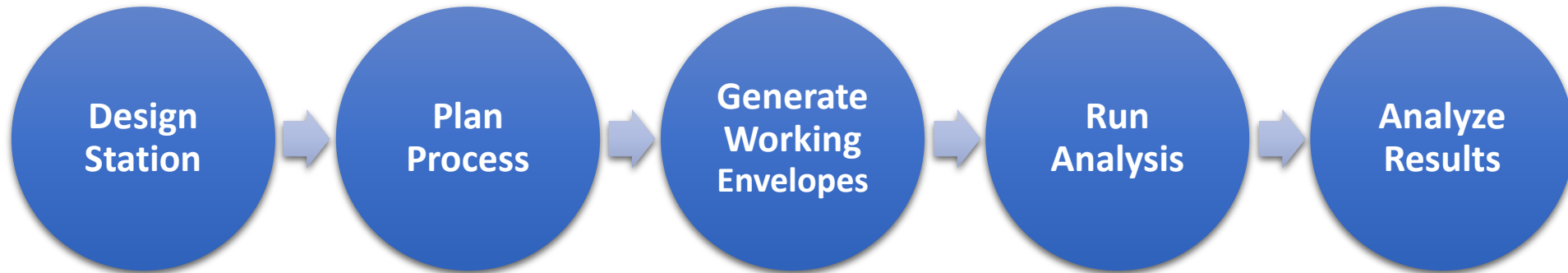
System Layout

Line Shutdown

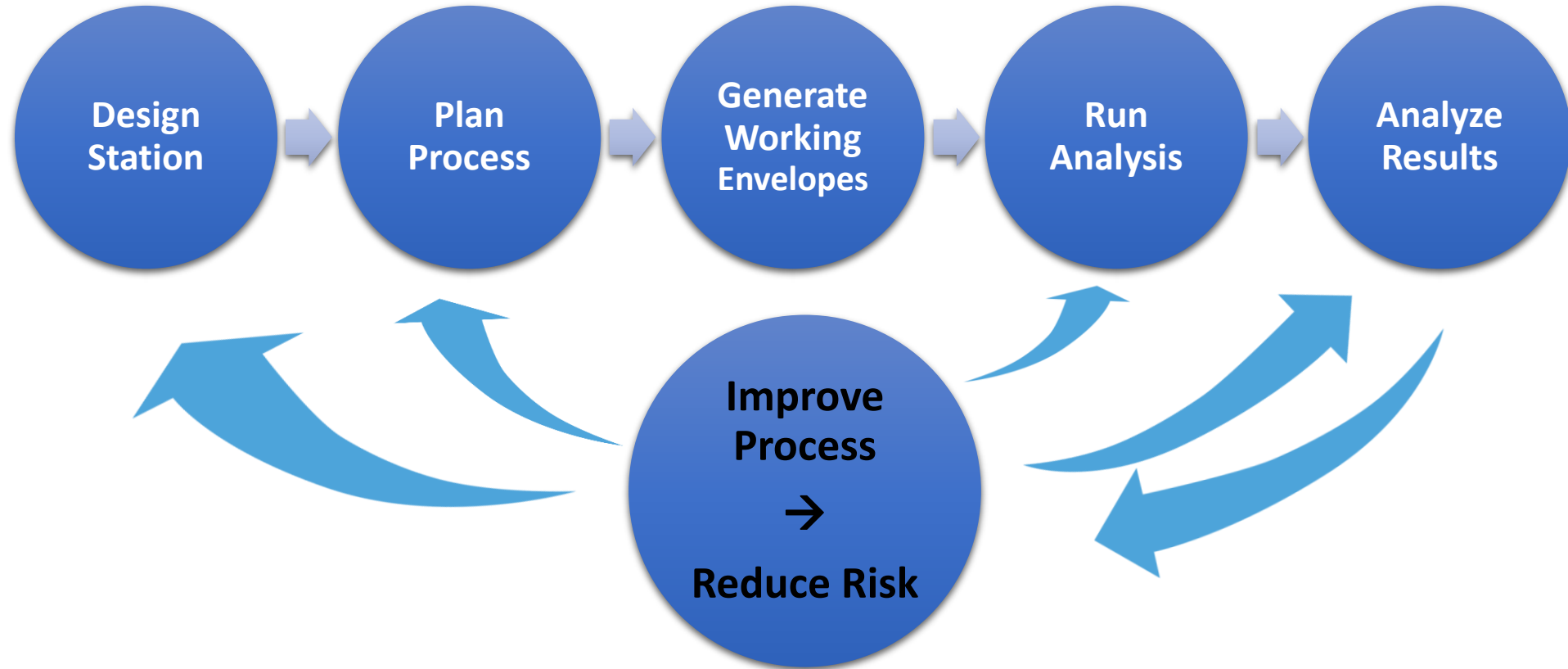
Throughput



Workflow

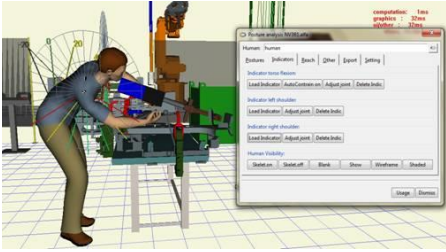


Workflow

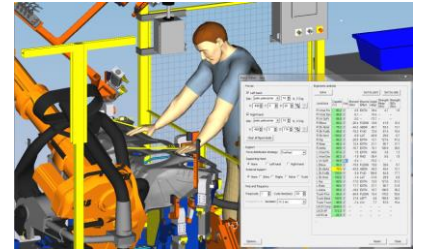


Jack vs Process Simulate Human

Jack

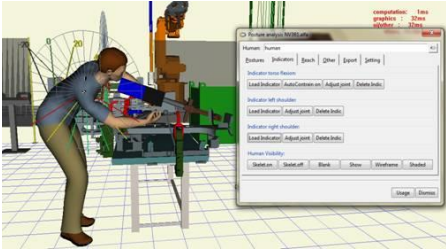


PS Human

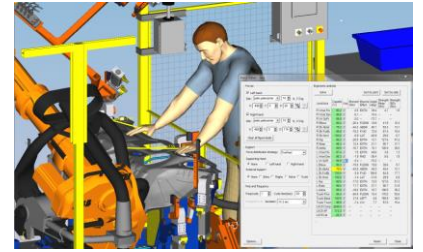


Jack vs Process Simulate Human

Jack



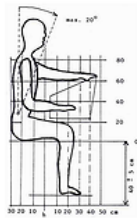
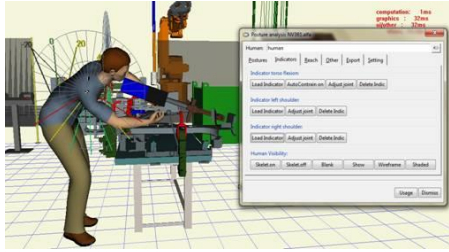
PS Human



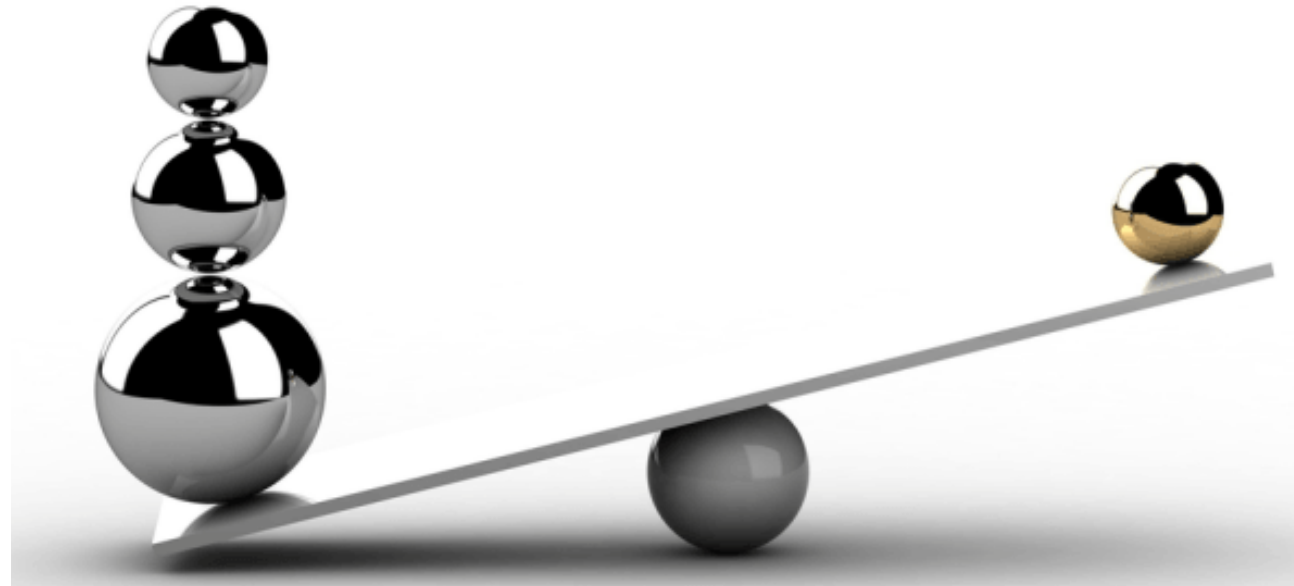
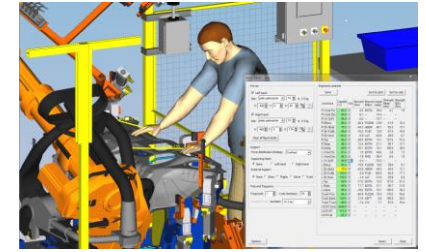
Much the same

Jack vs Process Simulate Human

Jack



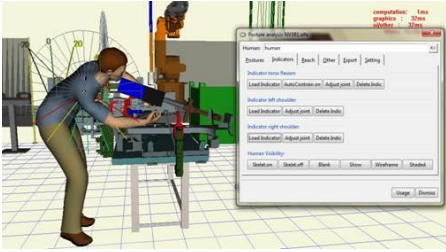
PS Human



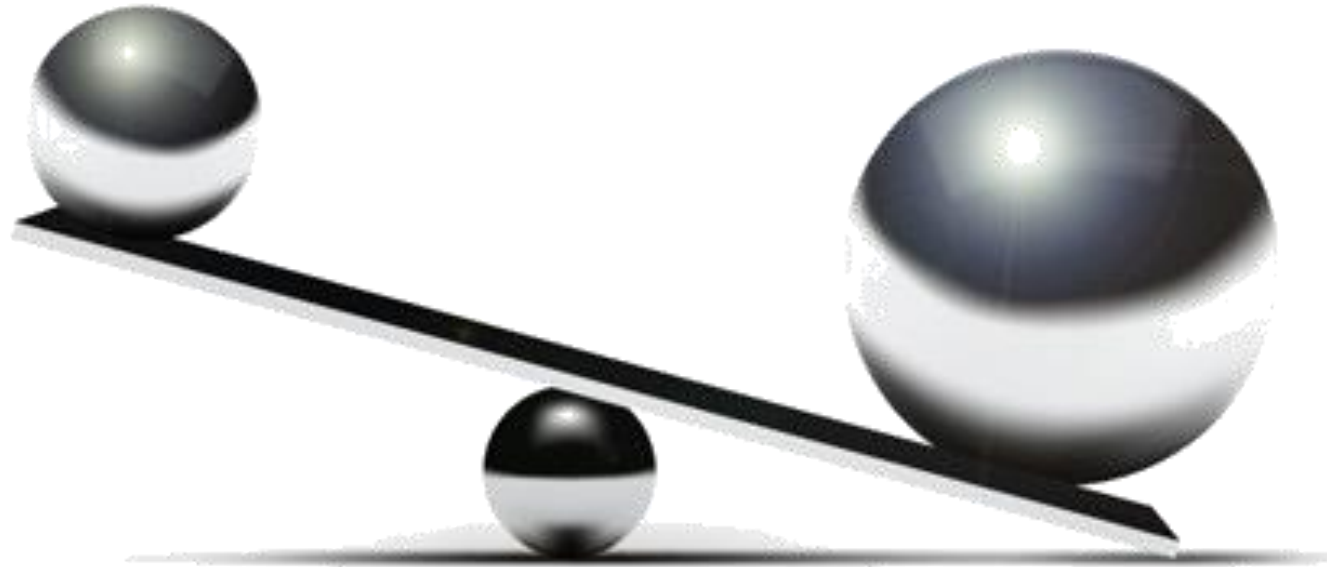
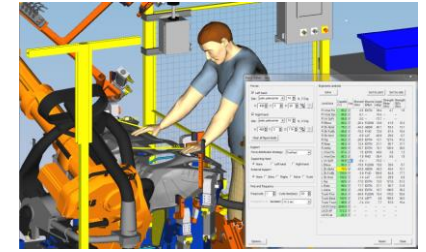
**Scripting, Detailed human scaling,
Occupant Packaging Toolkit, Add-Ons**

Jack vs Process Simulate Human

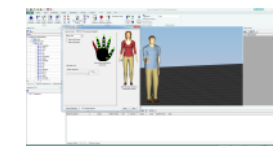
Jack



PS Human



PLM support, Robotics, VC, HRC, Assembly simulation, 3D modelling, enhanced reporting, VR, point cloud, Motion Capture for TSB, ...



Summary

1



Increase
Customer
Satisfaction

2



Compress
time to
Launch

3



Reduction of
medical and
absenteeism
costs

4



Ensure
Serviceability

5

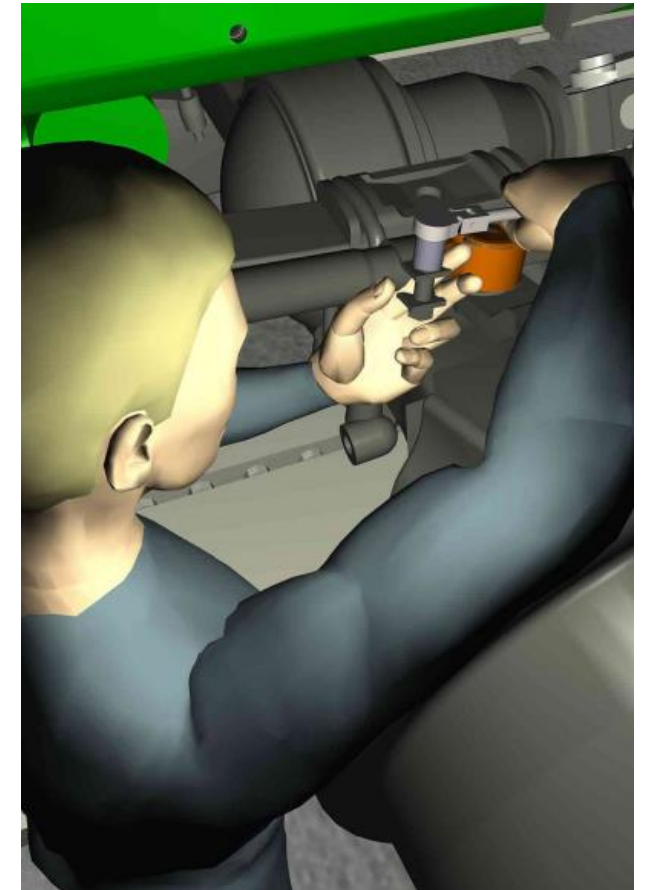
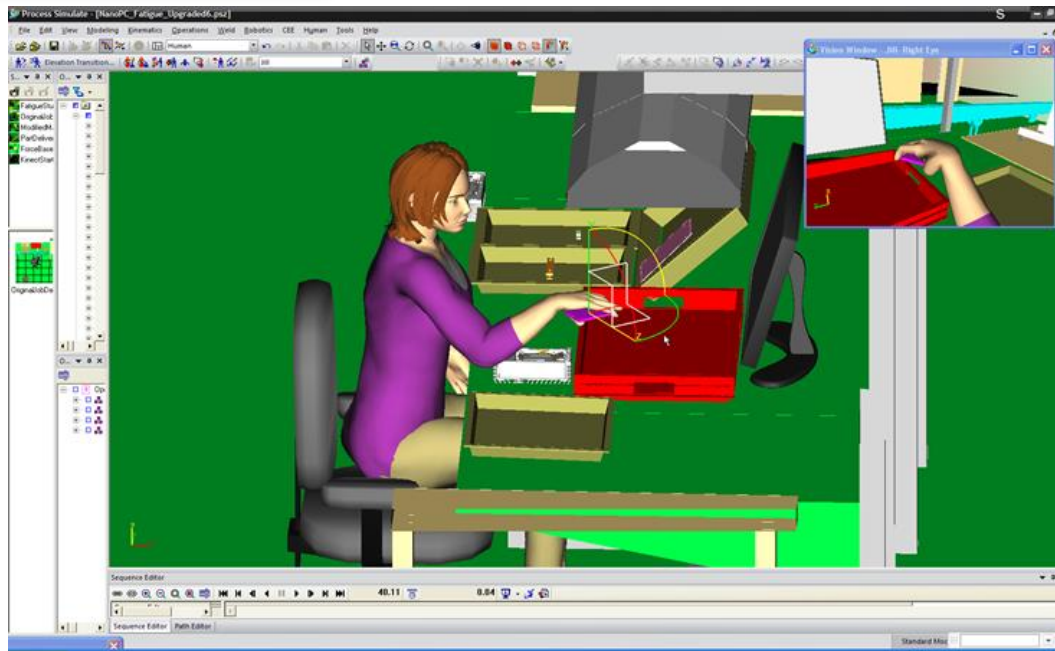
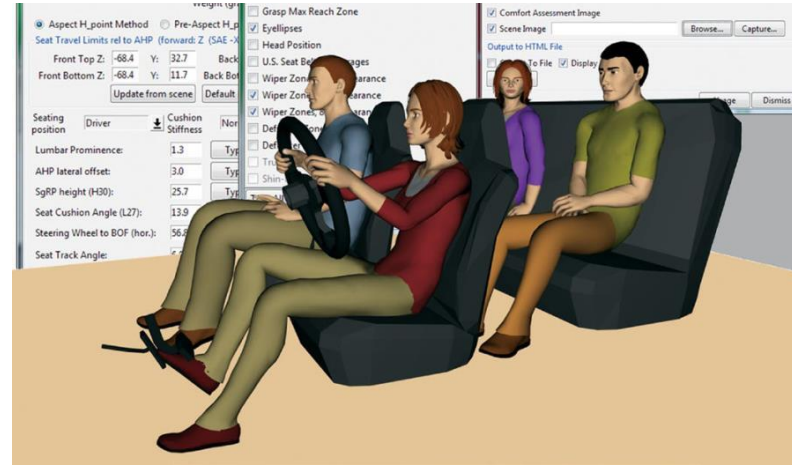


Visualization
of human
tasks

Summary

Target users:

- Mechanical designers
- Ergonomics experts
- Process engineers
- Human safety specialists



Conclusion

Thank you for your attention

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