VIVE LAB ERGO

USER MANUAL

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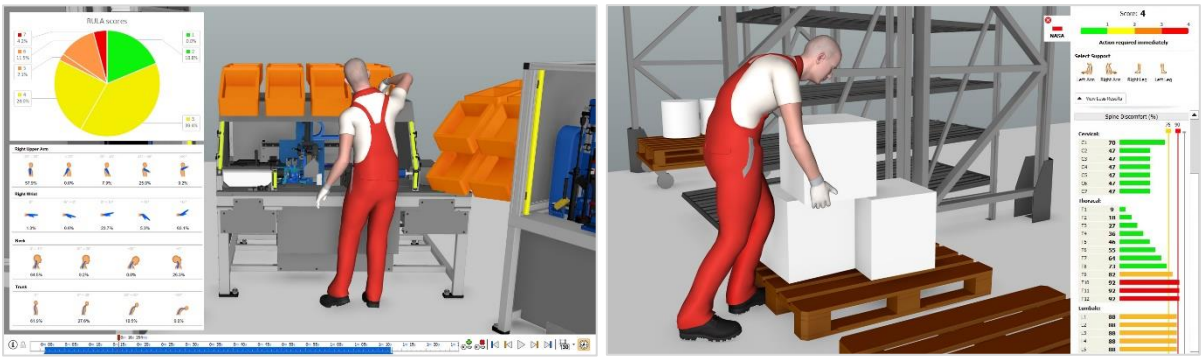
OVERVIEW

ViveLab Ergo is a complex ergonomic system for virtual testing and verification of product plans or manufacturing processes. With this simulation tool you can model and analyze the effects and the mechanisms of almost any complex system or product in real time.

In ViveLab Ergo system seven types of analyses are implemented for evaluating human motion and posture:

- RULA
- OWAS
- NASA-OBI
- ISO 11226
- EN 1005-4
- Spaghetti diagram (Motion Measurement)
- Reachability Test

With the easy-to-use software solutions we transfer the human movement into anatomically correct and realistic models. By using ViveLab Ergo you also get access to our large anthropometric databank.



This User Manual will help you to use the ViveLab Ergo system. If you need more help, please read the hints in the software (if you hover with the cursor over any button a detailed description of its function appears) **and/or watch the tutorial videos on our official YouTube channel:** https://www.youtube.com/playlist?list=PLSP_48GBsX55fLNvmzq4rVzZVKOvM5gDf.

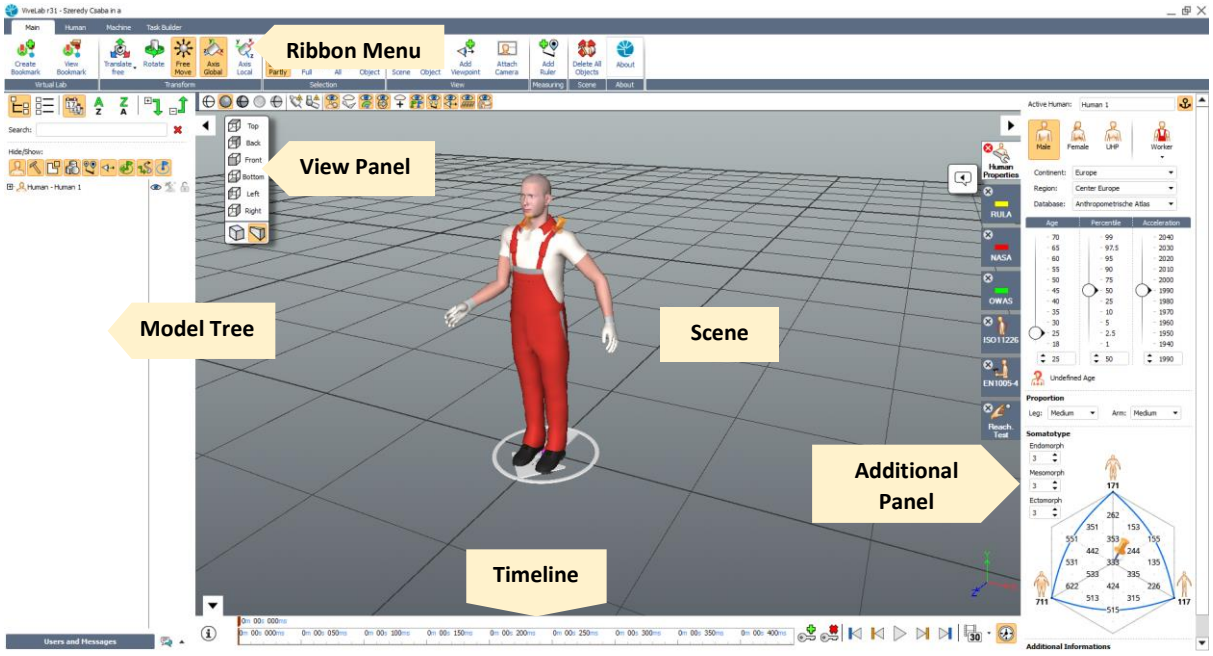
1 DESKTOP

1.1 Download and install

To download and install the ViveLab Ergo Application please see the ViveLab Ergo Install Guide!

2 SCENE

After opening a new ViveLab an empty three-dimensional space can be seen.

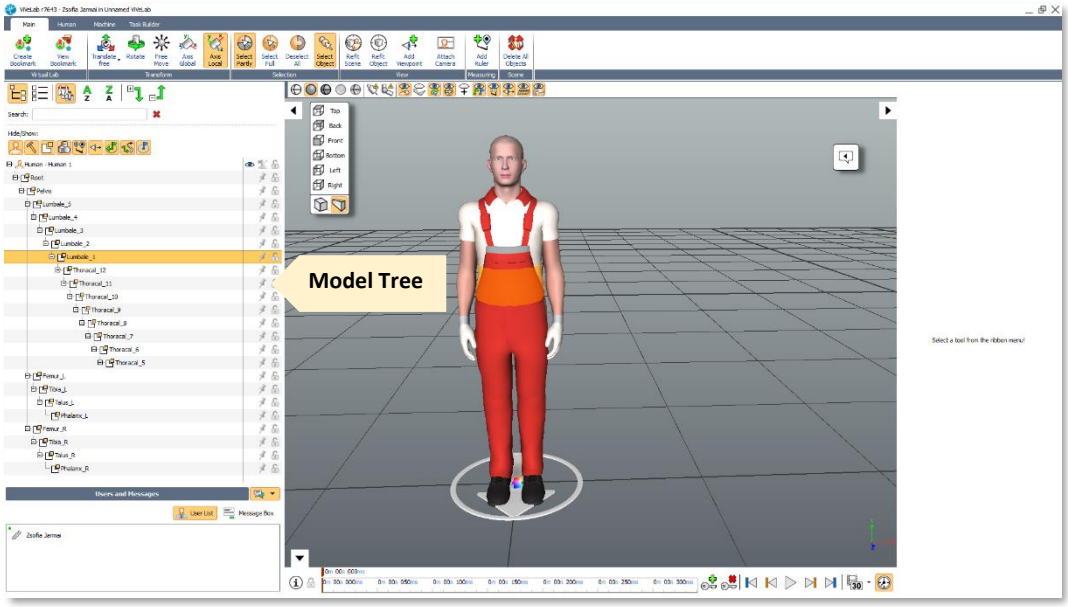


The screen can be rotated by holding the right mouse button while moving the mouse. It can be zoomed in and out using the scroll wheel. The speed of scrolling can be augmented by pressing ‘Shift’. Panning can be done by holding the scroll wheel while moving the mouse to the left , right, top or bottom.

There are four main menus at the top: the ‘HUMAN’ menu serves to set all data related to the human character, the ‘MACHINE’ menu helps to create the work environment by importing CAD models, the ‘TASK BUILDER’ menu helps to specify tasks for the human character and generates an animation from it, while the ‘MAIN’ menu, among others, serves to set the method of transformation and selection.

You can choose between an orthogonal or perspective representation at the panel in the top left corner and reach other view options as well.

On the left side panel a ‘Model Tree’ is placed. This tree contains all objects which have been created. For human characters the tree will represent the natural hierarchy of the body parts. (→ Chapter 14)

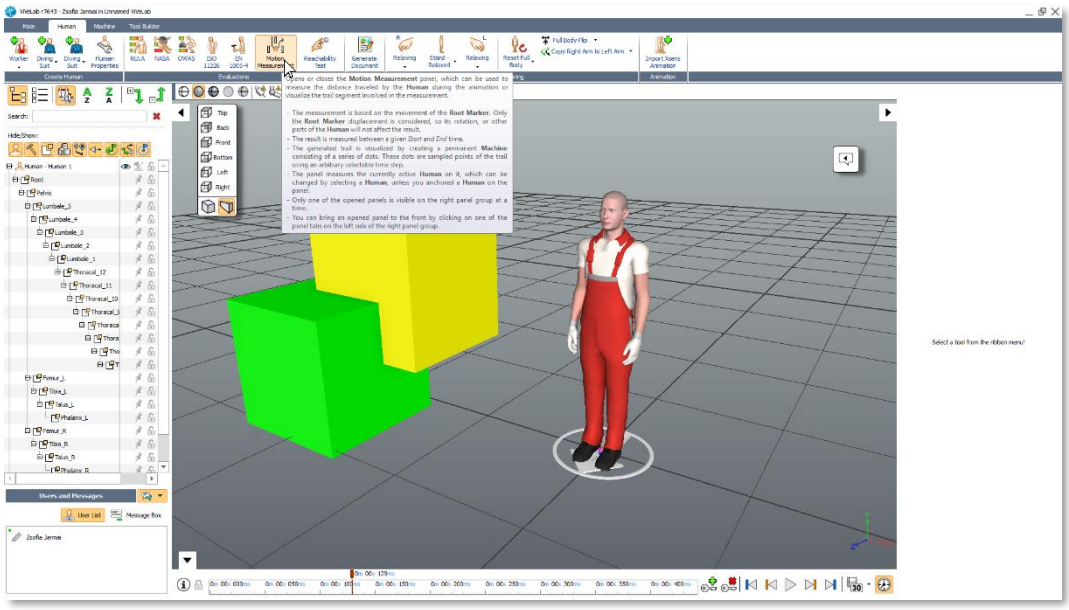


In the bottom left corner there is the ‘Message Box’ where you may leave notes for yourself or for colleagues working on the same project.

There is a timeline at the bottom, where animation for certain objects of the scene can be created. It is possible to zoom in or out the timeline with the scroll wheel while the cursor is on the timeline. It can be moved by dragging it with the right mouse button horizontally and you can set the current time by left clicking on it. (→ Chapter 6)

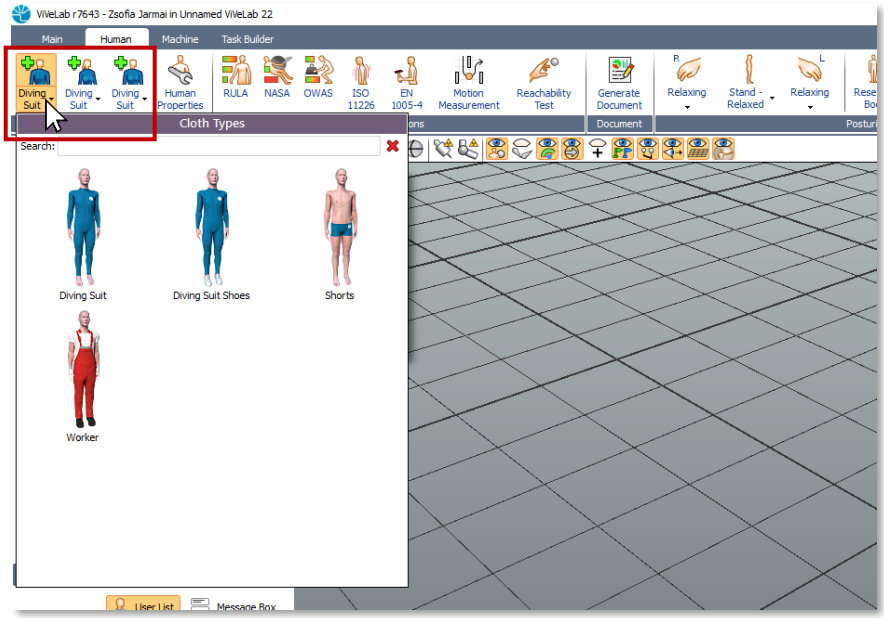
By clicking on one of the evaluation icons, its panel will open on the Additional Panel on right side and settings can be made there. (→ Chapter 10)

If you hover with the cursor over any button a detailed description of its function appears, which guarantees a user-friendly interface.



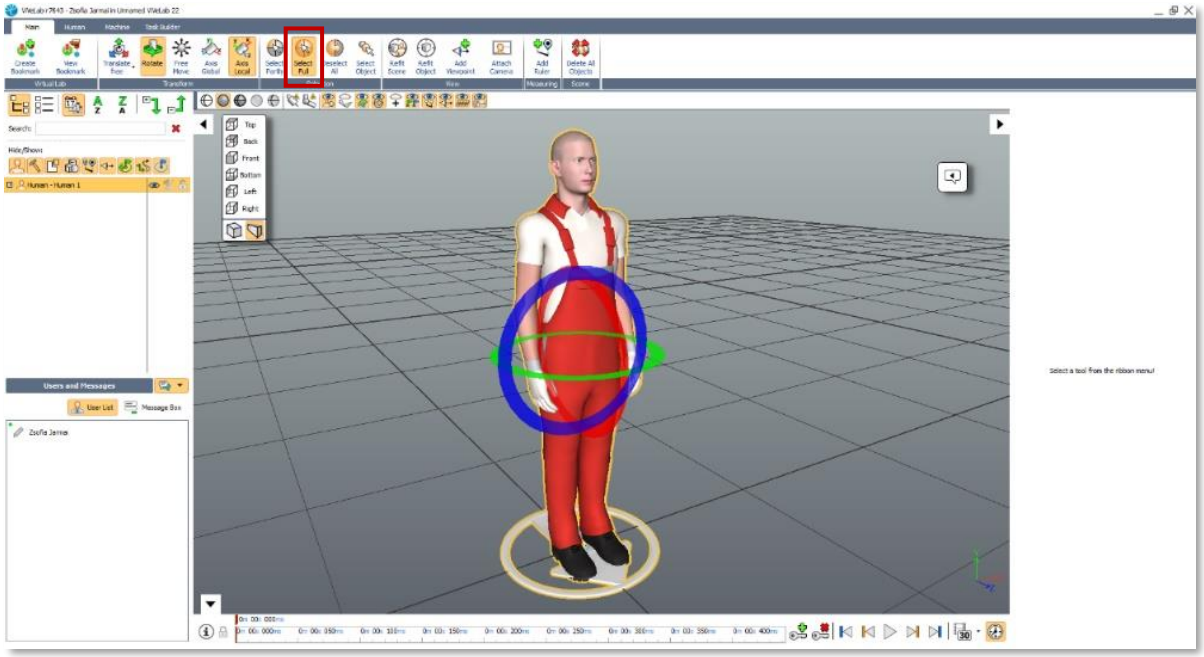
3 CREATE HUMAN AND POSTURES

The ‘HUMAN’ menu enables the creation of human characters. It can be a male, a female or an UHP (Uniform Human Phantom) character. The UHP character represents the arithmetic mean of the male and female body measures. There is a roll-out menu in case of each of the three gender types, where it is possible to choose the outfit of the character.

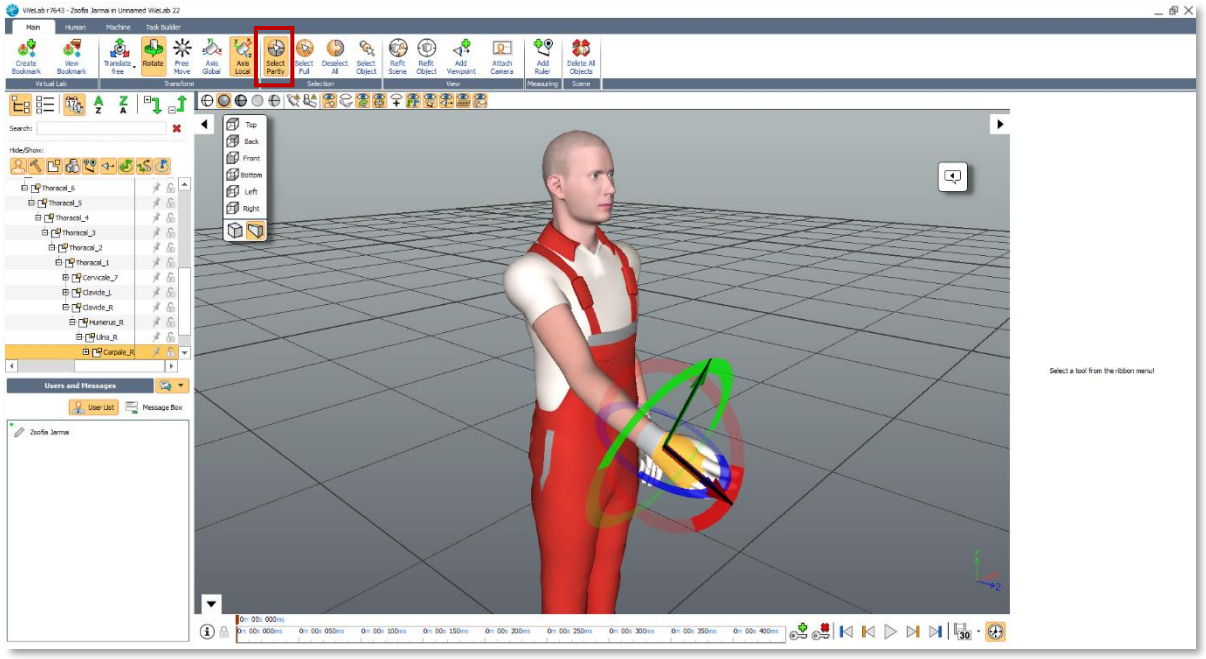


The new human characters are always placed at the origo of the scene.

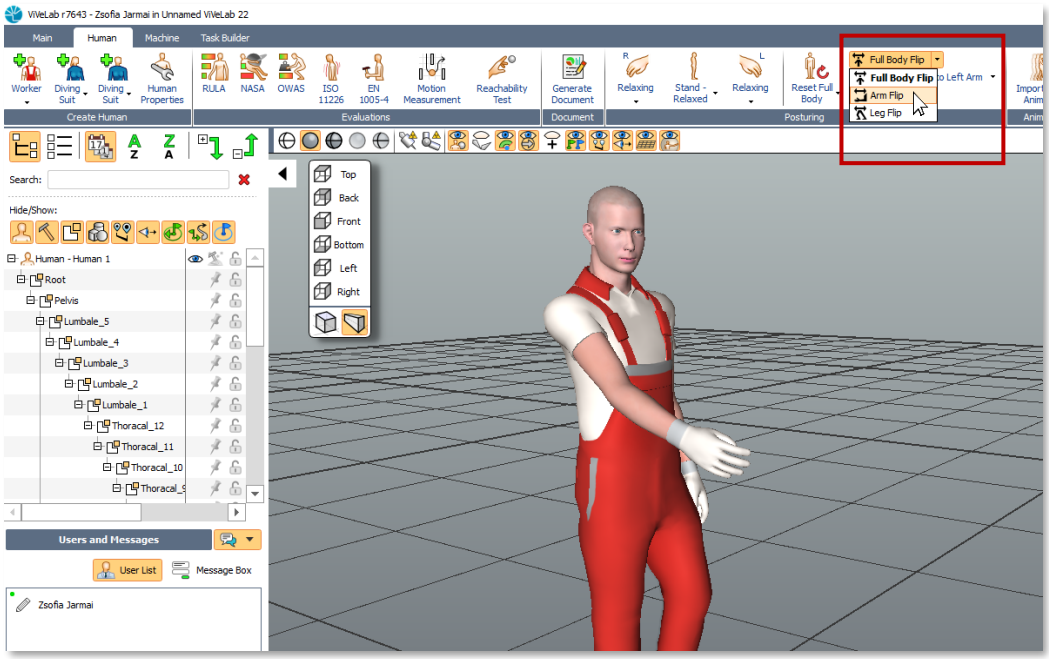
After clicking the **‘Select Full’** icon in the ‘MAIN’ menu the human can be moved using the ‘Translate’ command and it can be rotated around its own axis with applying the ‘Rotate’ button. By activating the ‘Free move’ icon, the human may be moved in horizontal direction.



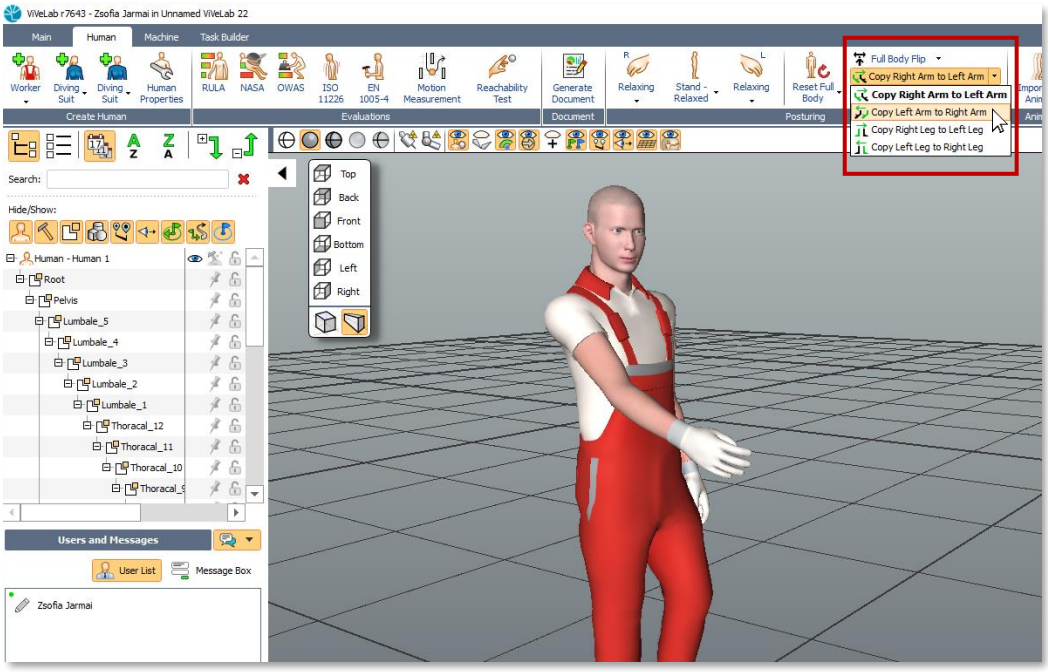
If the **'Select Partly'** option is chosen, the different body parts of the human character can be selected and moved or rotated within the specified angular range that corresponds to the real limits of bodily movements. It is possible to move the character using the 'Free Move' command which is useful for the purpose of fine tuning.



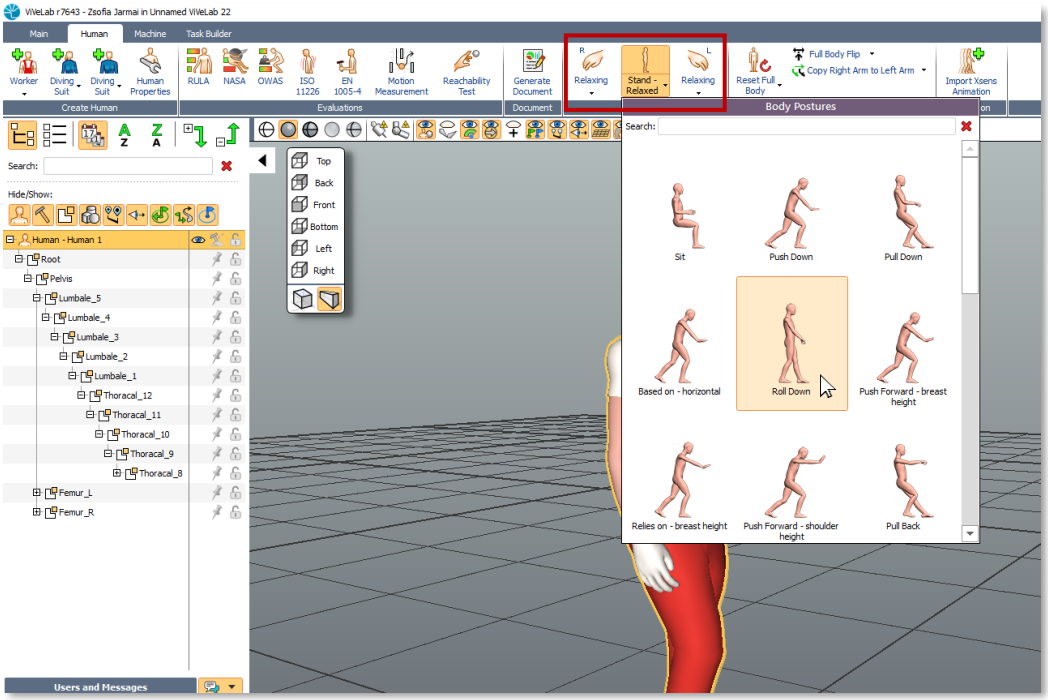
In case of non-symmetrical body postures, the left and right postures of the extremities can be flipped.



It is possible to copy the hand and leg posture of one side to the other.



In the 'Body Postures' tab of the 'HUMAN' menu pre-set body postures can be chosen. It is also possible to select a pre-set hand position separately for the left and right hand. The properties of the character can be changed any time regardless of the body posture. There are still further opportunities to change or modify the body posture of the human character in order to get the most accurate pose needed.



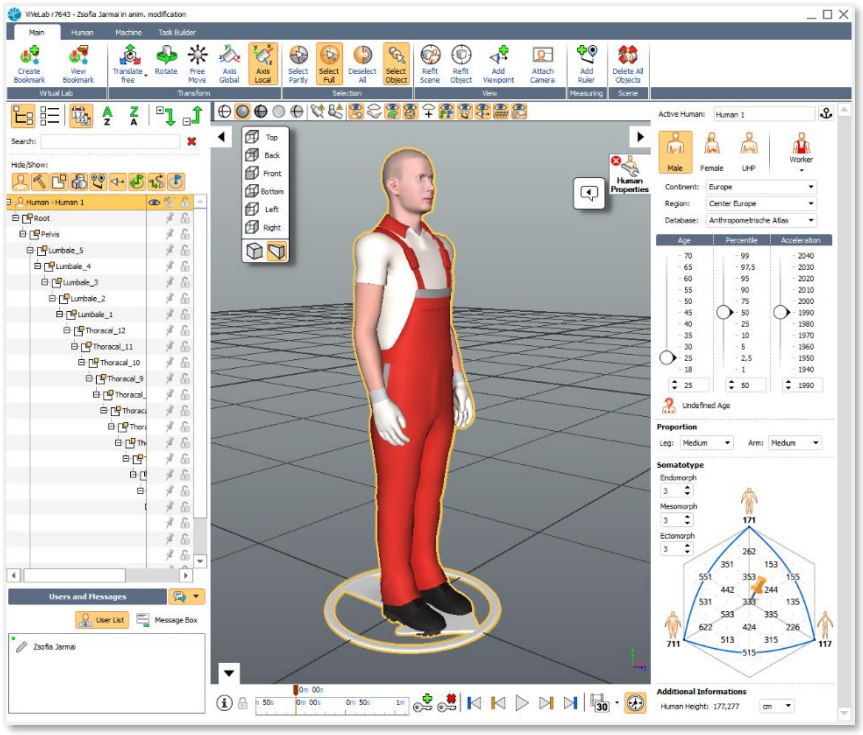
4 HUMAN PROPERTIES

After clicking the ‘Human Properties’ command, a panel appears on the Additional Panel on the right side where the character can be personalized. A Human character must be selected for activating the panel.

It is also possible to change the gender of the created character to female or UHP. The clothing can also be altered. The character can be renamed in the ‘Active Human’ field. The modified name is going to appear in the model-tree as well. You can choose the origin of the character for the given analysis by choosing the respective continent, region and database. The look of the character changes in real time according to the modifications.

The height of the human character is displayed at the bottom of the panel, its units can be changed.

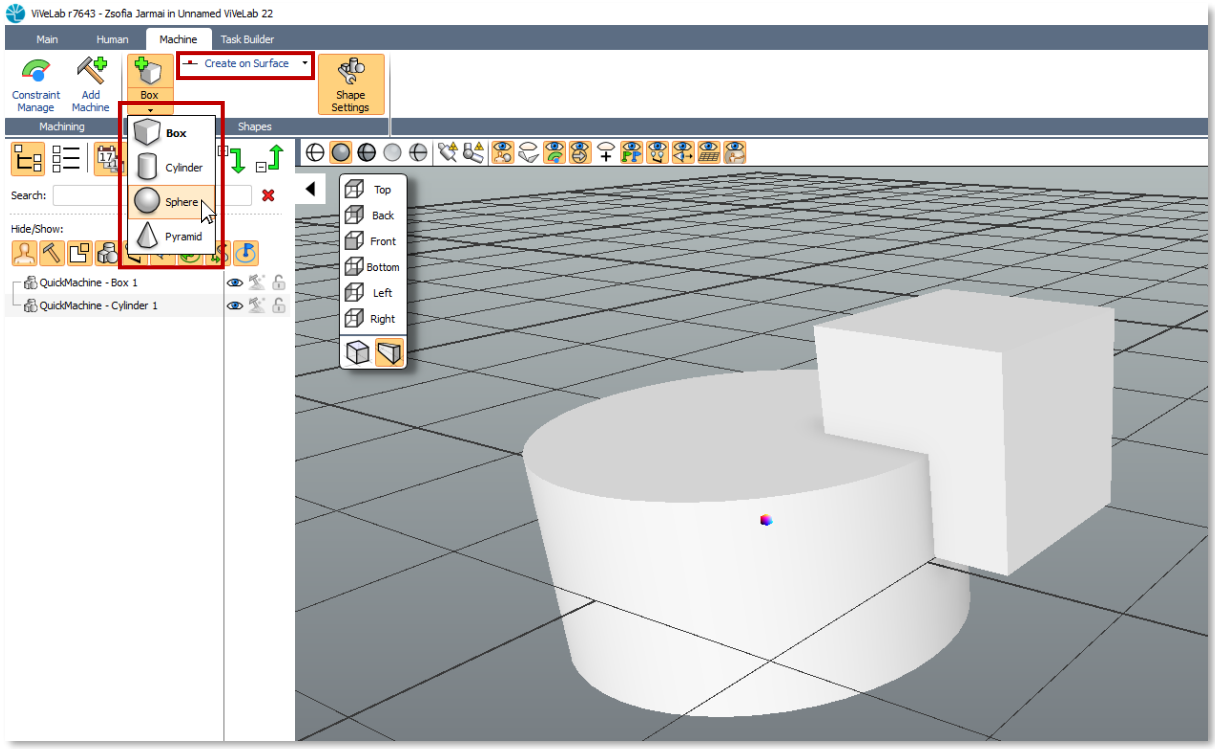
The age of the character can be set. It is possible to select ‘Undefined Age’ for which the body sizes of the human character are averaged from the body measures of all age ranges. The percentile and the acceleration of the human character can also be set.



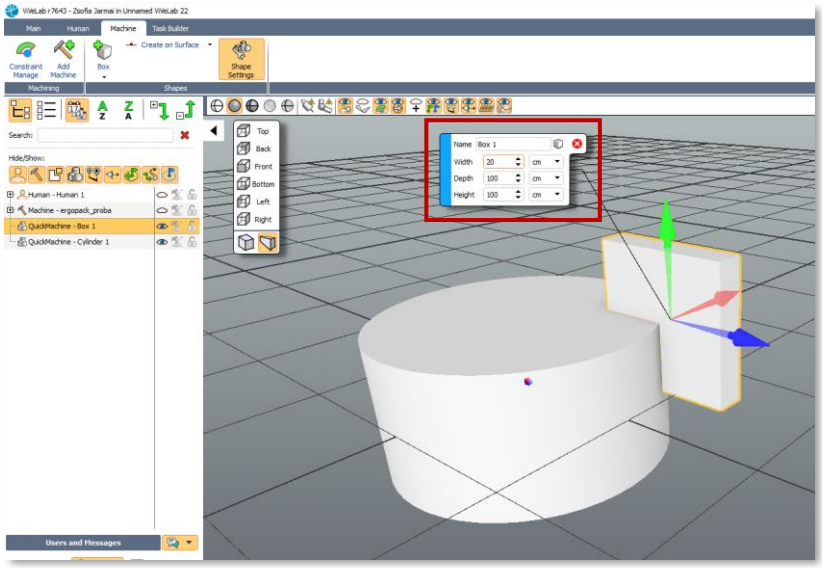
The proportions of the extremities can be specified as medium, short or long. The category of the human physique can be defined by choosing between the three main somatotypes: Endomorph, Mesomorph and Ectomorph.

5 MACHINES

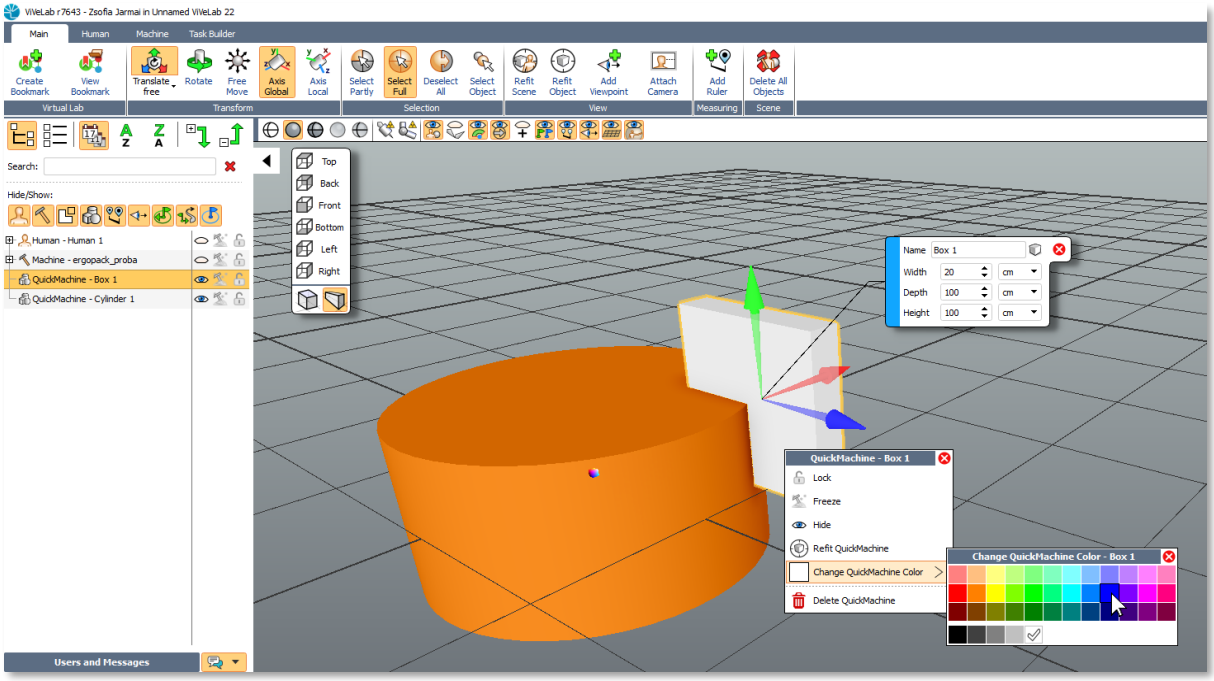
It is possible with the help of the 'MACHINE' menu to create so-called 'QuickMachines', these can be cubes, cylinders, spheres or pyramids. On the next tab, the position of the created 'QuickMachine' can be given (create in origo; create on Surface; create on grid; create on grid point).



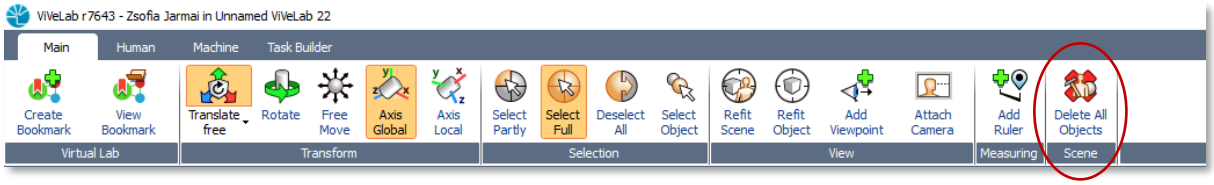
The dimensions of these machines can be defined and their unit can be set. The Shape Settings floating panel belongs to the currently selected QuickMachine, the panel is not visible if no QuickMachine is selected. The floating panel can be moved in the viewport by dragging on the left side of it (blue) with the left mouse button. If the Shape Setting floating panel is closed, you can open it again from Machine tab of the ribbon menu.



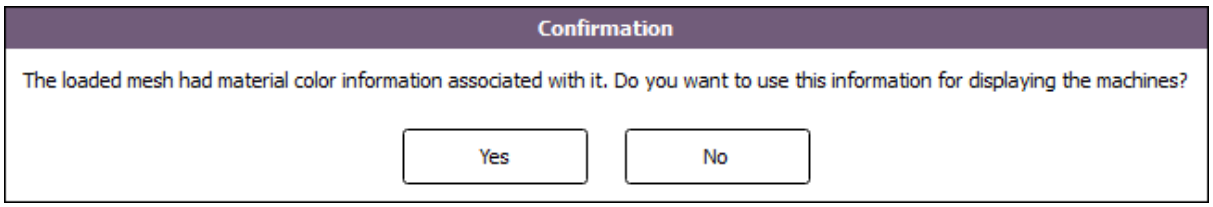
The colors of ‘QuickMachines’ can be set (right mouse button clicking on the selected machine) and also these can be transformed and animated like other objects.



You can delete all elements, both humans and/or machines, by switching to the ‘MAIN’ menu and choosing the ‘Delete all Objects’ command.



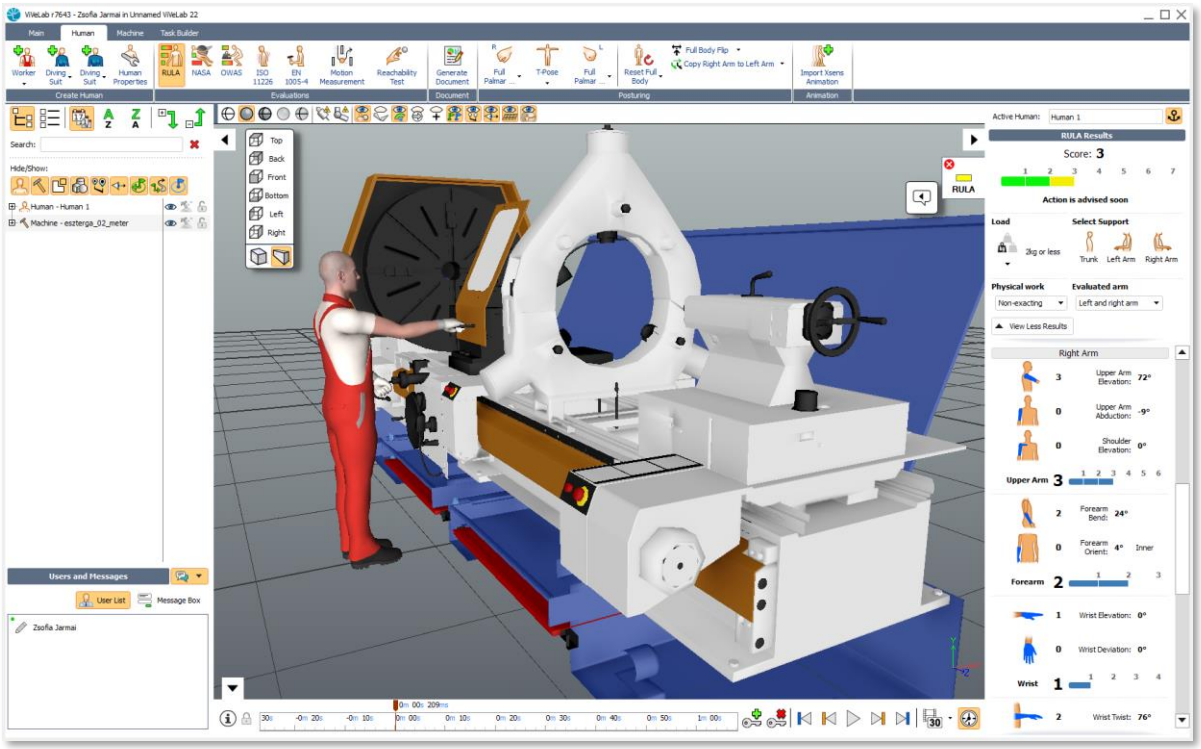
When returning to the ‘MACHINE’ menu any CAD model can be imported by clicking the ‘Add Machine’ button. **The application can only handle files with .dae extension.** Therefore, the CAD models to be imported should always previously been converted to a .dae file. It’s important to know that the maximum number of parts that a model may have is 2000 and the size limit of machines or environments imported is 50x50m. If the loaded mesh has associated material color information, the application asks whether these should be used for displaying the machine.



The imported model can be rotated in order to see it from an appropriate angle and at a suitable position. Colors used can be changed for every part of the machine.

An example for use:

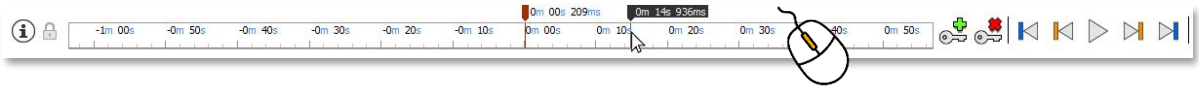
After importing a human character and placing it in the correct position and body posture at the lathe machine, the human-machine relationship can be examined and analyzed. It's important to know that human characters cannot interact with machines. Machines serve as a visual aid to set up correct postures and animations.



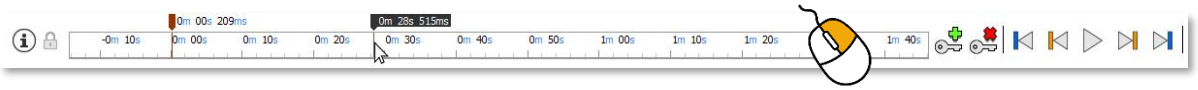
6 CREATE ANIMATION I.

Animations can be created on the timeline for certain objects in the scene.

The timeline can be zoomed in or out scrolling the scroll wheel while the cursor is on it.



It can be moved by dragging horizontally with the right mouse button.



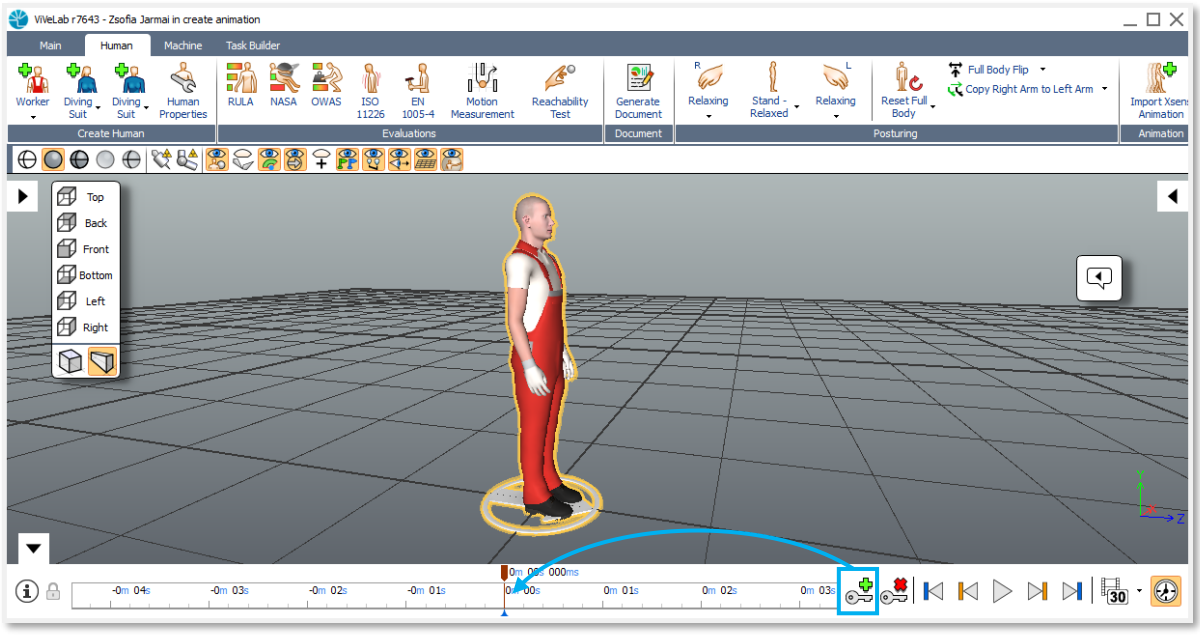
You can set the required time by left clicking on the timeline or it is also possible to write the time into the yellow square.

Just to show an example, the process of taking down a box from the upper shelf is animated. The movement of the human and the box are going to be recorded separately with the use of the 'Create Key' button. The human character cannot interact with the box as that just serves as a visual aid to set up correct postures and animations.

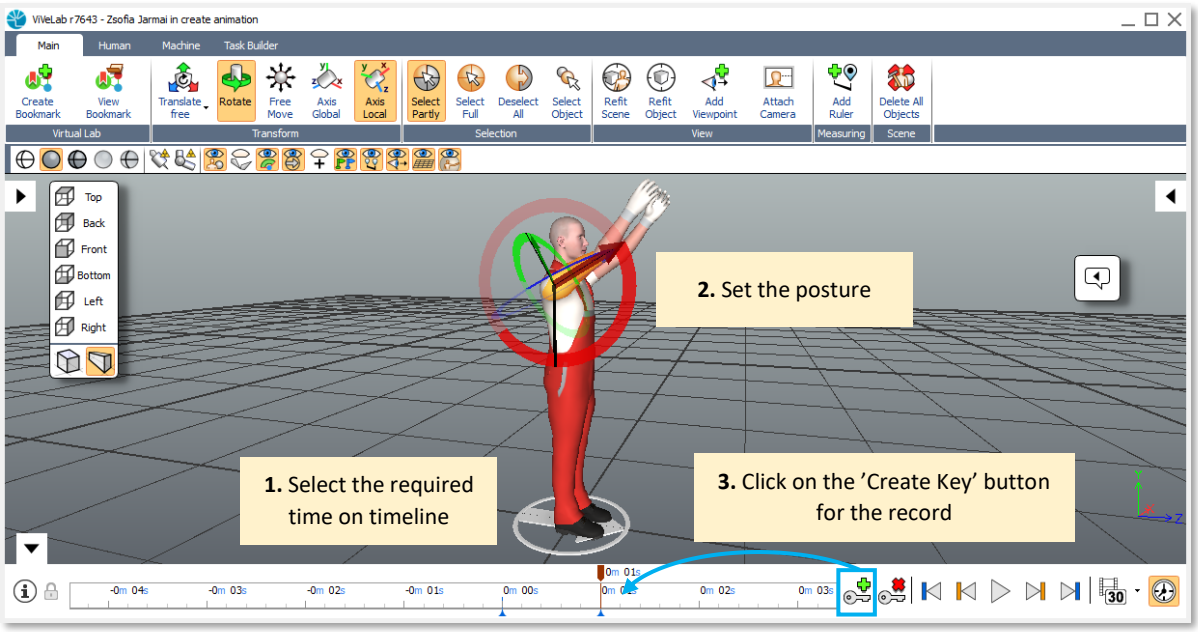
To make an animation for an object first the current time should be set to the point where a 'Key' has to be added. Please note that the changes made to the object are lost if the current time is changed before the object's state is saved by adding a 'Key'.

Let's see the animation's process of taking down a box from the upper shelf:

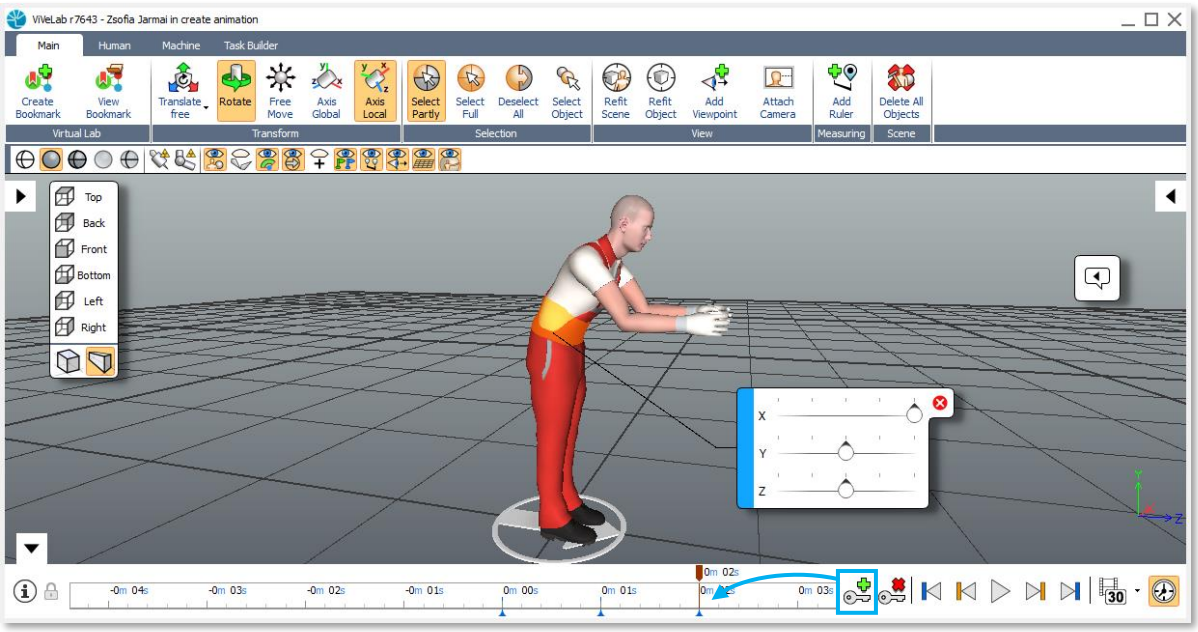
First a human character is created then its body posture is recorded on the timeline by pressing the 'Create Key' button (0sec). The created Key will appear as a blue triangle with line on the timeline.



The next time is selected (1sec) and after that the posture is set. By pressing the ‘Create Key’ button the posture is recorded.

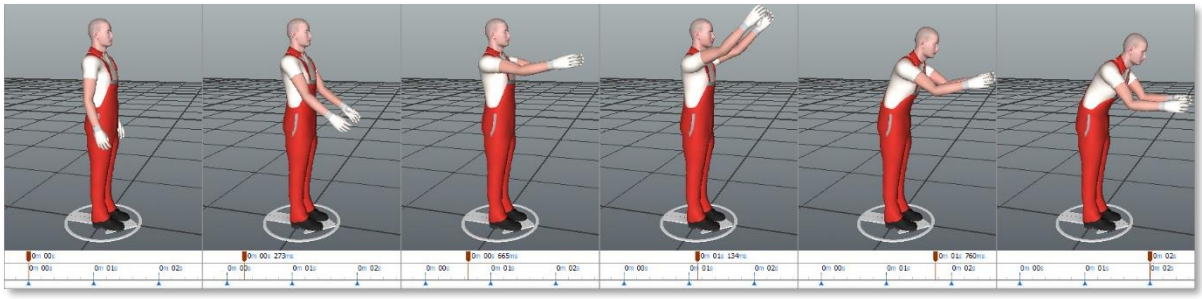


The required procedure is the same hereinafter. Body posture is recorded on the timeline by pressing the ‘Create Key’ button (2sec).

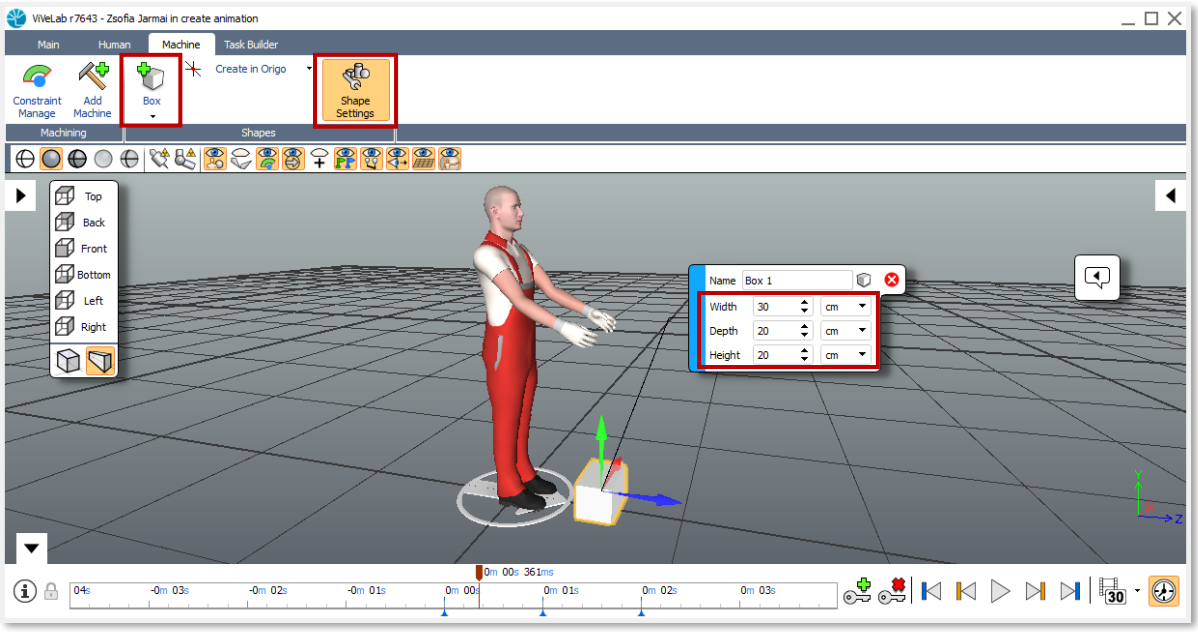


It is possible to skip to the next or previous key. The animation can be started with the play button.

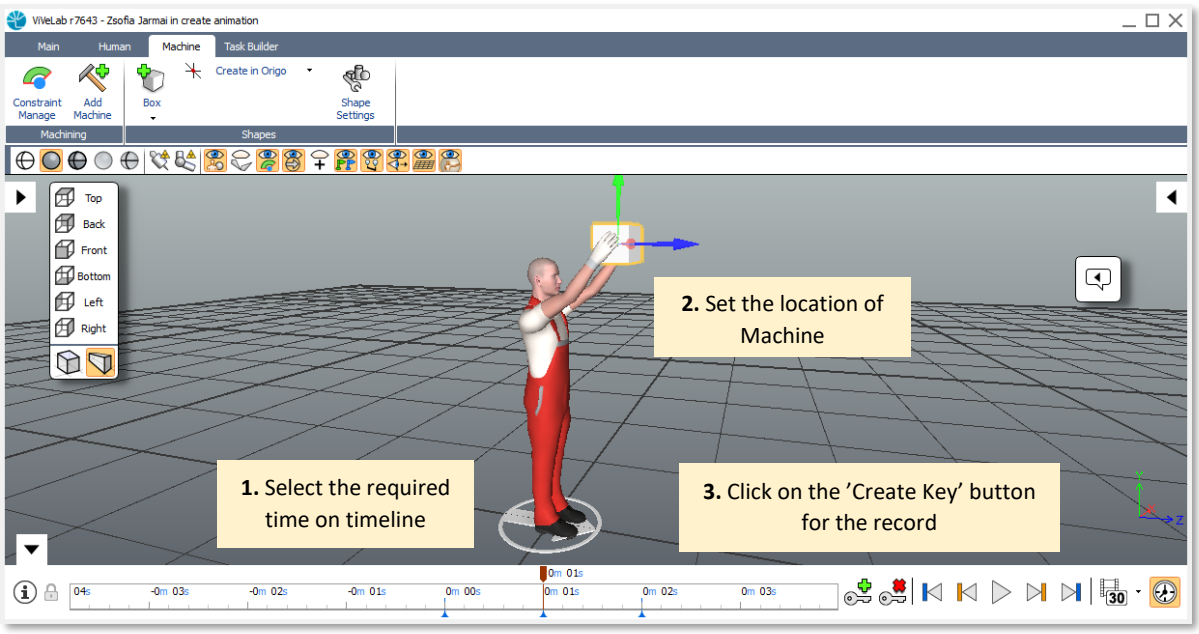
The human's movement:



When the required human's movement is built the box's movement can be recorded. A box is created and its dimensions are changed.

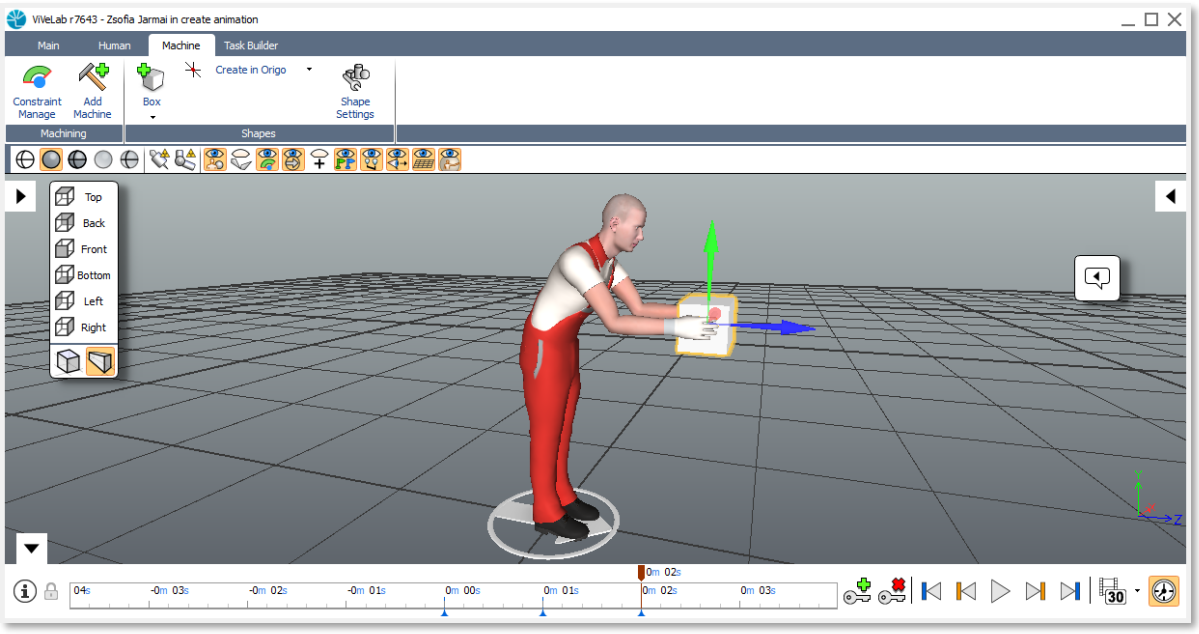


I jump to 1sec on the timeline and I set the location of box and I record it by pressing the 'Create Key'.

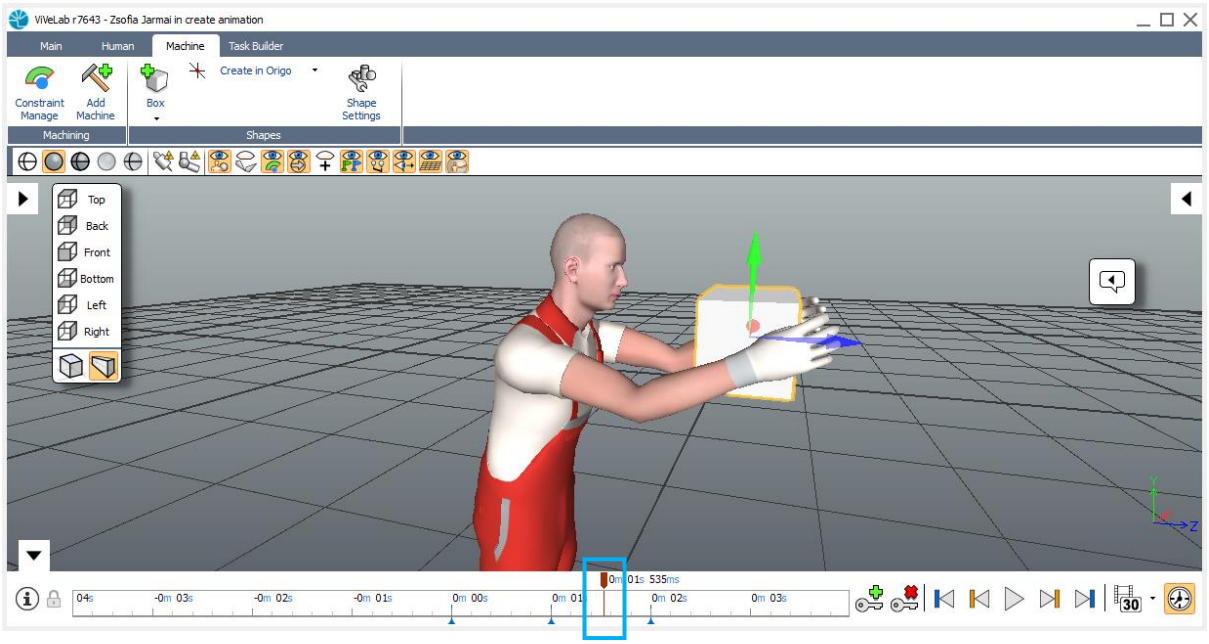


I repeat the procedure:

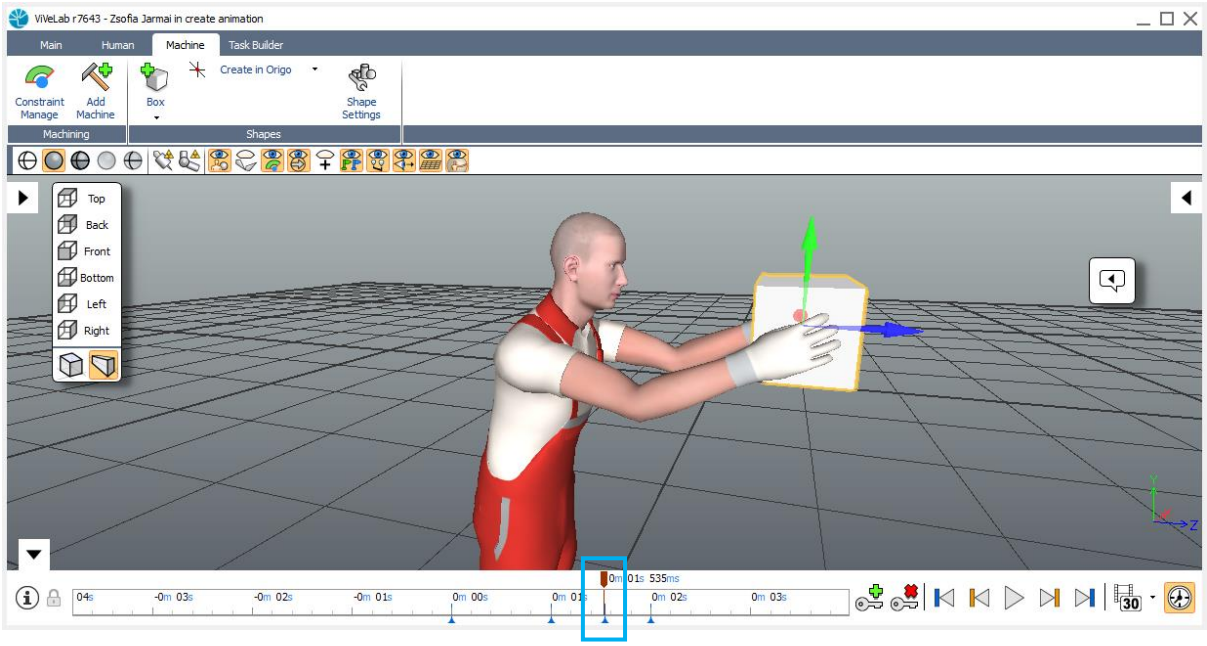
1. jump to 2sec on the timeline
2. put the box on the human's hand
3. click on the 'Create Key' button.



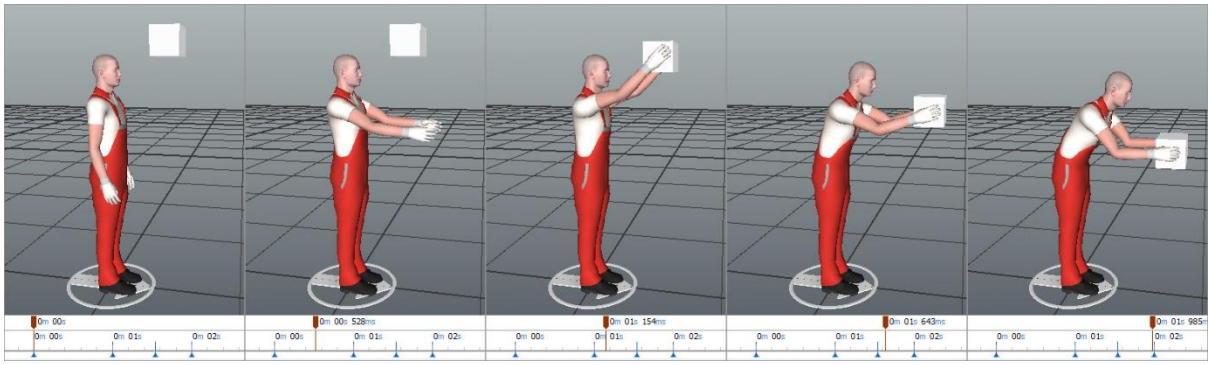
If you are not completely satisfied with the animation (for example, in this case, the box doesn't fit exactly in the human's hand between the two keys) then you can put additional keys in.



In this case select the required time on timeline, set the box to the correct position and record it by pressing the ‘Create Key’ button.



Pictures from the animation:



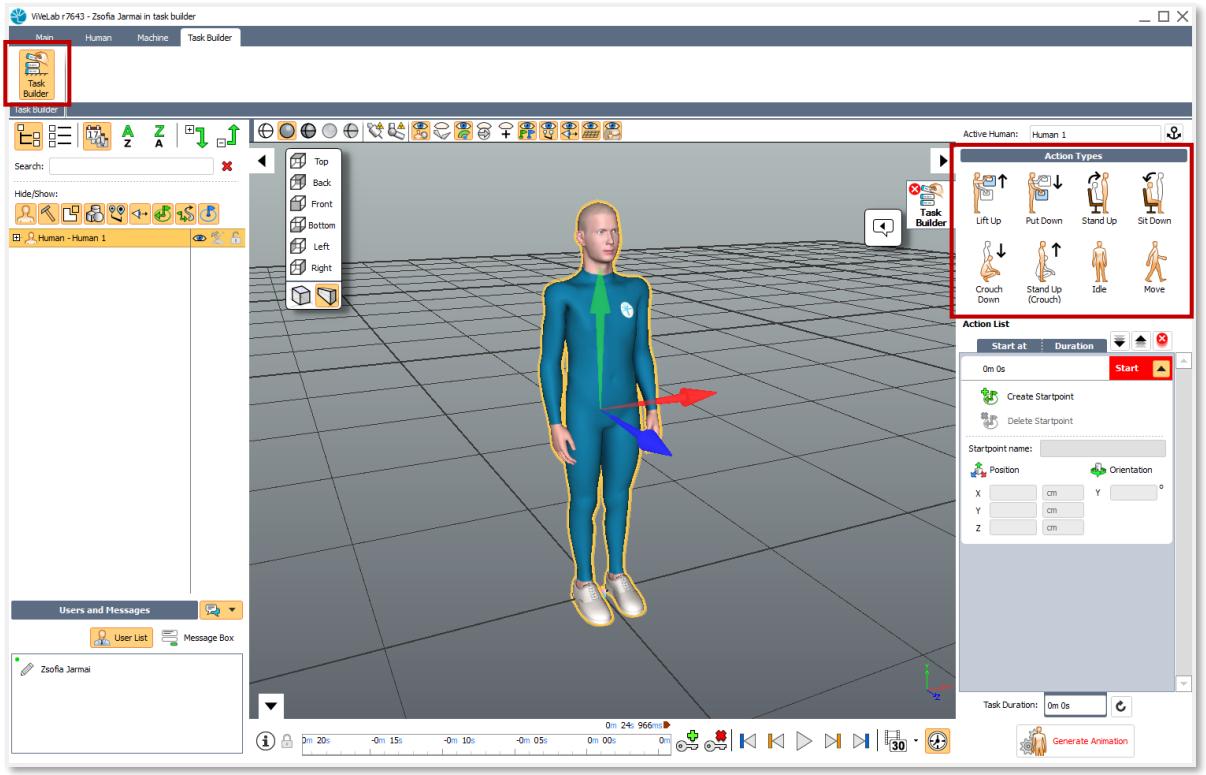
It’s important to know:

You can’t move or transfer the inserted Keys, therefore you have to think first how much time the process is (for example the process of taking down a box from the upper shelf).

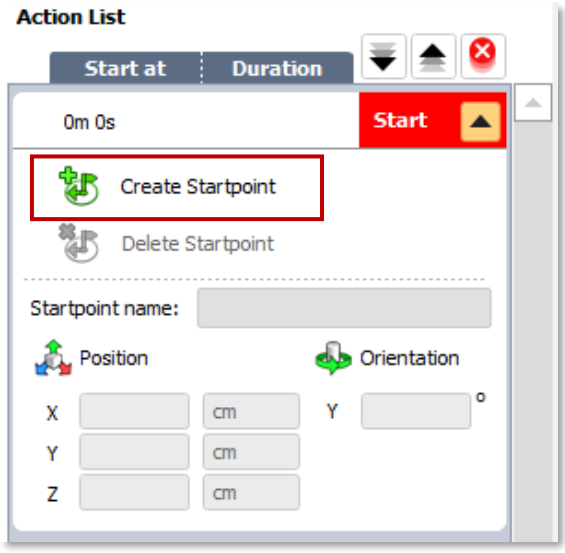
7 CREATE ANIMATION II.

The '**Task Builder**' panel is for specifying tasks for a human character and generating animation from it. Please note, that the development of the Task Builder module is in progress therefore in some cases the result will be different from the expected.

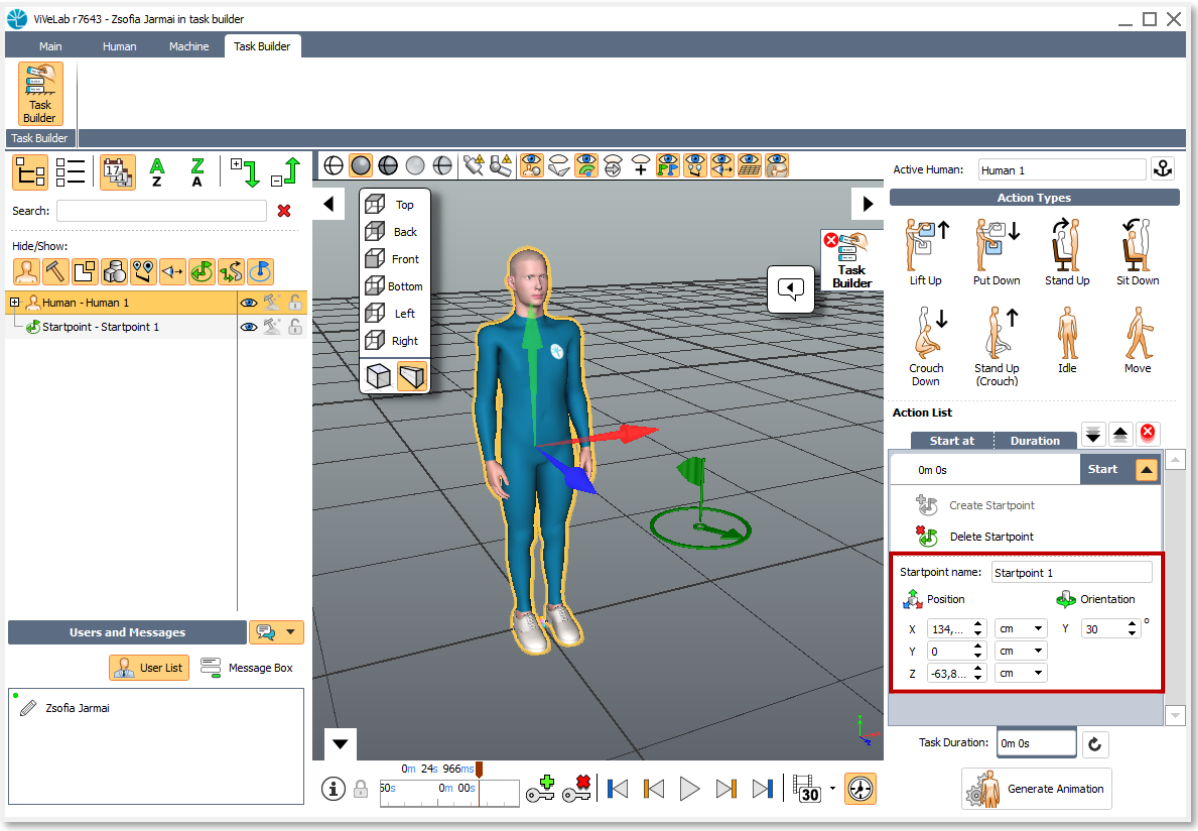
Each action type describes a generic motion which frequently occurs during manual work. The 'Lift Up', 'Put Down', 'Stand Up' and 'Sit Down' action types are unavailable yet.



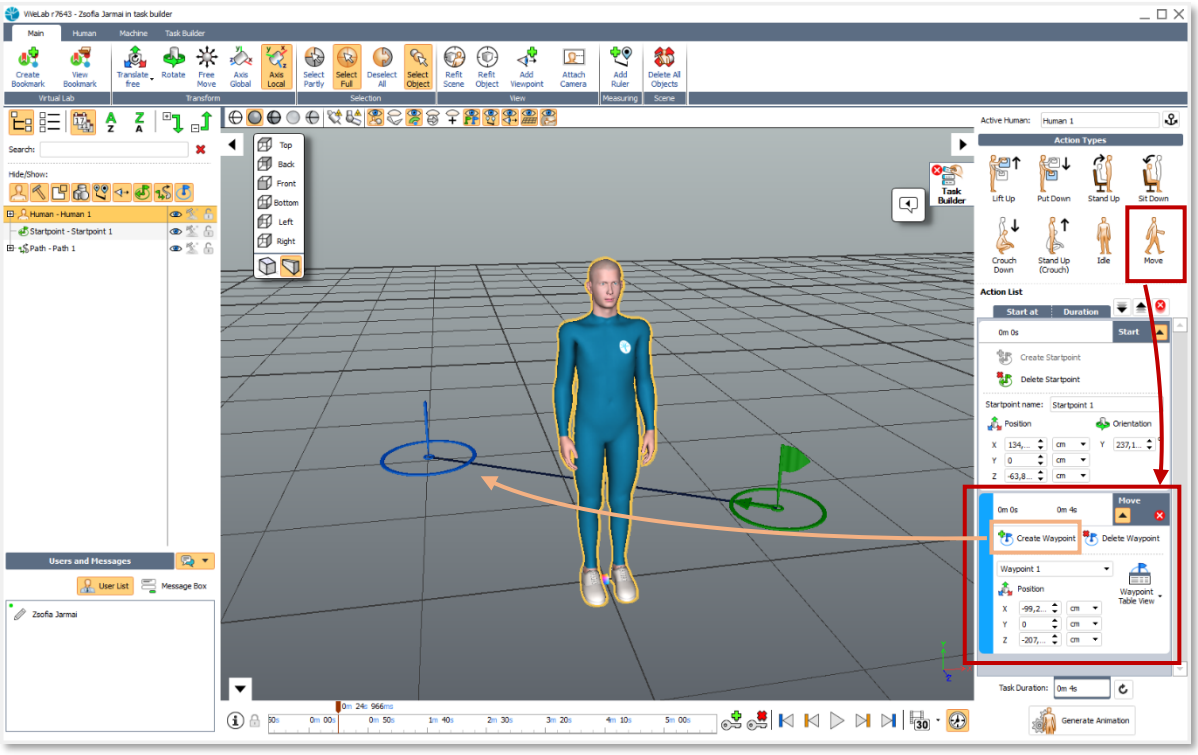
First a 'Startpoint' has to be created which marks the position of the human character at the beginning of its task. The 'Startpoint' will snap to the grid or to the surface of machines.



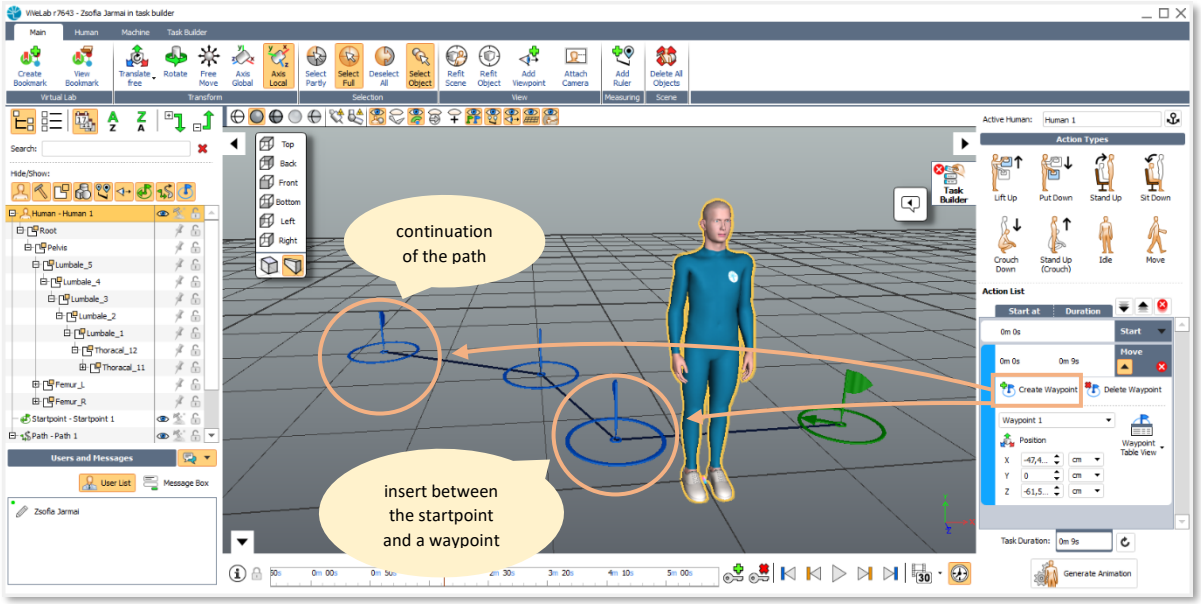
The ‘Startpoint’s orientation and position can be changed with the controls below or using the transformation modes on the main tab of the ribbon menu.



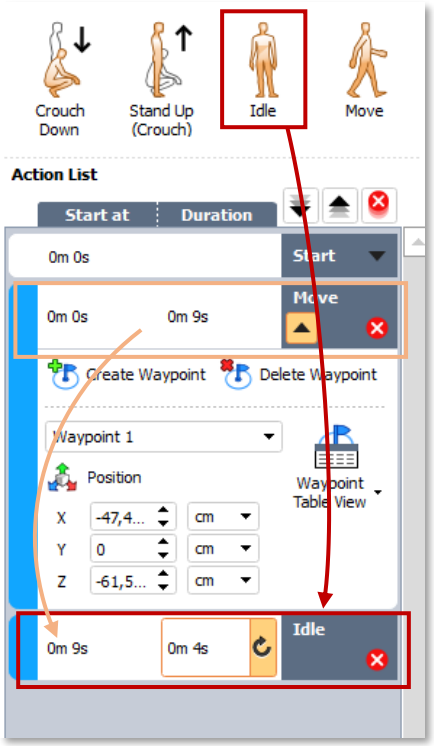
The first ‘Action Card’ to be added to the ‘Action List’ is ‘Move’. By ‘Creating Waypoints’ a path is generated that the human character will walk along during its ‘Move’ action.



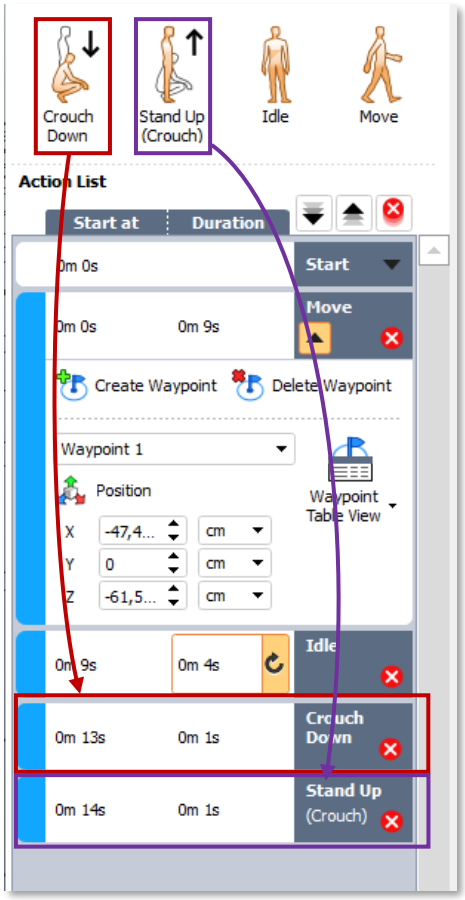
If a ‘Waypoint’ is placed closest to the last ‘Waypoint’ of the path, it will act as the continuation of the path. If a position for a new ‘Waypoint’ is picked between two previously defined ones, it will be inserted between them. The ‘Waypoints’ can be created or deleted any time.



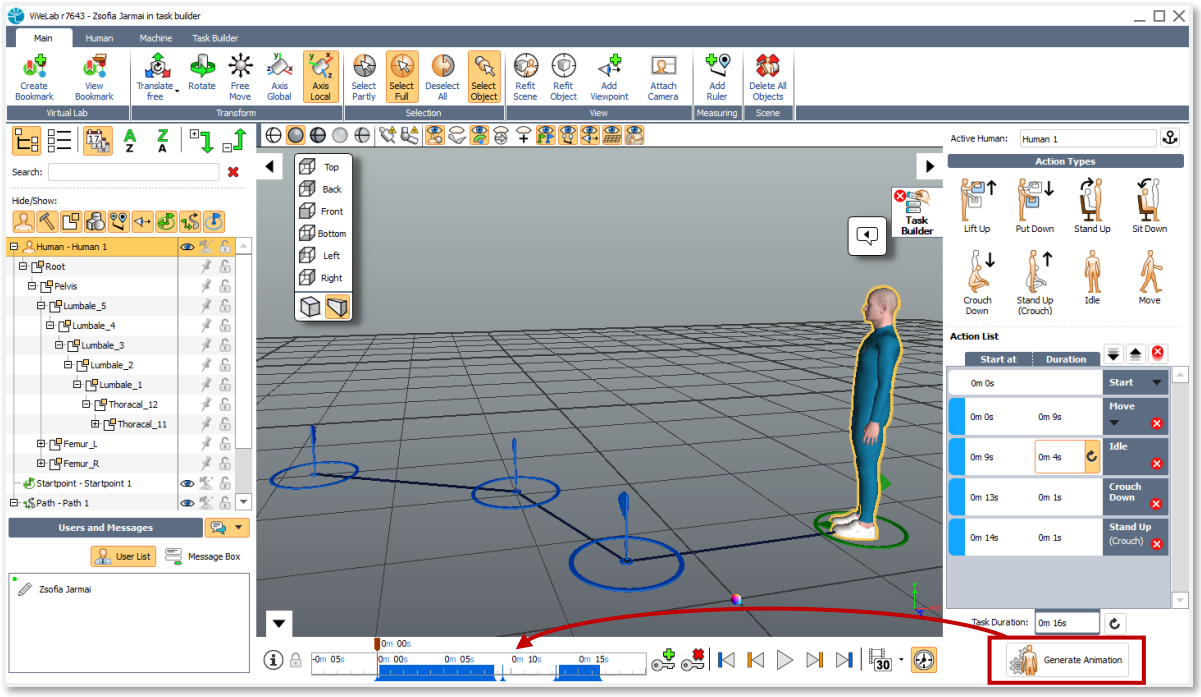
A new action card called ‘Idle’ is added to the end of the human character’s task list. In this case of this action duration is to be set. Each action starts exactly after when the previous action ends. When a duration is set explicitly, the other starting times and durations are recalculated to fit the previously given conditions.



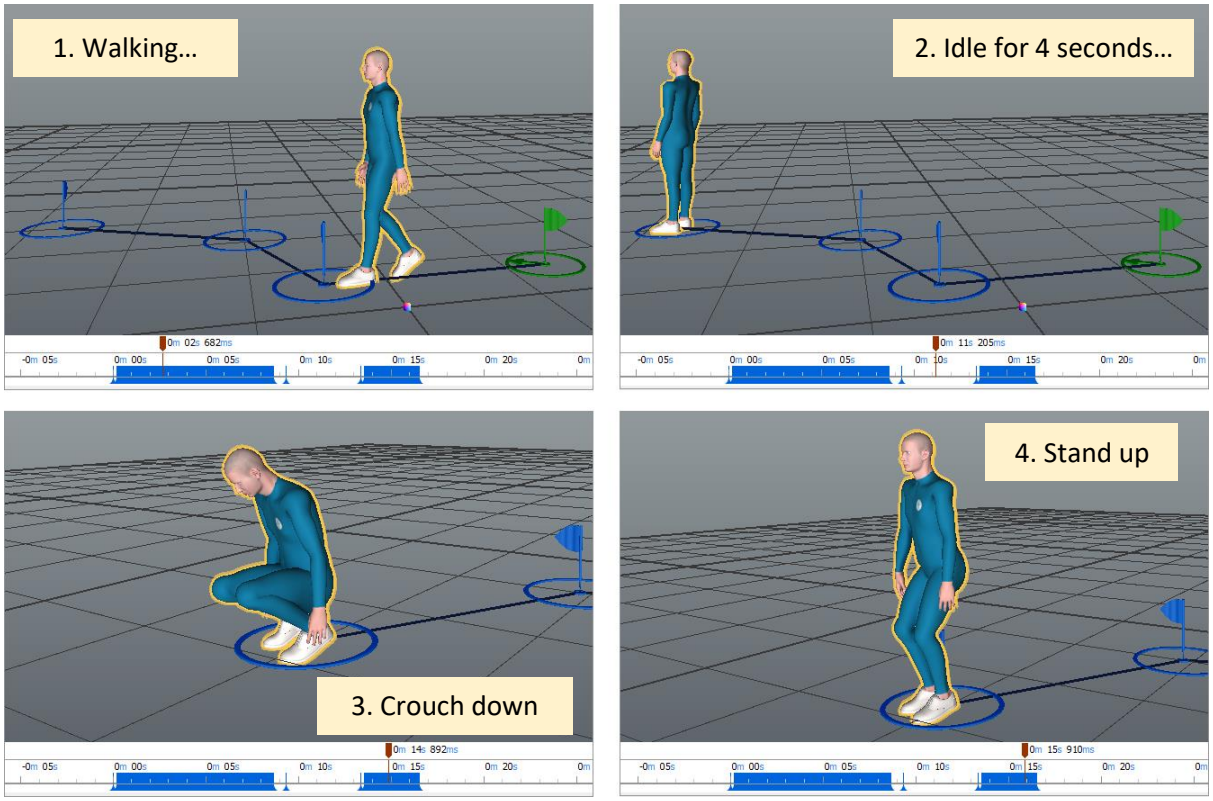
Next a ‘Crouch Down’ and a ‘Stand Up’ action card is created. Both of them last for 1 second, but you can modify the duration time.



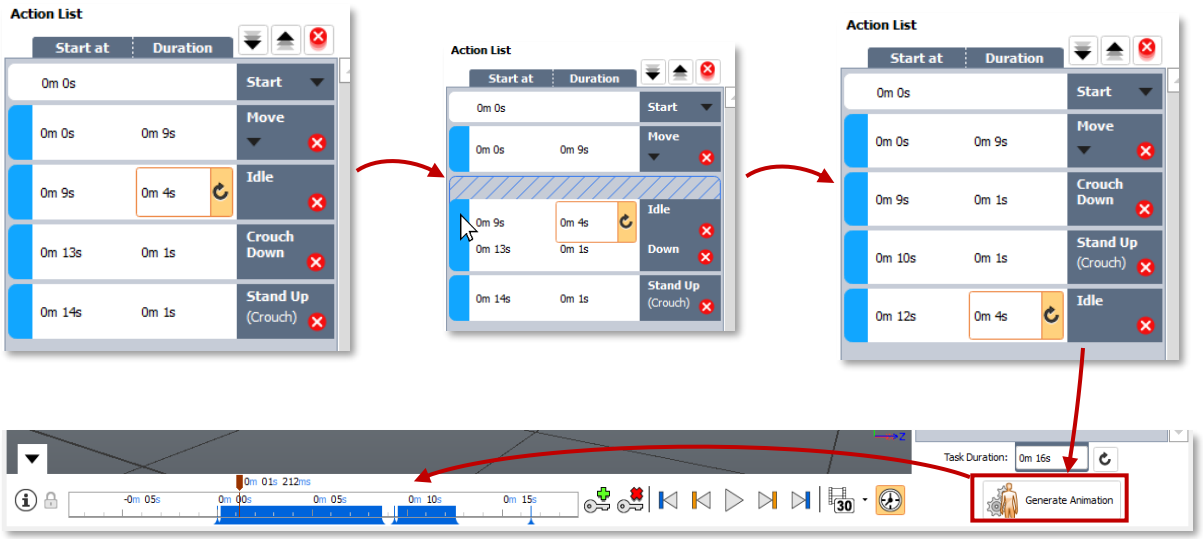
The animation is generated for the human character based on its given tasks. The keys which describe the given tasks can be seen on the timeline.



The animation is played: Walking…. Idle for 4 seconds….. Crouch Down…. And Stand Up.

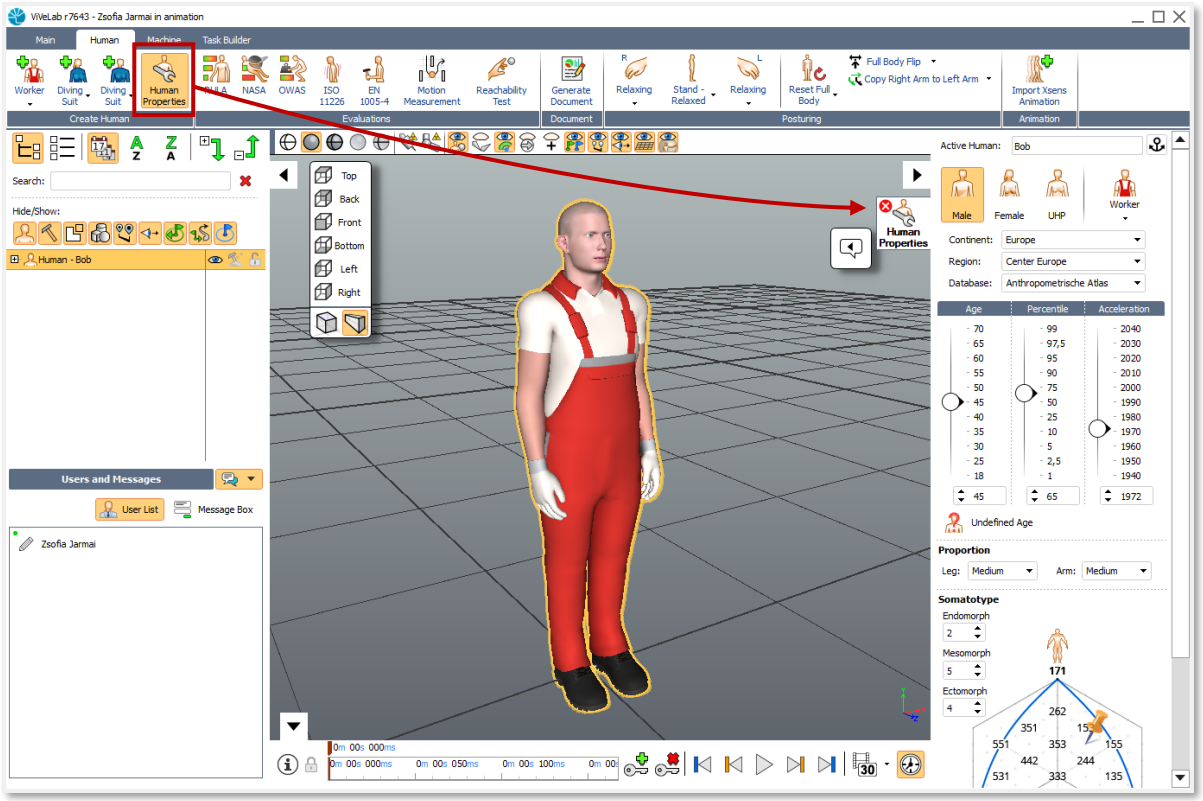


The order of actions can be changed by dragging one forward or backward in the list on its left (blue stripe) with using the left mouse button. In this case the 'Starting Times' are recalculated to fit the previously given conditions. **It's important to click on the 'Generate Animation' button again to regenerate the movement.** After that, the animation can be played: Walking…. Crouch Down…. and Stand Up……. Idle for 4 seconds.

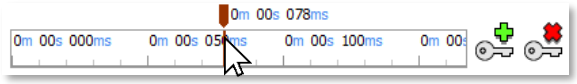


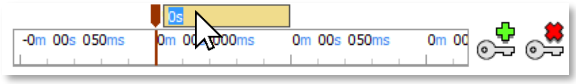
8 IMPORT ANIMATION

For creating an animation, first a human character should be created. Human properties should be defined before importing an animation. The character movement will only be realistic if it has similar body measures to the represented person.



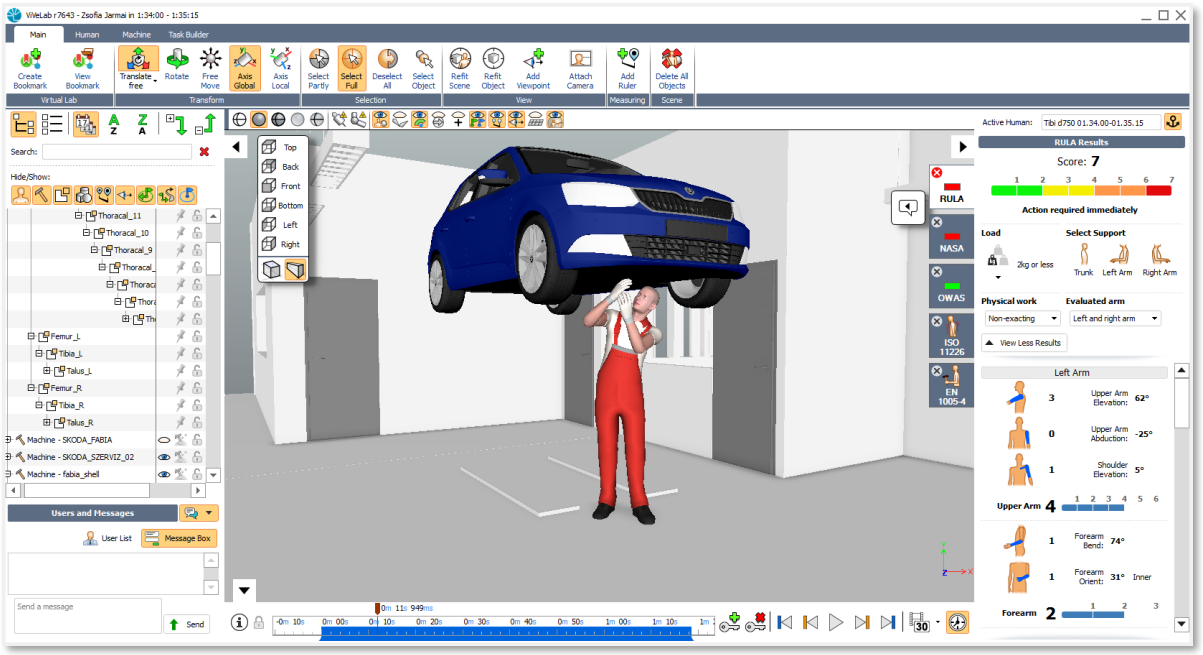
The loaded animation will start in the given trice of time on the timeline. You can set the required time by left clicking on the timeline or it is also possible to write the time into the yellow square.





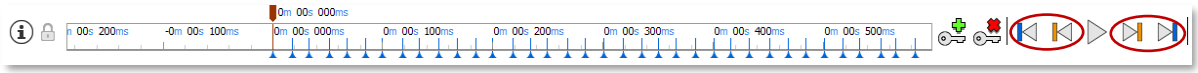
The software supports only records made by **Xsens MVM motion capture technology**. The maximum length of animation for a character is 54 000 frame. If the recording to be used is bigger than that, the captured interval should be spade (by Xsens MVM Studio) and the different parts should be loaded to separate characters. Accordingly, where the first human character stops with its animation, the following character continues with its part and so on. An animation file can be chosen by clicking the 'Open' button in the 'Xsens Files' panel. The chosen file can only be an **Xsens MVN motion capture file (.mvnx)** which can be exported from Xsens MVN Studio or an MVN file if you have a valid Xsens Animate or Analyze Pro or an XME redistributable license. To activate MVN opening feature you need to change the settings.cfg file in the Vivelab/Data folder: In the Input section set the MVNOpenDLL parameter from 'false' to 'true'. To receive the motion stream from the MVN Studio you also need to do the same.

In the following scene a car repair shop is loaded and an animation belonging to it. The whole scene can be built if the appropriate models are available. A car and the service-place layout are imported and then have to be moved so that they are aligned to the movement of the character. In any case the 'Machine' should be joined to the human character since the latter after being animated cannot be moved in the scene.

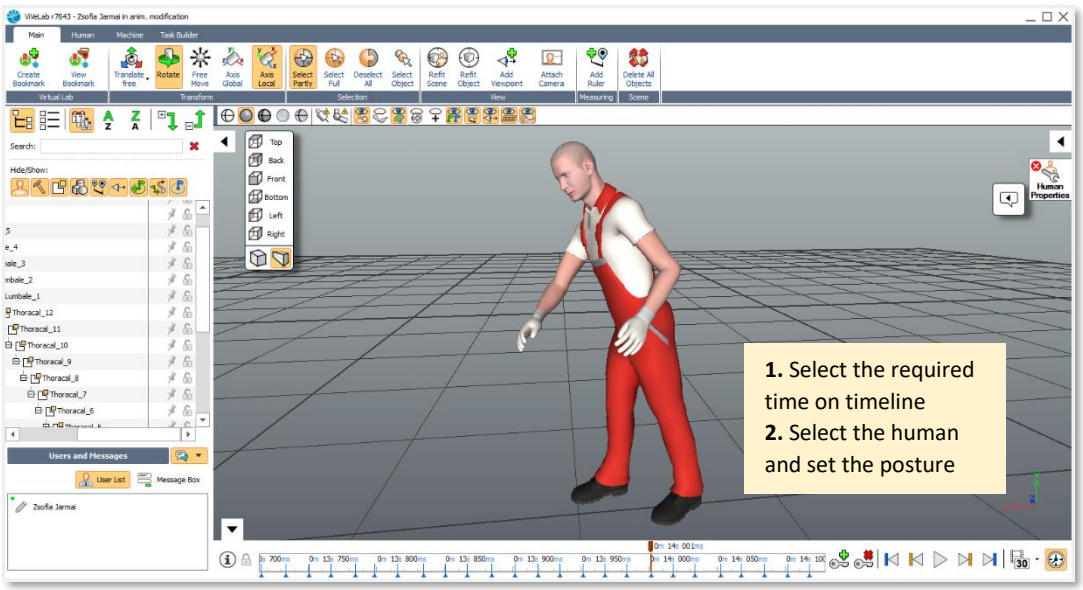


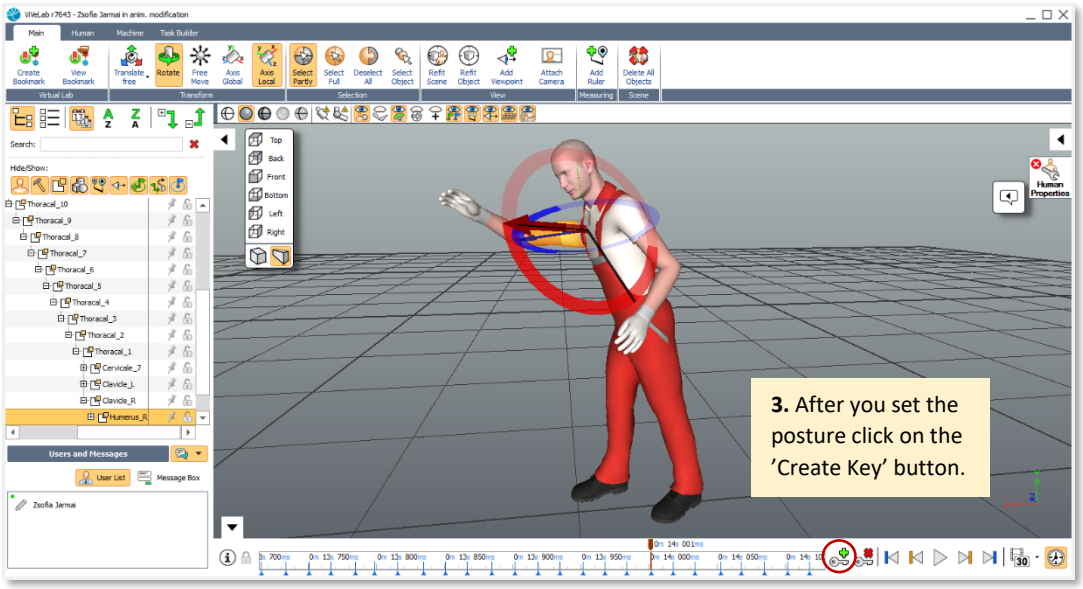
9 ANIMATION MODIFICATION

Modifying an animation in ViveLab is not easy, but it's not impossible. Zooming into the timeline we can see the 'Keys' building up the animation. It is possible to step forward and backward between these 'Keys'.



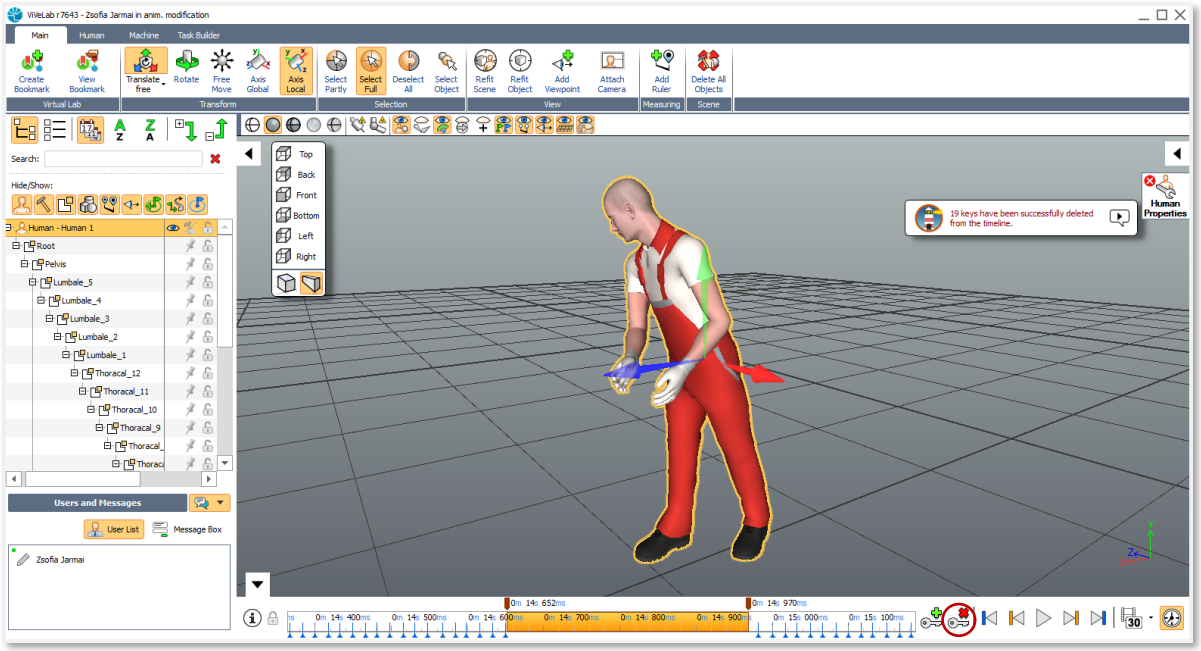
When stepping on a 'Key' the position saved by it should be changed and overwritten by the 'Create Key' command. When selecting the human character and changing the posture of the right hand, the 'Create Key' can be used to overwrite the previous settings.





All other ‘Keys’ should be changed corresponding to this pose in the interval in question if its hand should maintain the given position. Following this example all other body part positions can be changed.

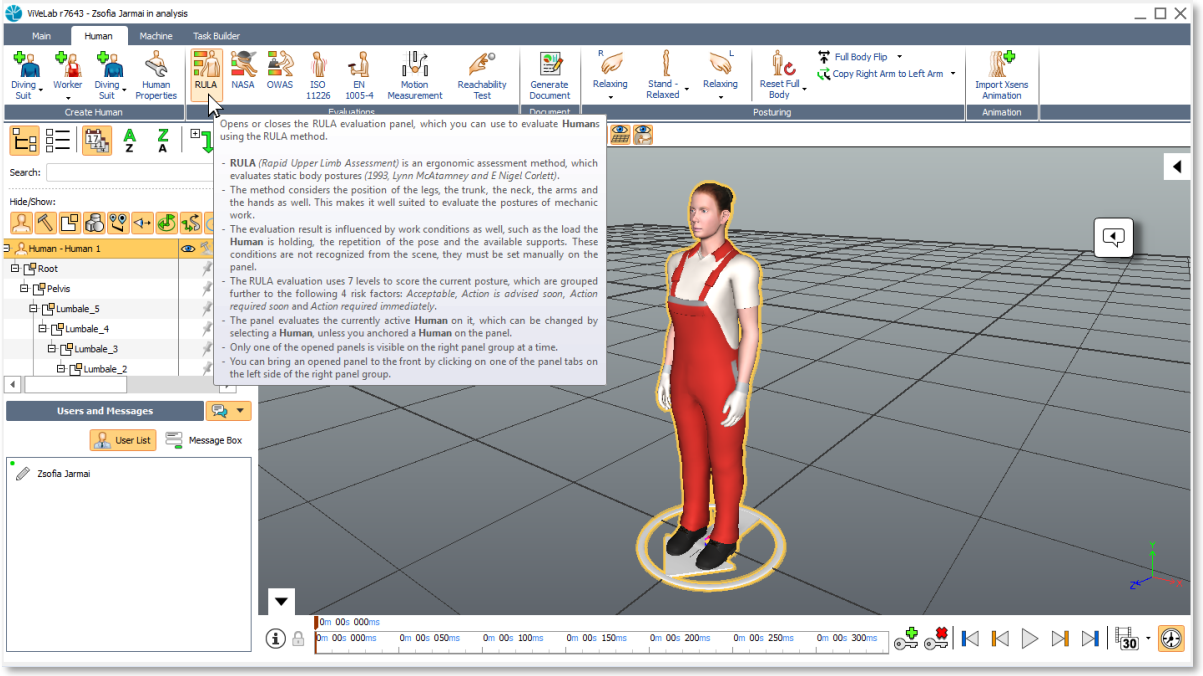
By holding ‘Shift’ button an interval and all the ‘Keys’ within can be highlighted, and also deleted by using ‘Delete Key’ command after you selected the desired Human or Machine.



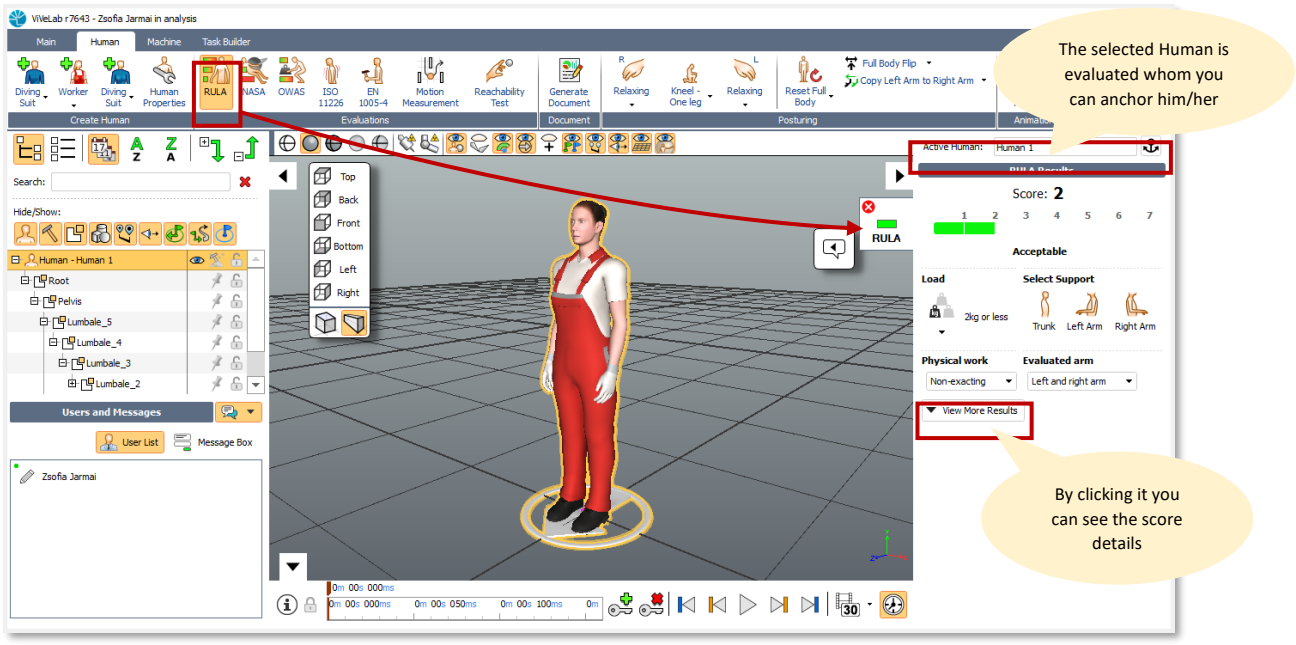
With this method the ‘Keys’ building up the animation can be thinned therefore fewer frames are needed to be modified for a change in the motion. However, be careful because too few ‘Keys’ may result in a discursive motion.

10 ANALYSIS PANEL

There are various methods that can be used for ergonomic analysis. In the ViveLab System currently the RULA, NASA, OWAS, ISO11226 and EN 1005-4 methods are available. If the cursor is hovering over one of the buttons of these methods a description of the main characteristics appears.

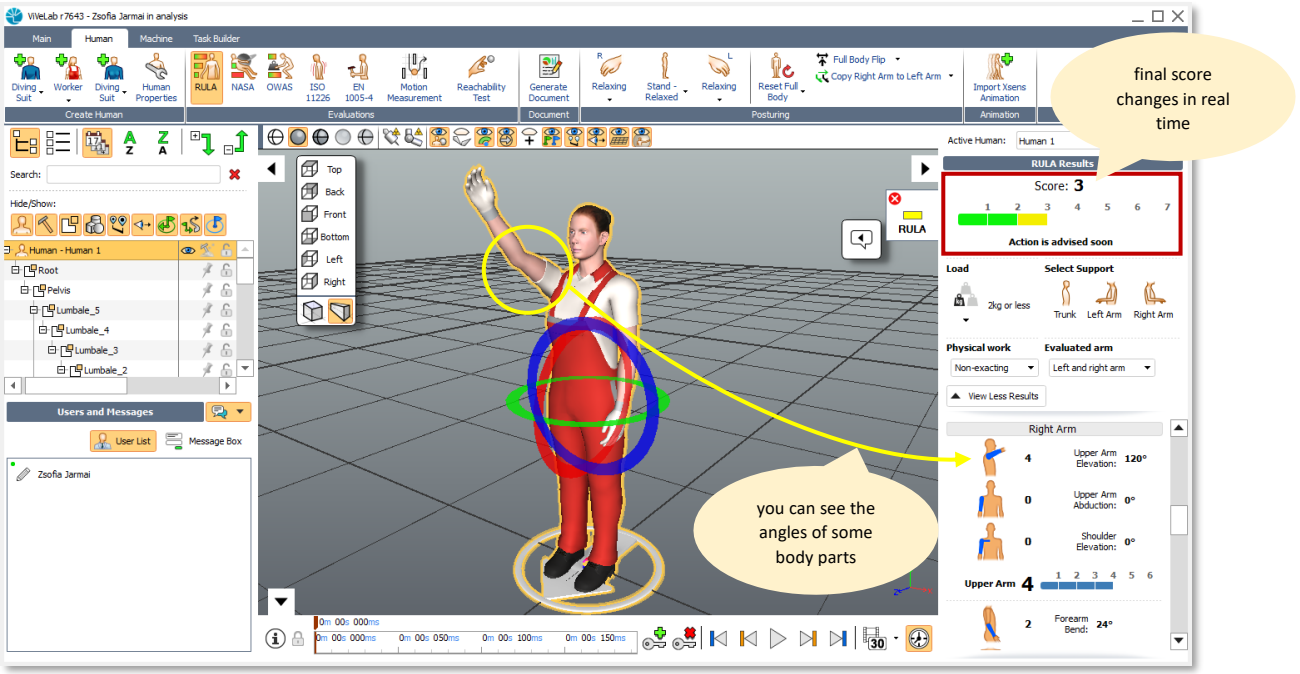


By clicking on one of the evaluation icons, the evaluation panel will open on the right side. You can show the score details by clicking 'View More Results' from which the final result is calculated. The

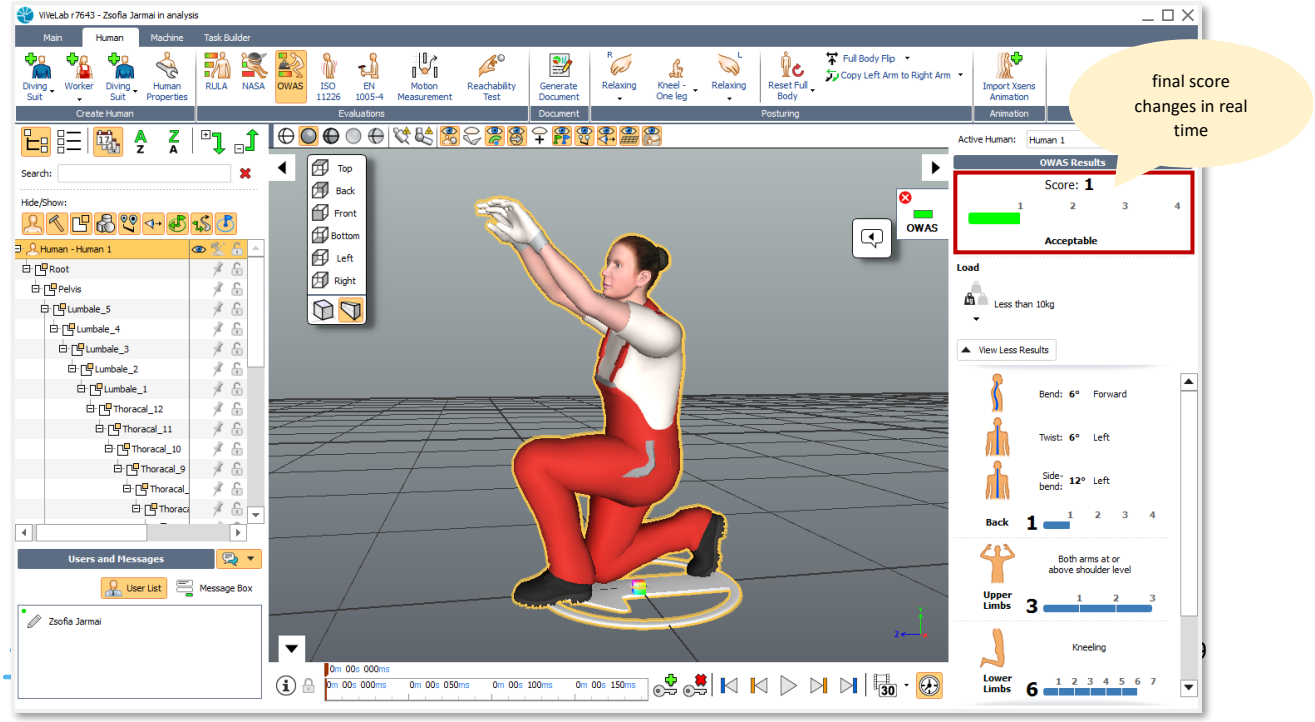


currently selected Human on the panel is evaluated except you click on the anchor icon. In this case you can keep the currently selected Human active on the panel regardless of your selection later.

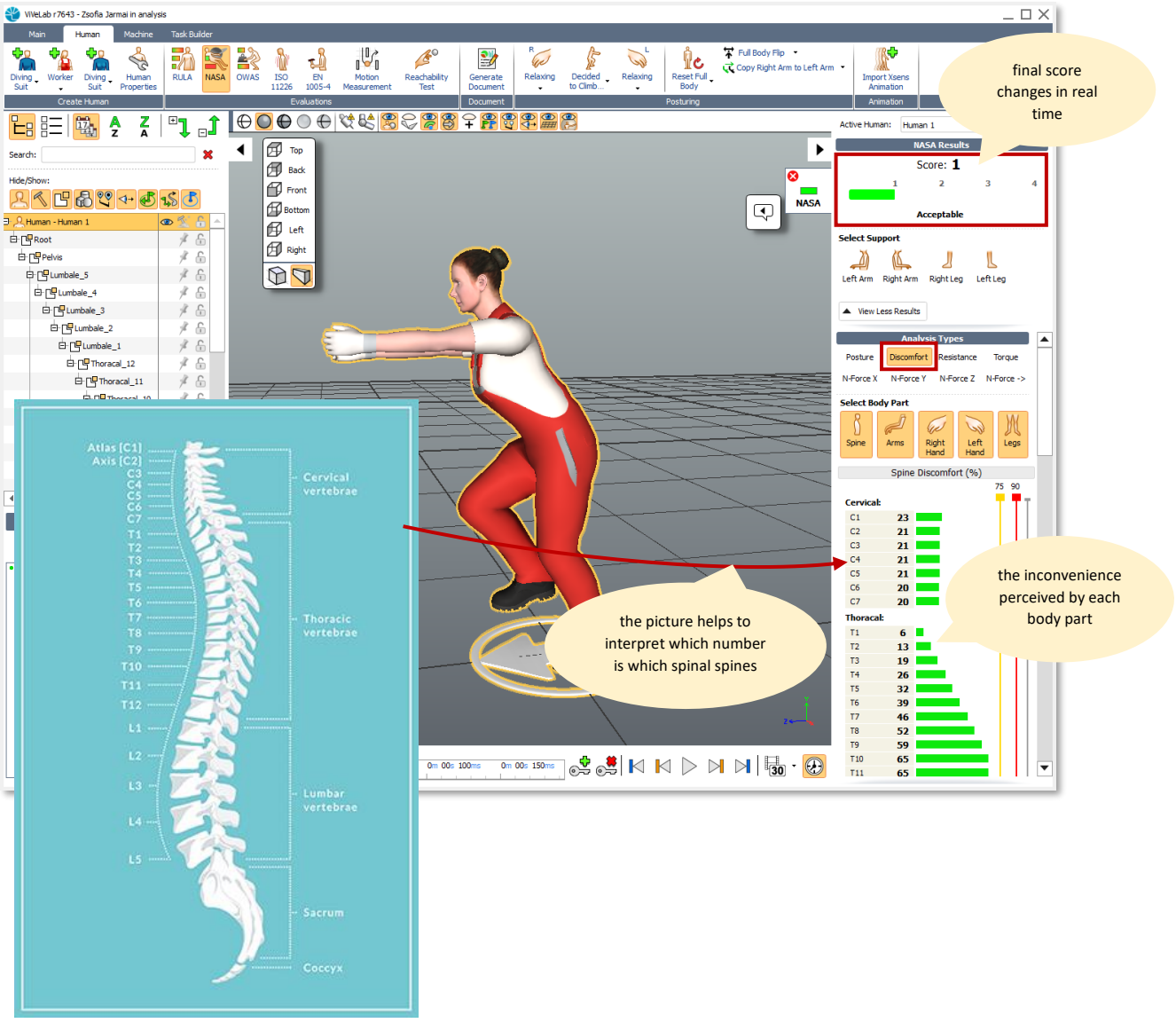
The **RULA method** evaluates the angles of the upper arm, forearm, wrist, neck and trunk, the status of the legs and the weight of the load or the exerted force. The type of load, supports and the type of physical work can be defined on the panel which all influences the final score. If the animation runs the RULA rating of the body parts and the final score changes in real time. The RULA evaluation uses 7 risk levels, which are further grouped to the following 4 risk categories: Acceptable, Action is advised soon, Action required soon, and Action required immediately.



The **OWAS method** evaluates the position of the trunk, arms and legs and takes into account the extent of load resulting in the definition of the urgency of action. The OWAS evaluation uses 4 risk levels to score the current posture: Acceptable, Action is advised soon, Action required soon, and Action required immediately.



The **NASA method** uses an advanced physical model, in which the torque and joint pressure of each bone is considered. The NASA evaluation uses 4 risk levels to score the current posture: Acceptable, Action is advised soon, Action required soon, and Action required immediately. If the animation runs the NASA rating of the body parts and the final score changes in real time. In Discomfort analysis view the inconvenience perceived by each body part is displayed in percentage.



In Posture analysis view the difference of the body parts compared to the relaxed posture is displayed in percentage. In Resistance analysis view the difference of body parts compared to the relaxed posture is displayed in percentage on the different scale. In Torque analysis view the torque required for each body part to hold the posture is displayed.

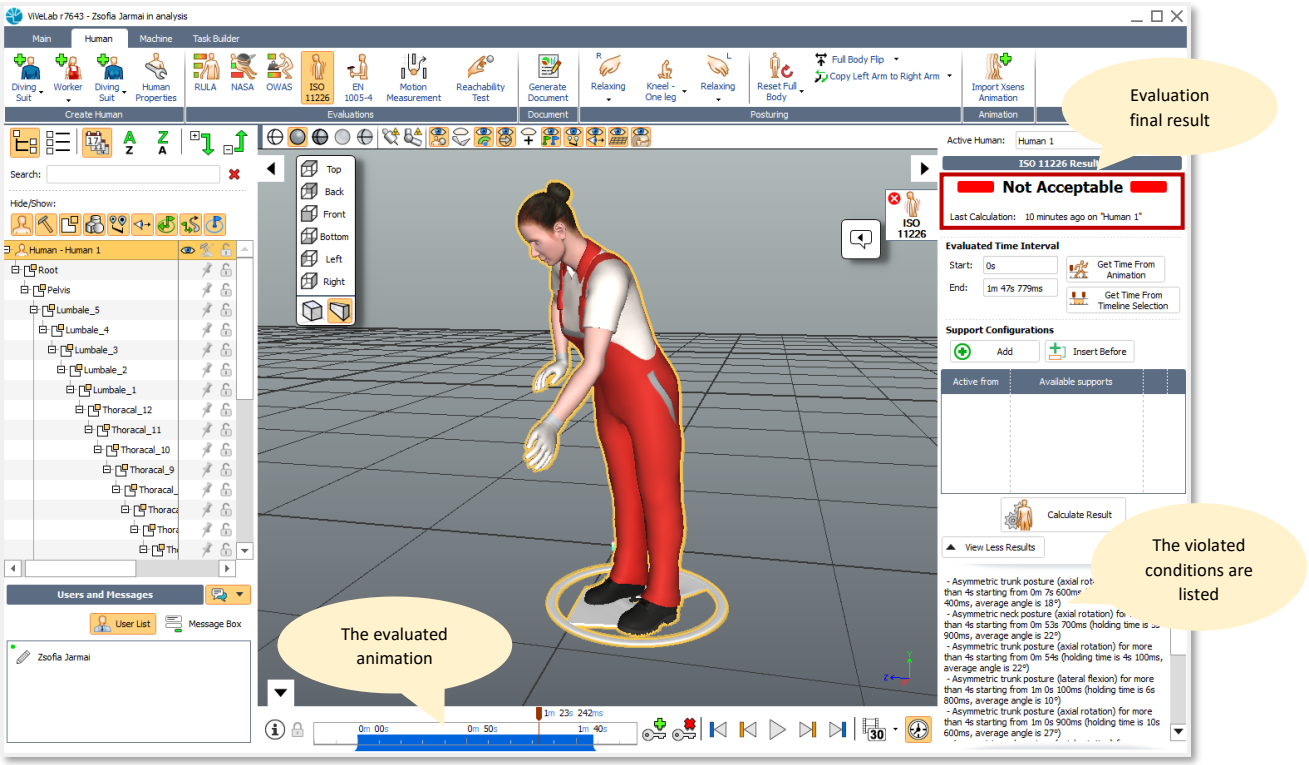
You can view the results of single or multiple body parts as well. It is possible to show the results for the parts of the spine, the arms, the hands and the legs.

The NASA method has only real time version, pdf report can't be generated.

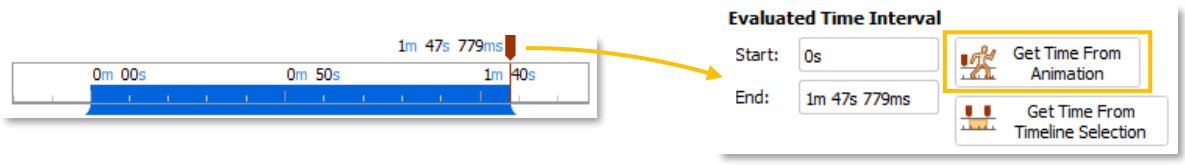
The **ISO 11226 standard** describes a method to determine the acceptability of static working postures. The standard considers the position of the body parts and the holding time of the postures as well as making it capable of evaluating an animated human character.

The ISO11226 works optimum if the imported animation is analyzed.

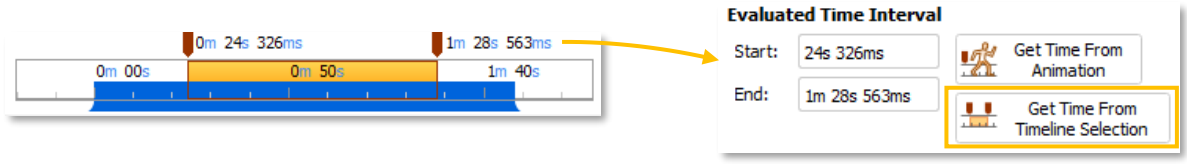
The method based on the standard evaluates the movement of the human character in a given time interval. The evaluation result is influenced by the supports available for the human, which must be set manually on its panel. The result of the ISO 11226 evaluation is either 'Acceptable' or 'Not Acceptable'. If the evaluation result is 'Not Acceptable', the violated conditions are listed on its panel.



'Get Time From Animation': The evaluated time interval based on the active Human's animation. The start and the end of evaluated time interval is set according the first and the last Key of the active Human on the timeline. By clicking the button it automatically picks up the time data.

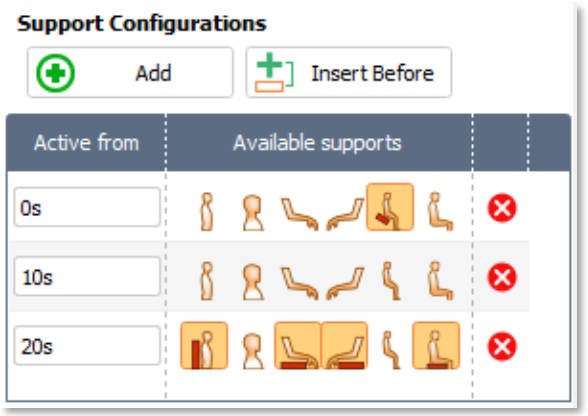


'Get Time From Timeline Selection': The evaluated time interval based on the selected time range on the timeline. You can select a time range by dragging on the timeline with left mouse button while holding Shift. By clicking the button it automatically picks up the time data.

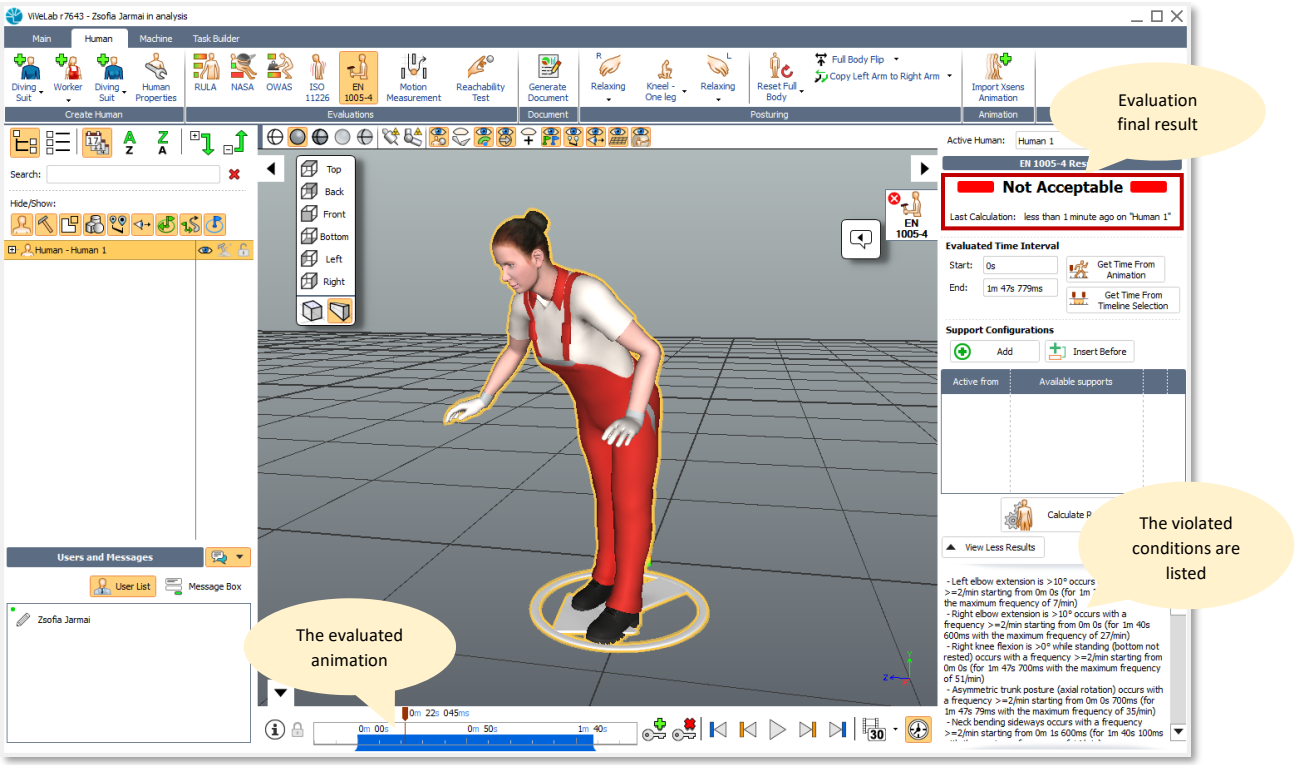


Of course you can fill the time interval manually as well using the ‘Start’ and ‘End‘ fields.

The applied support is not recognized from the scene, you must always set it manually by creating Support Configurations. A Support Configuration defines which supports are available for the Human from the specified time until the next Support Configuration or the end of the evaluation. For example: The Bottom support is active from 0sec until 10sec. There is no support from 10sec until 20sec. Trunk, left arm, right arm and sitting supports are active from 20sec until the end of animation.



The **EN 1005-4** standard considers the position of the body parts and the frequency of certain postures’ occurrence which makes it capable of evaluating an animated human character. The settings on the panel of EN1005-4 are similar to the ones of the ISO 11226 standard.

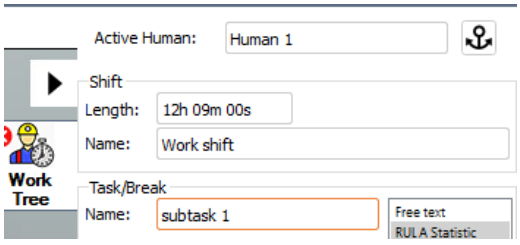


The ISO11226 and EN1005-4 standards aren't real time analyzes such as RULA, OWAS and NASA, therefore we recommend you generate pdf report from these standards using 'Generate Document' feature. The violated conditions are more readable and interpretable in pdf. (→ Chapter 11)

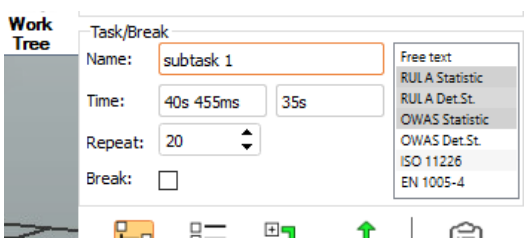
A new function of ViveLab is the **Work Tree**, in which you can define a shift's load on the employees based on the motion capture recording imported. You may divide up the shift into work tasks, subtasks, and technical actions. In the sequence of tasks and breaks, you may name all elements and define repetition characteristics. The time-interval of tasks are got from the timeline selection and their build-up structure can be followed on the right-side panel.

You can assign analyses to the tasks (work tasks, subtasks, and technical tasks as well) which appear in the Generate Document module with all attributes. When the analysis report is done the results will appear in waning order, work tasks first, subtasks follow, and technical at last.

First, you have to choose a human character. Functions and information are valid for the selected human only. You may name the shift by clicking in the box typing the name, its length is calculated from the Task information given.



A shift is a period of working time of a workday that consists of work cycles and tasks within. You may separate the created or imported motion sequence into tasks, subtasks, and technical actions. These levels appear in the work-tree as you define it by a timeline selection or by giving the starting time and the length. When you fill the 'Repeat' box you should write the number of repetitions per shift. And if you thick 'Break' the task is turned into a break of the given length. In the Task/Break section, you may choose the analysis

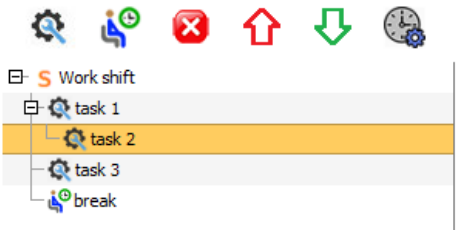


methods for the given task. The analysis methods clicked will appear in the 'Generate Document' module after clicking the last ikon of the following row. Its role is to send information to the documentation. You should click on it for updating any case you made a change.

You may change the appearance of the work-tree in the next section. You may choose from tree-view, list-view, expand all, and collapse all.

You can search for tasks by writing in the 'Search' box, results will temporarily replace the work-tree.

The next row of ikons serves for creating, erasing tasks, changing their display order. With the clock ikon at the end, time data is taken from the timeline selection. You may add tasks and breaks to the shift. While tasks may have subjected actions, breaks don't. The new tasks are subjected to the highlighted shift or task.

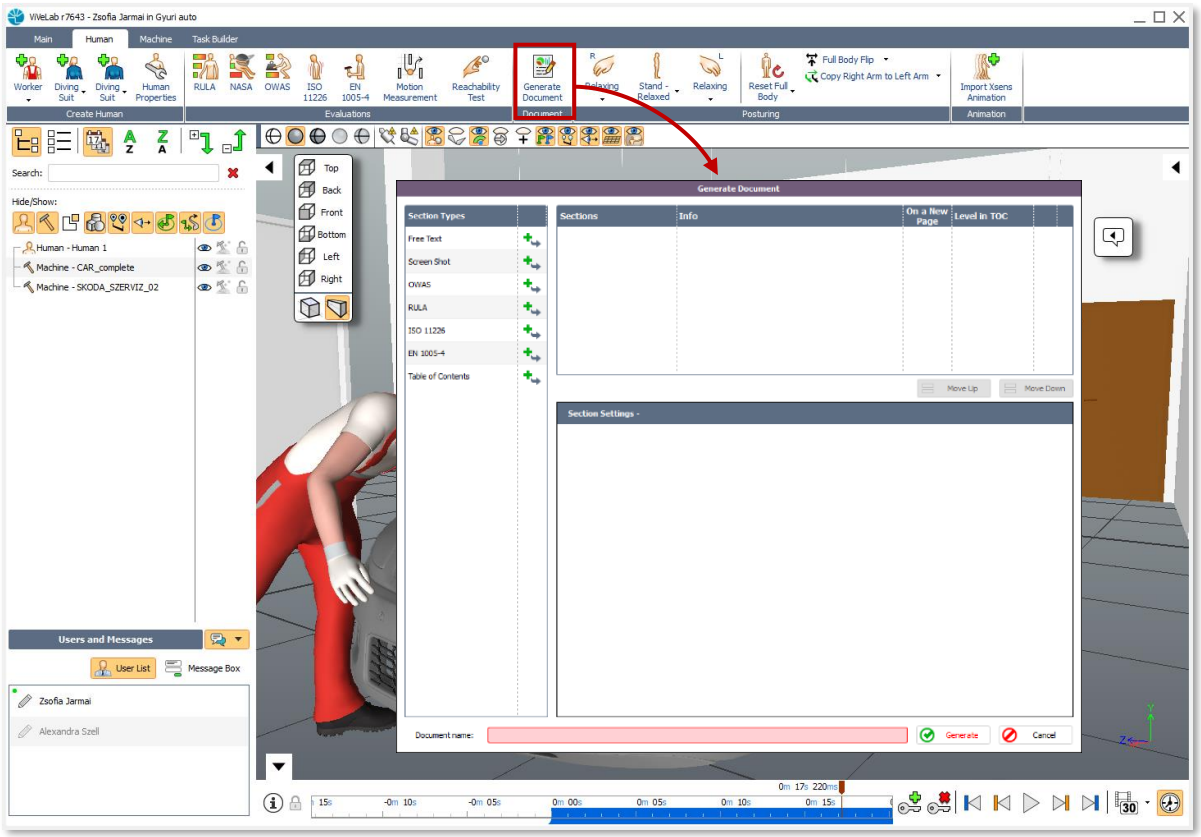


Using the work-tree module motions and work processes can be divided for more intricate analysis.

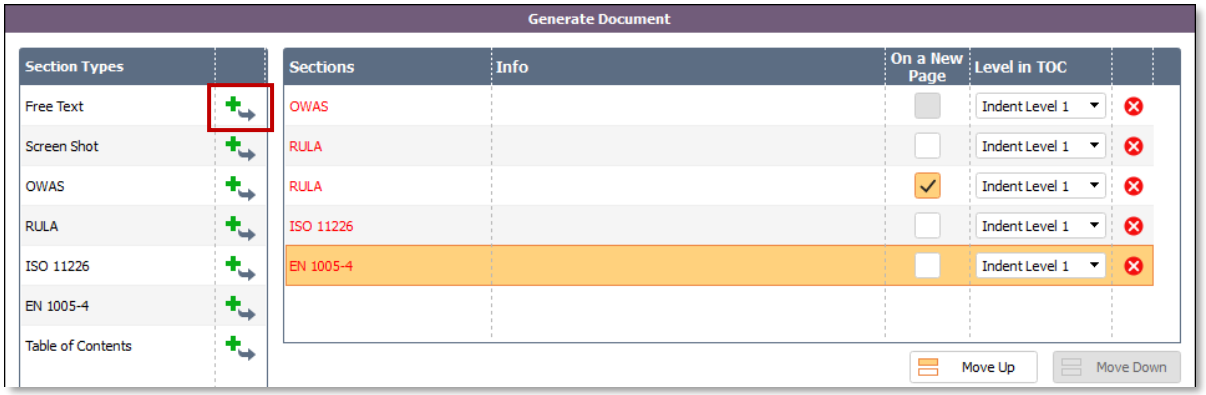
11 EXPORT ANALYSIS REPORT

First, we need a human and an animation which we can evaluate using ergonomic analyzes. This animation can be imported or made by ourselves. In the example, a car repair scene will be evaluated. Pictures are shown from the animation below: the character walks to the car, bends over the engine compartment, walks to the other side of the car, bends over again and stops straight next to the car. The animation lasts for 22 seconds.

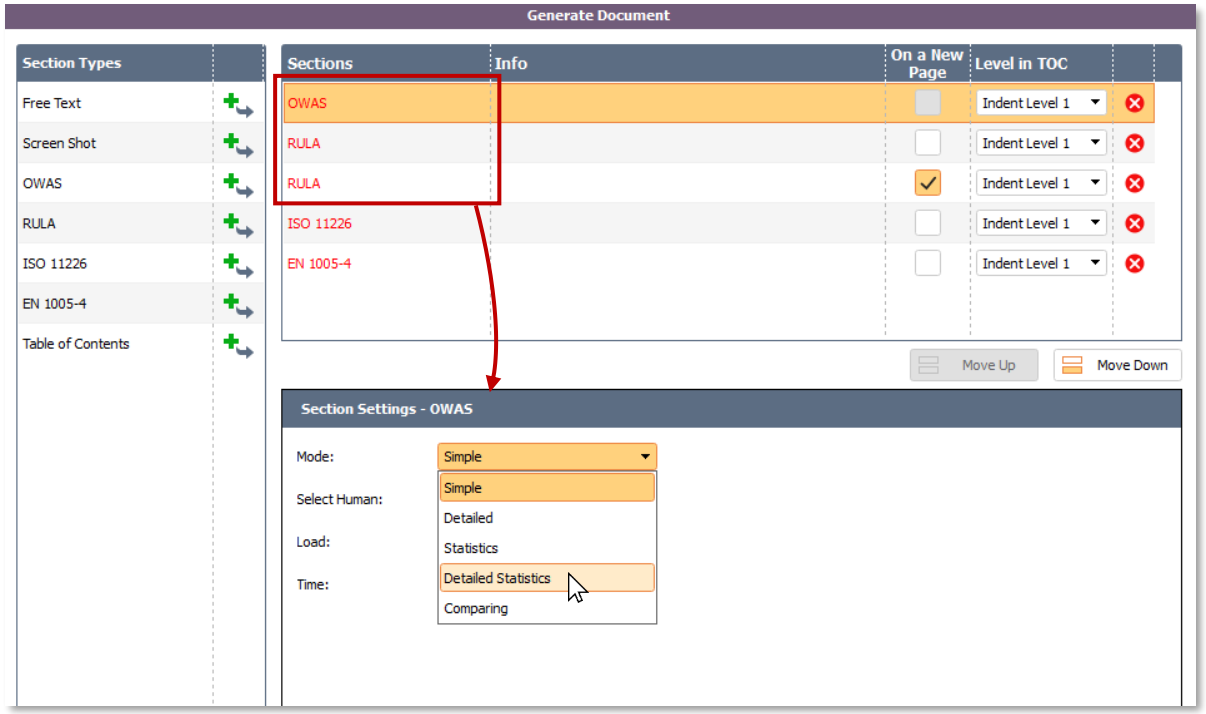
By clicking '**Generate Document**', the methods can be selected from which a pdf file will be generated and pictures can be made to the documentation.



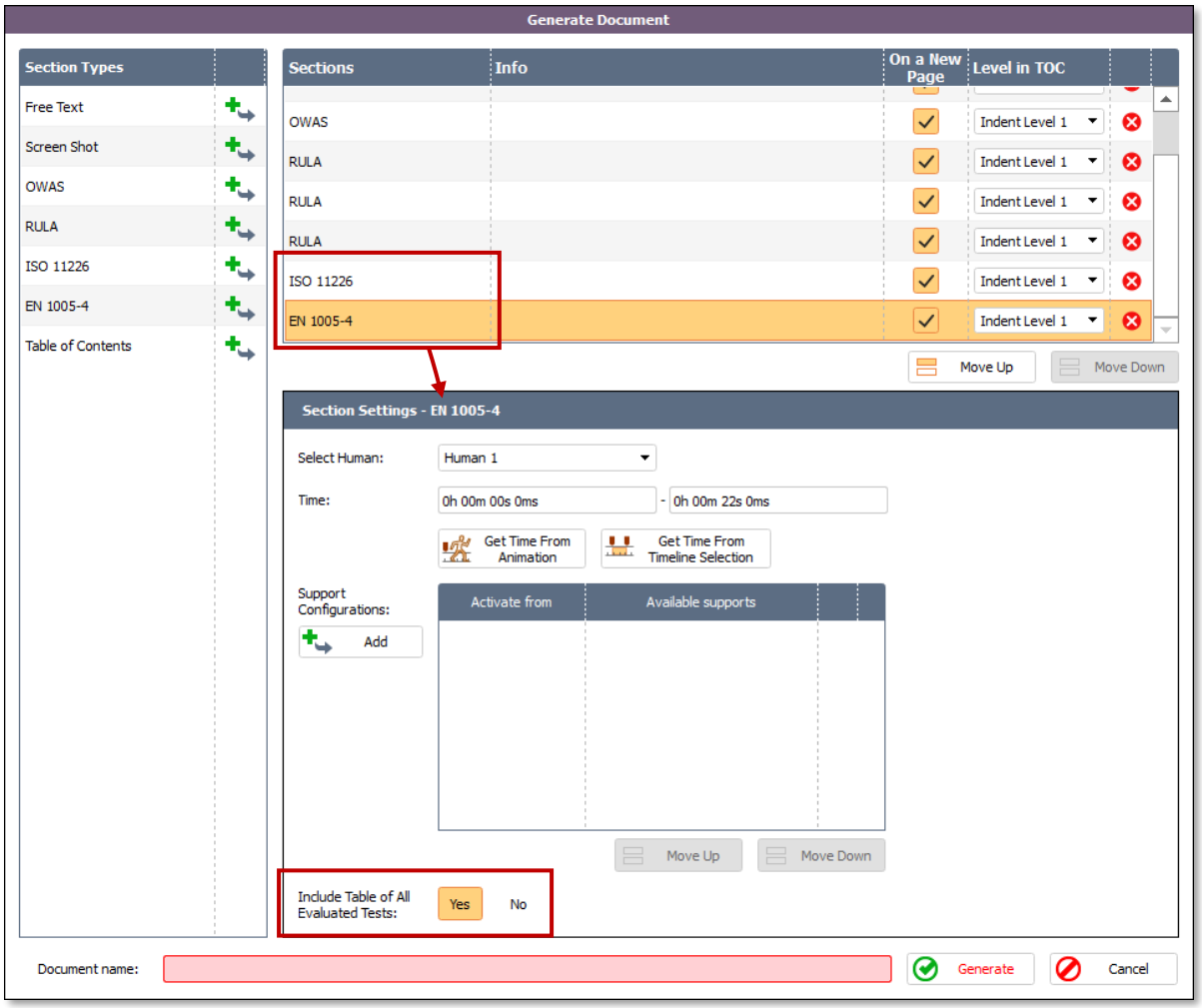
You can choose from several ‘Selection Types’ from the left side of the ‘Generate Document’ Panel. If you click the ‘Add New Section’ icon, the new Section is added to the list. You can add multiple Sections of the same type. You can change the order of the Sections any time, with the ‘Move up’ and ‘Move Down’ buttons. If you check the ‘On a New Page’ the Section will start on a new page in the generated document. The added Sections’ names are red until the details aren’t set.



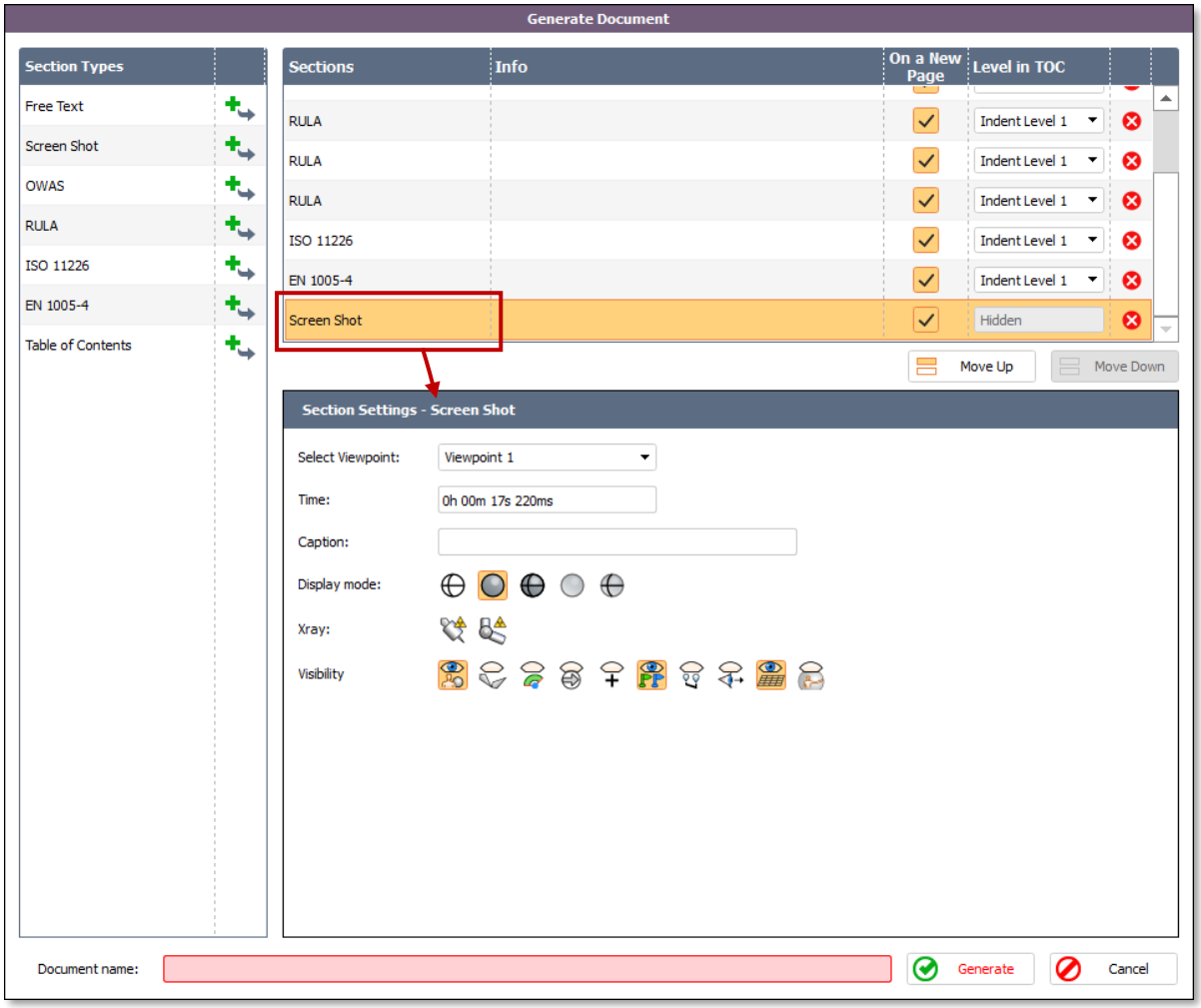
For the different methods variant setting options are offered by the software. In RULA and OWAS ‘Simple’ and ‘Detailed’ options give results for the posture in the given time. For ‘Statistics’ and ‘Detailed Statistics’ a given interval is needed for getting statistical analysis of postures and movement.



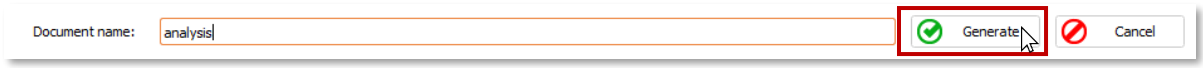
With the use of ISO11226 and EN1005-4 wrong postures are strained of the motion sequence therefore a time interval should be given in 'Time' box to perform the analysis. If 'Include table of all evaluated tests' is active than all wrong postures (based on these two methods) will appear in the pdf documentation.



To include a picture in the documentation a '**Screen Shot**' should be chosen and in its submenu it can be seen that a 'Viewpoint' and a trice of time is needed to be given. A 'Viewpoint' can be created by using the 'Add Viewpoint' function in the 'MAIN' menu (→ Chapter 15). A trice of time is chosen on the timeline then copied by using 'Ctrl+C'. The picture can be added with opening the 'Generate Document' window and adding the viewpoint that was created there previously and pasting in the given time using Ctrl+V.



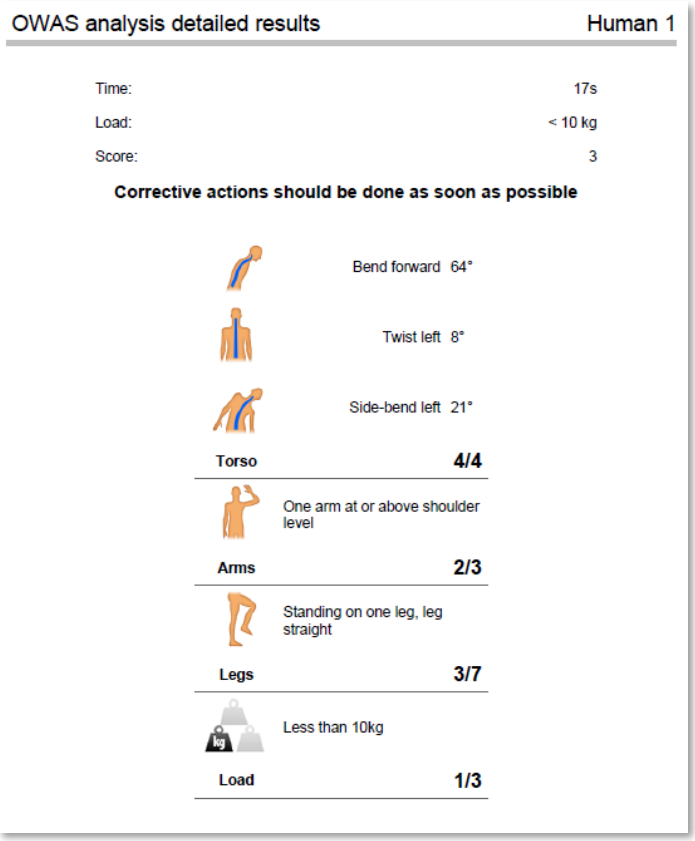
A document in progress should be named at the bottom of the table.



I generated a document about OWAS Detailed, OWAS Statistics, OWAS Detailed Statistics, RULA Detailed, RULA Statistics, RULA Detailed Statistics, ISO11226, EN1005-4 and a Screen shot.

After clicking 'Generate' the **pdf document is available in the 'Documents' block of ViveLab.**

On the first page, the **OWAS method's 'Detailed'** analysis can be seen evaluating the posture in the given time (17s). The subject was exposed to less than 10kg load. The evaluation score is 3, which means corrective actions should be done as soon as possible. You can see in the table below the partial points of the body parts. The back got score 4 out of 4 which is derived from the angular values, the arm got score 2 out of 3 because one is arm at or above shoulder level, the legs got score 3 out of 7 because the character is standing on one straight leg and the score for load is 1 out of 3.



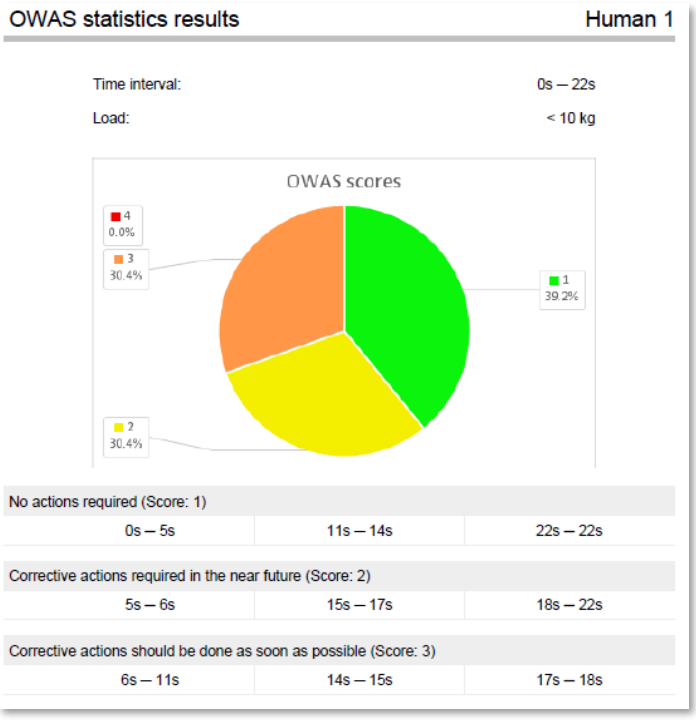
OWAS analysis detailed results — Human 1

Time:	17s
Load:	< 10 kg
Score:	3

Corrective actions should be done as soon as possible

Bend forward 64°	
Twist left 8°	
Side-bend left 21°	
Torso	**4/4**
One arm at or above shoulder level	
Arms	**2/3**
Standing on one leg, leg straight	
Legs	**3/7**
Less than 10kg	
Load	**1/3**

In **OWAS 'Statistics'** you can find a pie chart evaluating all movements in the given interval (0s-22s), 1 indicating the acceptable postures and 4 the ones that need to be changed immediately. We can see in the table under the pie chart which moment gets which score, thus in ViveLab we can easily look at these listed time intervals, hereby the reasons of the crucial postures can be seen.

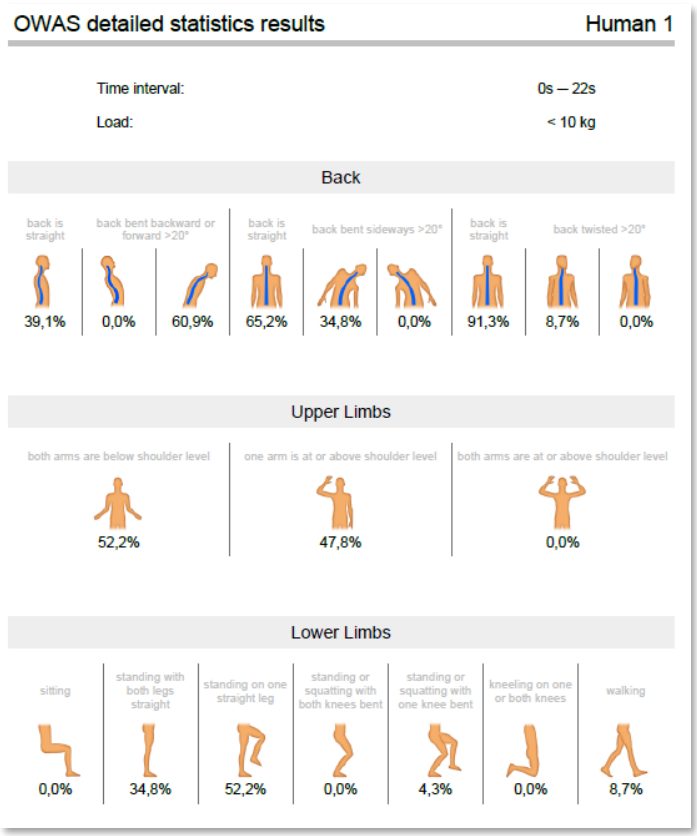


OWAS statistics results — Human 1

Time interval:	0s – 22s
Load:	< 10 kg

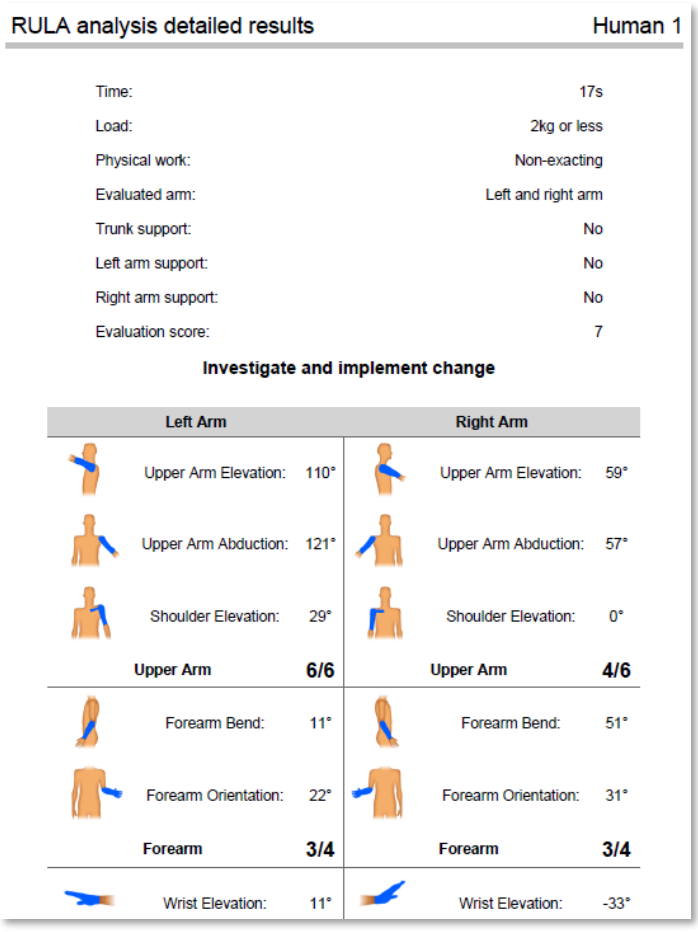
No actions required (Score: 1)		
0s – 5s	11s – 14s	22s – 22s
Corrective actions required in the near future (Score: 2)		
5s – 6s	15s – 17s	18s – 22s
Corrective actions should be done as soon as possible (Score: 3)		
6s – 11s	14s – 15s	17s – 18s

OWAS 'Detailed Statistics' analyses a motion sequence of the given interval (0s-22s) based on the extent to which a posture is represented in it. The subject was exposed to less than 10kg load. The evaluation of the back was divided into 3 blocks based on the direction of the motion. The first block shows how many percent of the time was spent in bent forward or backward position. Similar to that the second shows the percentage that was spent bent sideways, while the third shows time spent in a twisted position. Each of these three is a 100%, however there is a possibility to overlap, so the human may did bent forward, bent sideways and back twisted too at the same time.

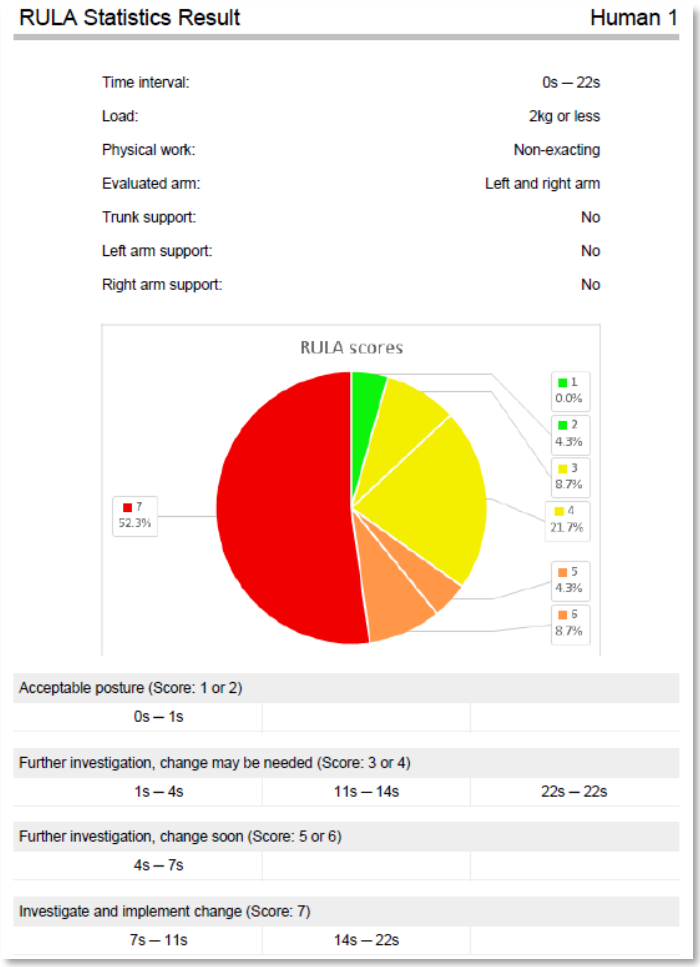


The moduls of RULA are very similar to OWAS, but RULA is more intricate therefore the analysis result are more punctual.

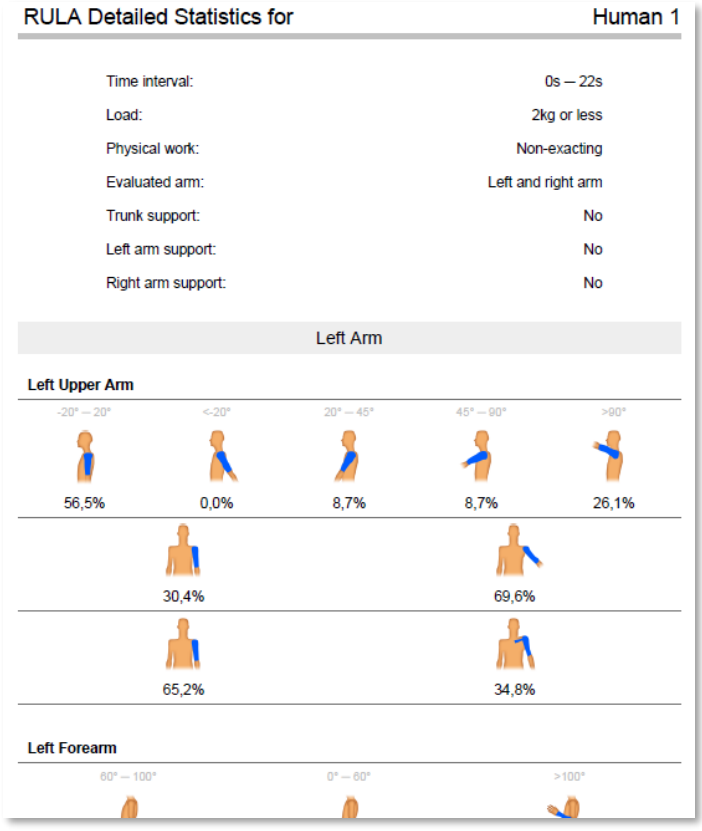
The **RULA 'Detailed'** mode evaluates a posture of a given time (17s) based on the rules of RULA method. The subject was exposed to 2kg or less load and the physical work wasn't exacting. The evaluation score is 7, which means investigate and implement change. You can see in the table below the partial points of the body parts and the angles of the limbs. The left upper arm got score 6 out of 6 and the right upper arm got score 4 out of 6. The left and the right forearm both got score 3 out of 4. The scores are derived from the angular values.



In **RULA 'Statistics'** a pie chart can be seen that evaluates a motion trail of a given time interval (0s-22s). Its results are represented on the RULA 1-7 scale, 1 stands for acceptable postures while 7 for the ones that need to be changed immediately. We can see in the table under the pie chart which moment gets which score, thus in ViveLab we can easily look at these time slots and recognize the reasons of the crucial postures.



RULA 'Detailed Statistics' mode also analyses a motion sequence of the given interval (0s-22s) based on the extent to which a posture is represented in it. In this example the left upper arm was between -20°– 20° in 56,5%, <-20° in 0%, between 20°– 45° in 8,7%, between 45°– 90° in 8,7% and >90° in 26,1% of the time interval. By summarizing these values we get 100%. The method does categorization according to angular values or based on occurrence of a movement. For instance, the upper arm uplifting to side and the shoulder lifting are categorized based on incidence. As you can see the example in the figure the left arm was abducted 69,6% of the time and the left shoulder was lifted 34,8% of the time.



In case of **ISO 11226** critical postures that occurred during the given interval of time (0s-22s) are listed in a table. The trunk twist in the first row had to be held for longer than allowed therefore this is indicated as an error. In case of a trunk twist the permitted holding time is 4 s, the average twisting angle in this case is 21° and that is to be hold for 5s 300ms.

Below in the table of 'All Evaluated Test' all examined items prescribed by the standard are represented. In the 'Passed' column it can be seen on which statement did the motion sequence fail.

ISO11226 evaluation results — **Human 1**

Start time:	0s
End time:	22s
Supports:	None

Not acceptable

	Critical Postures	Average Angle	Starting Time	Holding Time
1	Asymmetric trunk posture (axial rotation) for more than 4s	21°	0s	5s 300ms
2	Neck flexion is >25° for more than 4s	30°	0s	4s 900ms
3	Asymmetric trunk posture (lateral flexion) for more than 4s	15°	3s 900ms	7s 100ms
4	Right upper arm elevation is >60° for more than 4s	92°	5s 200ms	5s 100ms
5	Right shoulder is raised for more than 4s	19°	5s 300ms	4s 800ms
6	Neck flexion is >25° for more than 4s	33°	5s 500ms	5s 500ms
7	Head inclination is >85° for more than 4s	89°	5s 700ms	4s 600ms
8	Left wrist radial abduction is >20° for more than 4s	21°	5s 700ms	4s 100ms
9	Neck flexion is >25° for more than 4s	34°	11s 200ms	5s 500ms
10	Asymmetric trunk posture (axial rotation) for	17°	14s	6s 700ms

In the table of **EN 1005-4** the critical postures are listed that occur during the given time interval. The trunk twist in the first row has a higher frequency than allowed, it happens more than 2 times per minute. This particular trunk twist occurred 5 times in 21s 900ms.

Below in the table of 'All Evaluated Test' all examined items prescribed by the standard are represented. In the 'Passed' column it can be seen on which statement did the motion sequence fail.

EN1005-4 evaluation results — **Human 1**

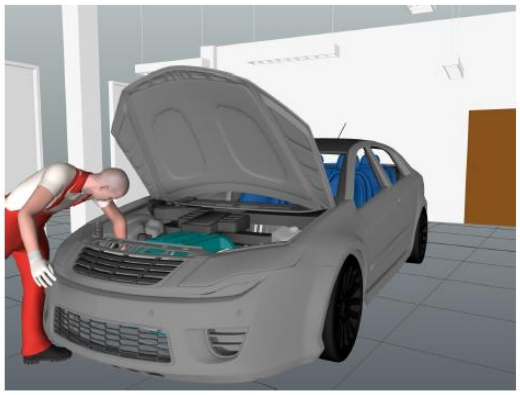
Start time:	0s
End time:	22s
Supports:	None

Not acceptable

	Critical Postures	Maximum Frequency	Starting Time	Holding Time
1	Asymmetric trunk posture (axial rotation) occurs with a frequency >=2/min	5/min	0s	21s 900ms
2	Asymmetric trunk posture (lateral flexion) occurs with a frequency >=2/min	8/min	0s	21s 400ms
3	Left elbow extension is >10° occurs with a frequency >=2/min	10/min	0s	21s 900ms
4	Right elbow extension is >10° occurs with a frequency >=2/min	5/min	0s	22s
5	Right knee flexion is >0° while standing (bottom not rested) occurs with a frequency >=2/min	3/min	2s 800ms	19s 200ms
6	Left knee flexion is >0° while standing (bottom not rested) occurs with a frequency >=2/min	6/min	3s 100ms	18s 600ms
7	Left shoulder raising occurs with a frequency	3/min	3s 200ms	17s 500ms

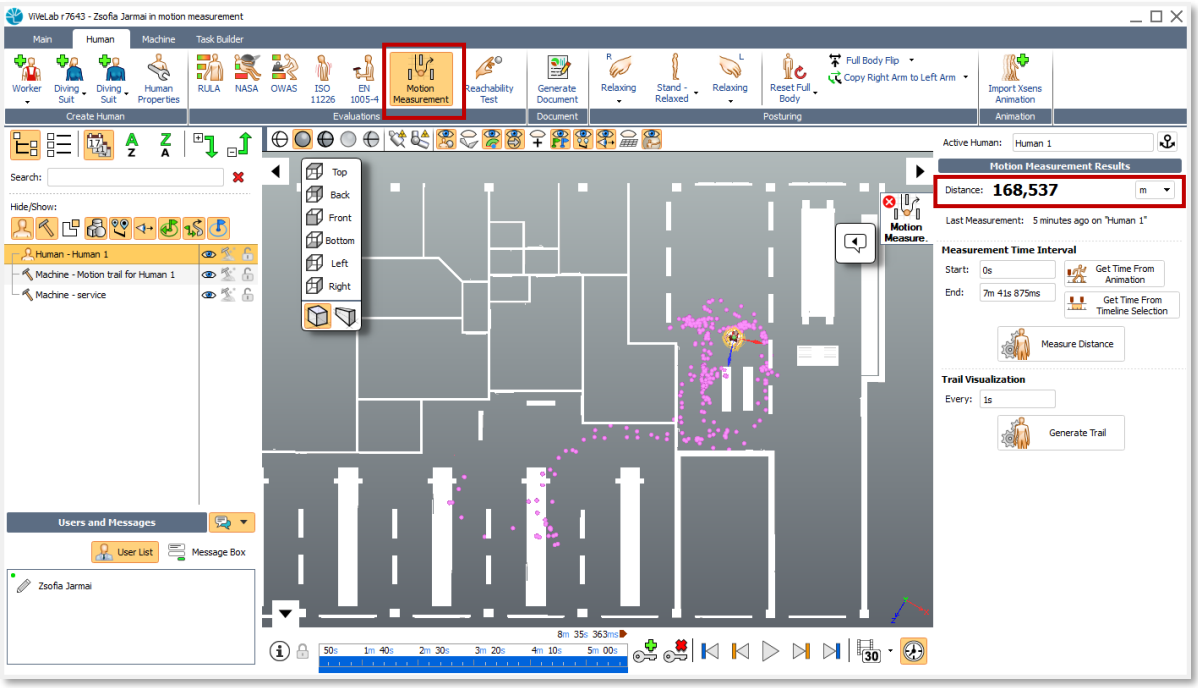
On the last page of the document, the picture can be seen which was previously created with '**Screen Shot**' function.

Figure 1.



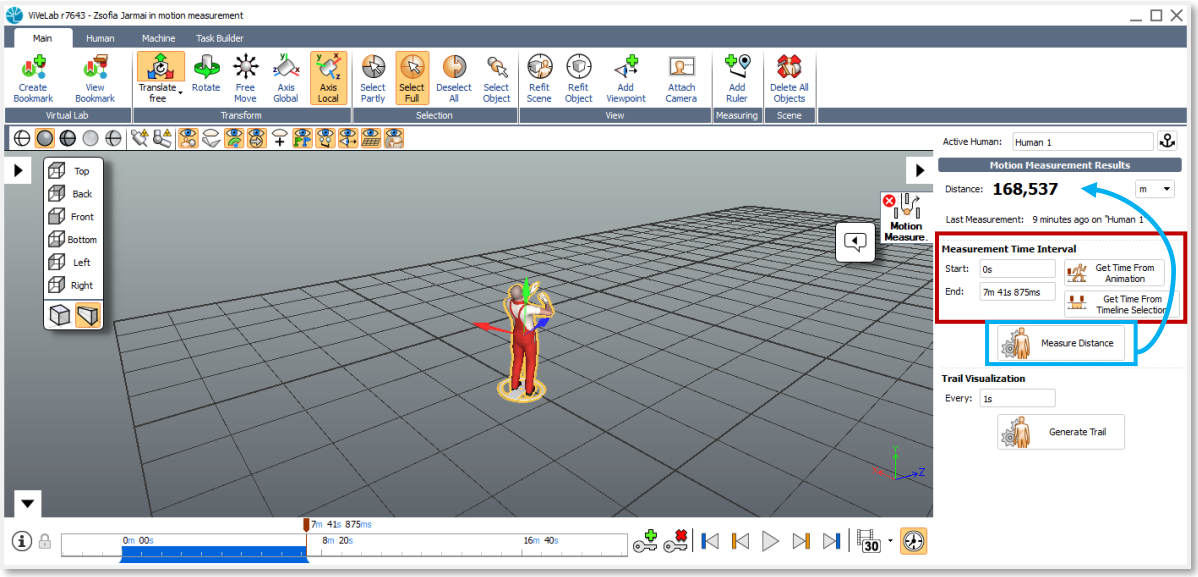
12 MOTION MEASUREMENT

The ‘Motion Measurement’ feature (Spaghetti Diagram) can be used to measure the distance traveled by a human character during animation or visualize the motion trail involved.

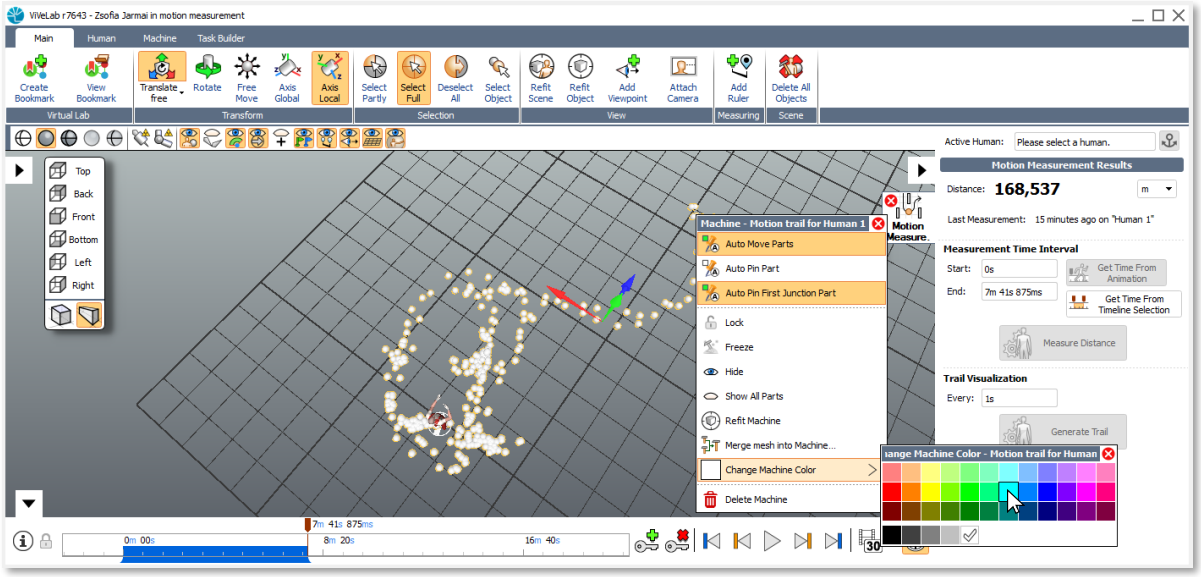


First, we need a human and an animation that we want to measure the walk path. An animation, recorded in a car service, is imported for the human character.

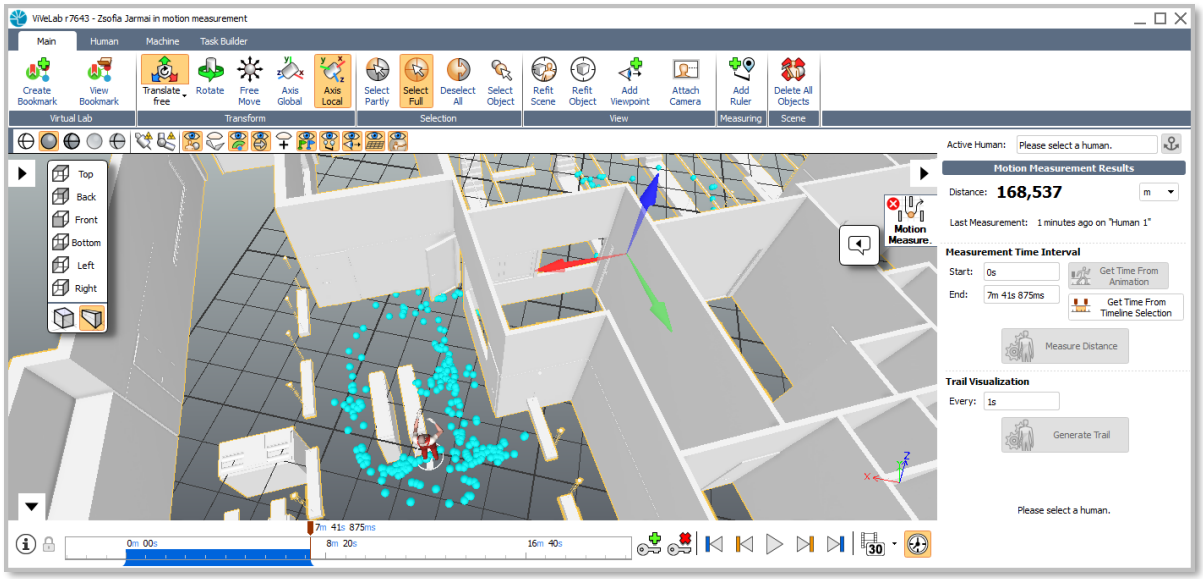
After clicking the ‘Motion Measurement’ command, a panel appears on the right side where you can set the time interval. The ‘Motion Measurement’ feature can measure the distance between a given *Start* and an *End* time. The values can be entered in the fields below or acquired from the animation or timeline selection using the buttons (‘Get Time From Animation’ or ‘Get Time From Timeline Selection’ → Chapter 10, Page 41). The unit of the length of the displayed distance traveled by the human character can be changed.



You can set the frequency of the balls that stand for representation and generate a trail. The created motion trail's color can be changed (right mouse button clicking on the motion trail) and the trail can be translated or rotated as well after you selected it.

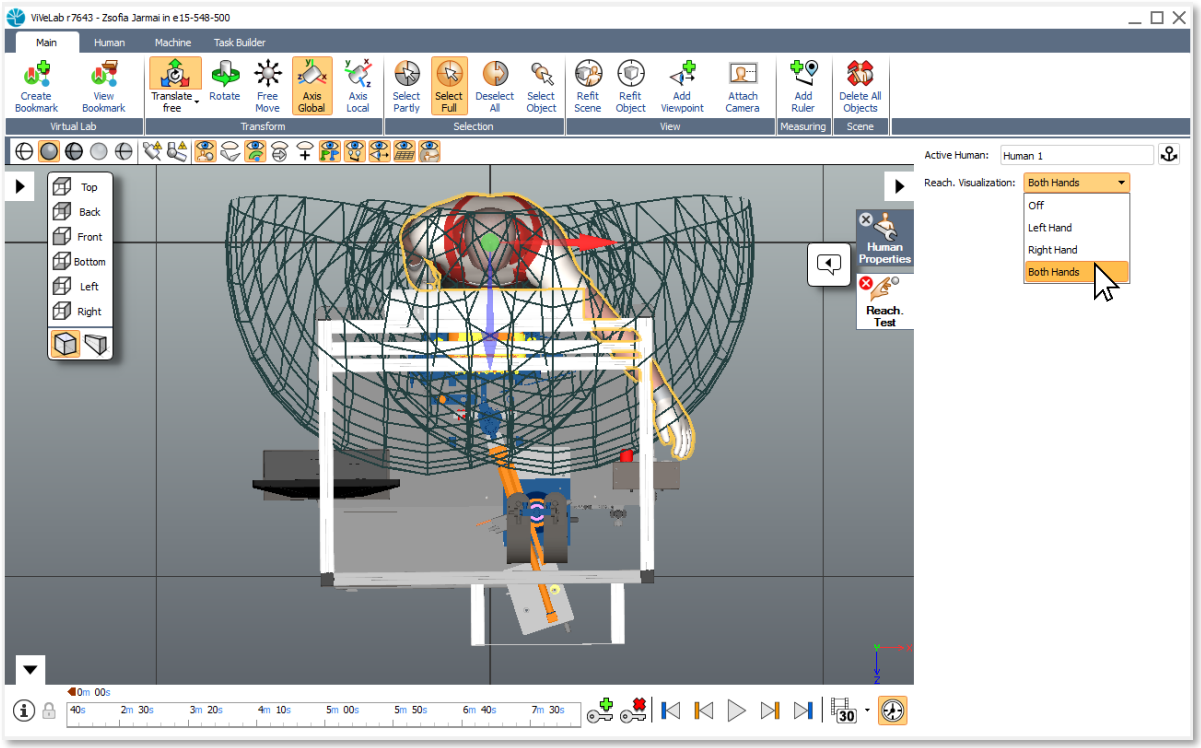


It can be seen in the viewport where the car was. The car service can be set up completely in the lab if the necessary CAD models are available. The layout of a car service shop is imported and adjusted to the motion trail.

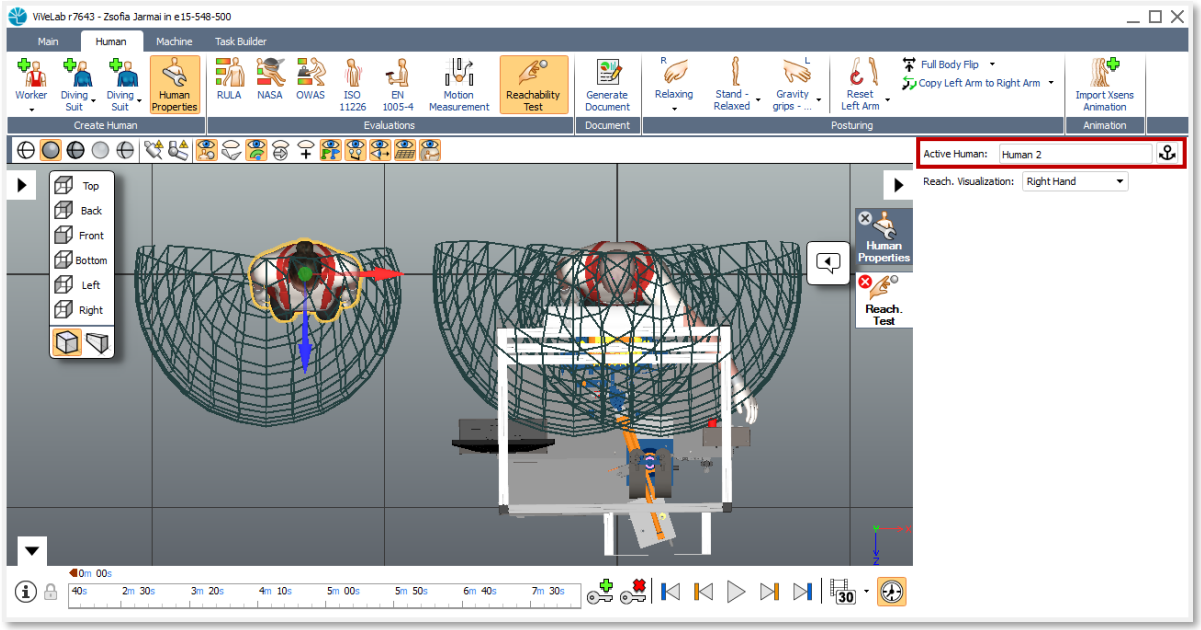


13 REACHABILITY ZONE

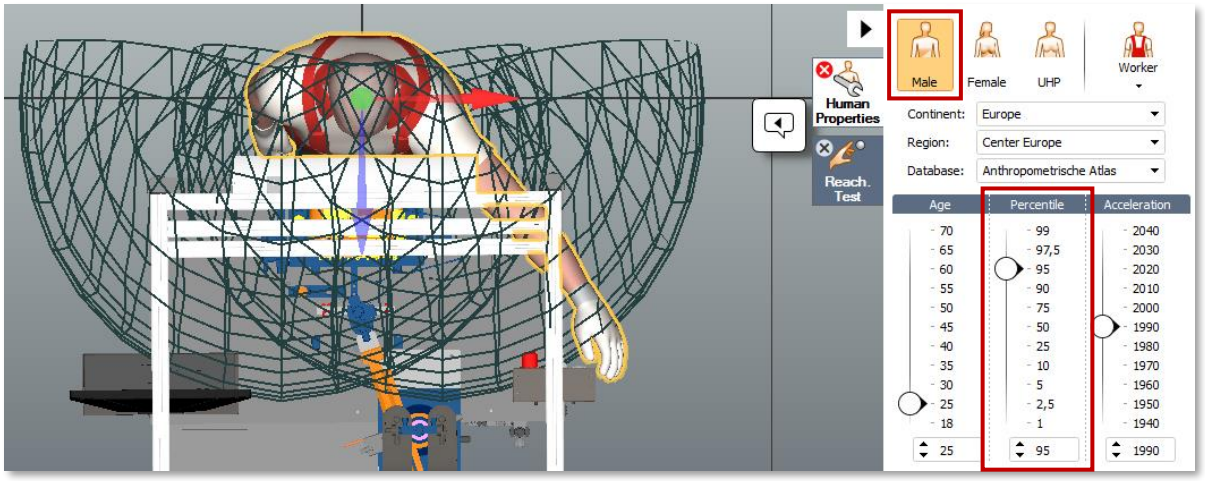
The ‘Reachability Test’ feature can be used to visualize the reachability zone of the hands of the human character. After clicking the ‘Reachability Test’ command a panel appears on the right side where the hand of the human character can be selected whose reachability zone is to be visualized.

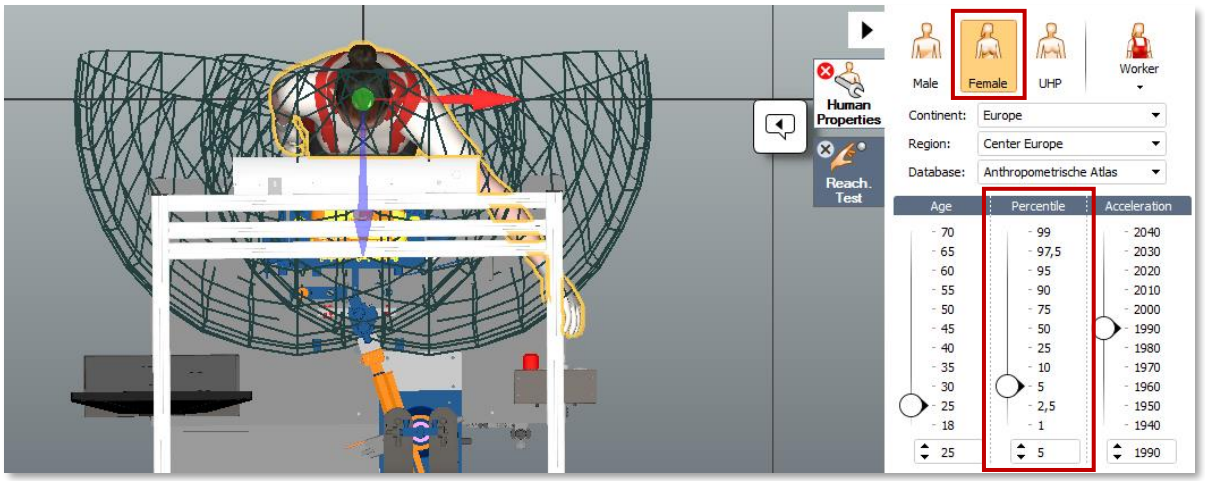


You can visualize the reachability zone of each hand independently. You can change the reachability zone visualization for the currently active human character on the panel which can be changed by selecting another human character unless you anchore a Human on the panel.



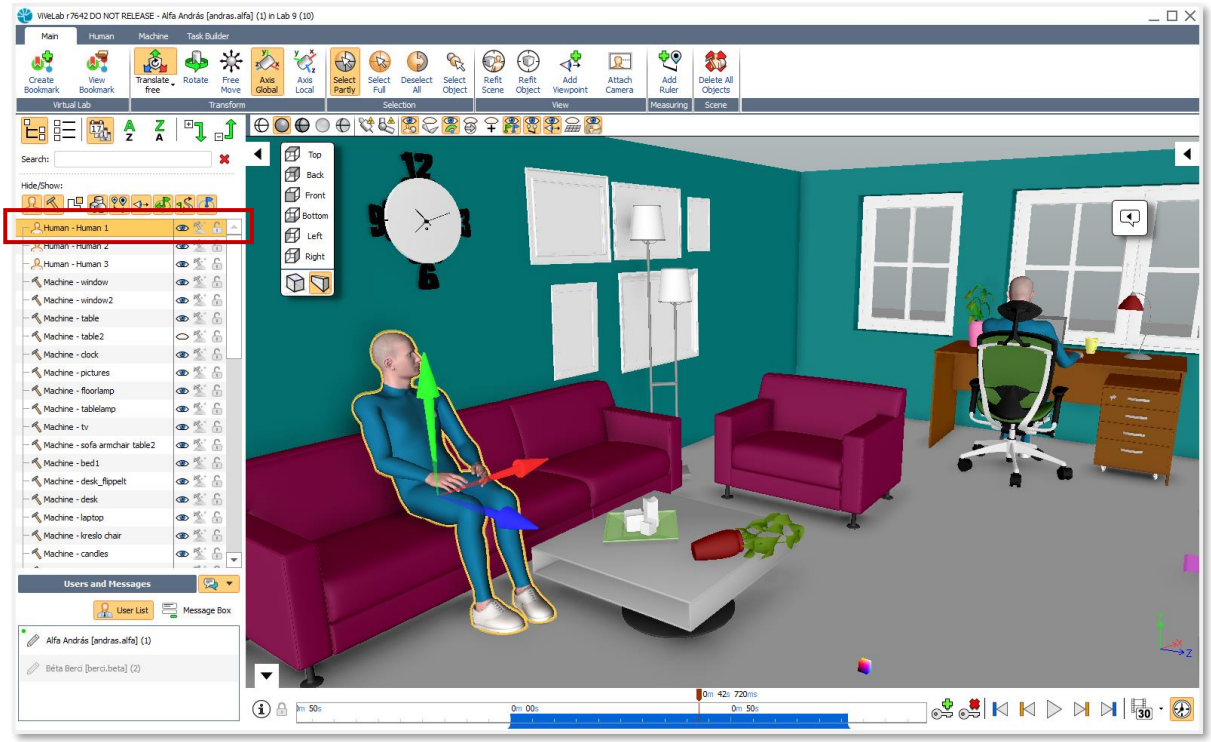
The reachability zone visualizations are automatically updated when the properties of the human character are changed. This calculation may take a few seconds, so the reachability zone visualization will not be updated immediately.



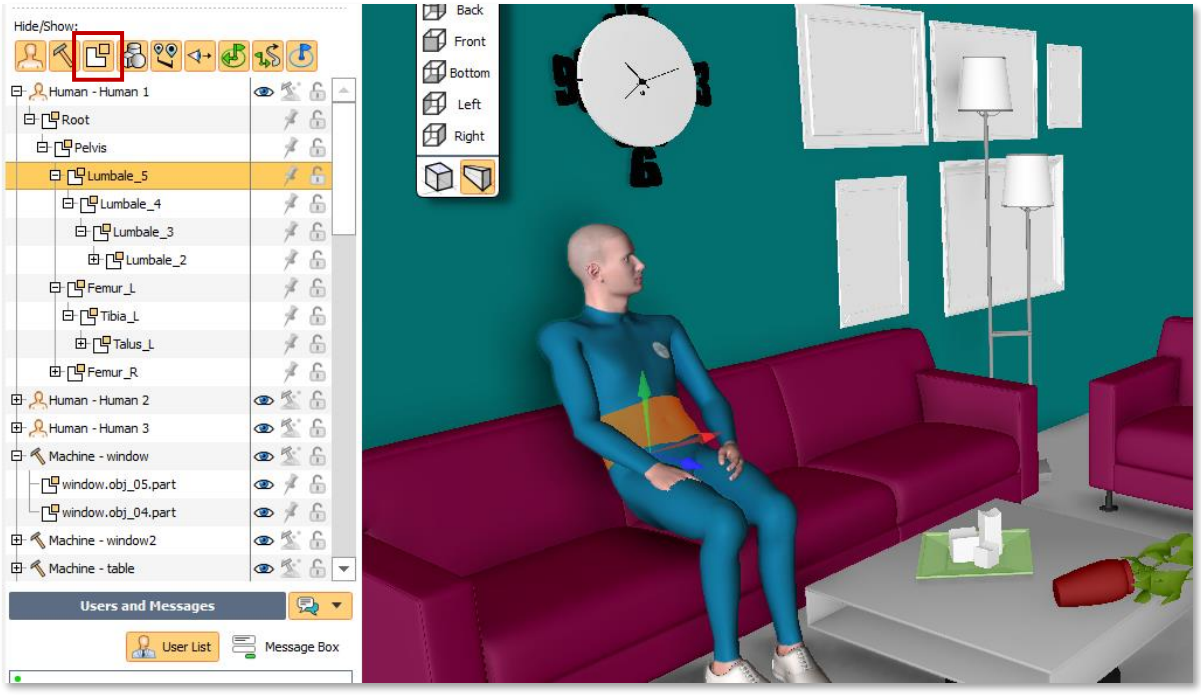


14 MODEL TREE

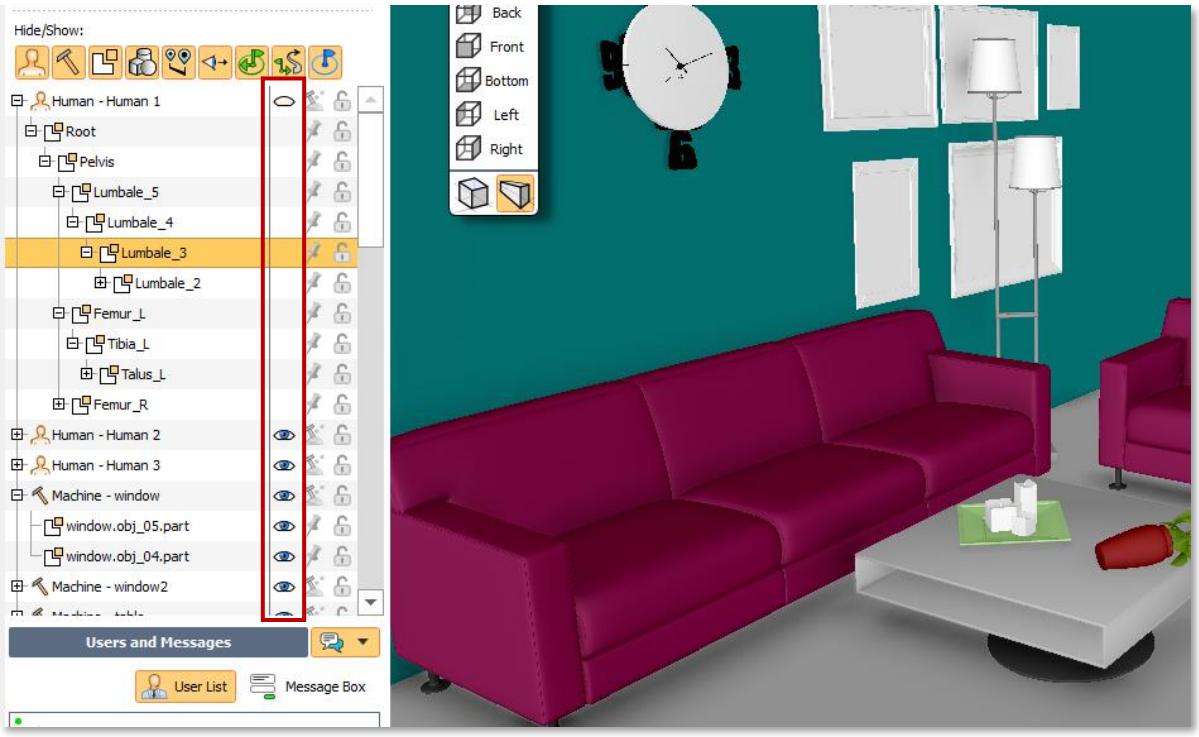
The left panel shows all objects placed in the ViveLab. If you click on one of them it will be highlighted in yellow on the panel and in the 'Viewport' as well.



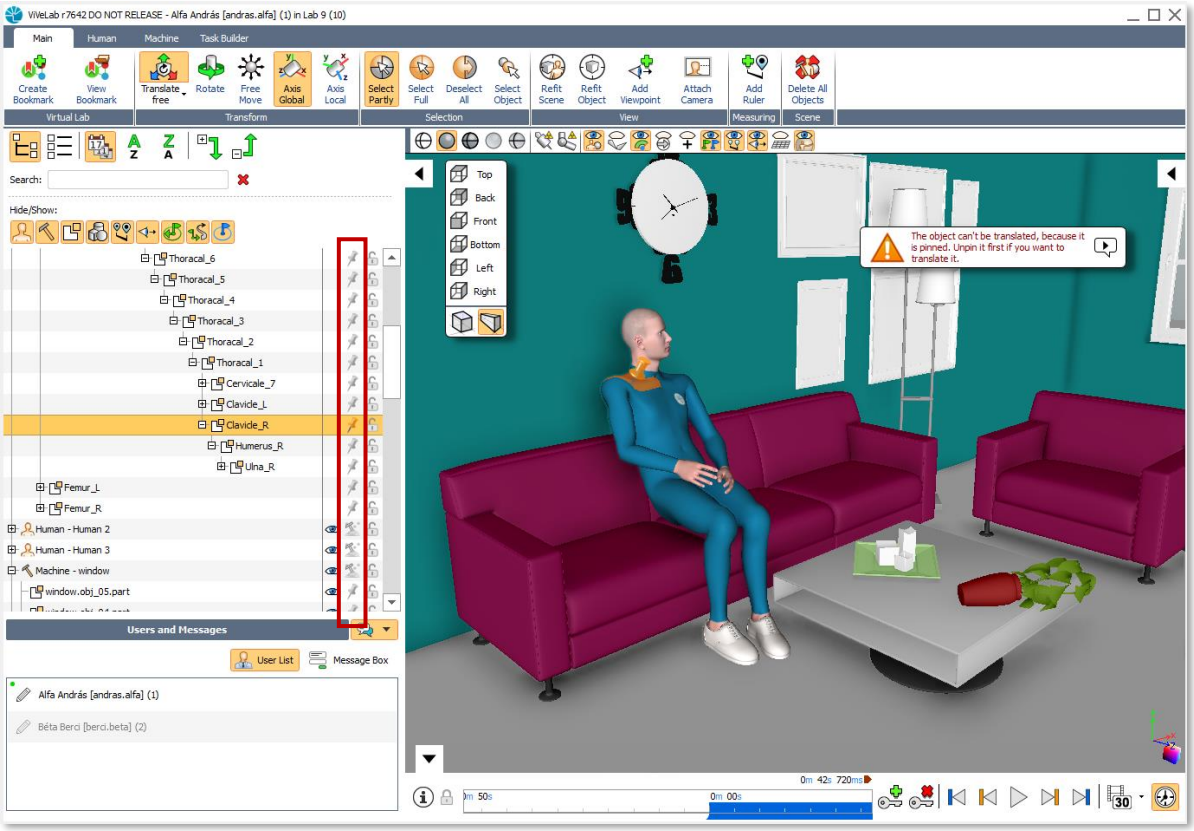
If you turn on the 'hide/show parts' feature you can see all parts of humans and machines. You can select one of the parts from the list and it will also be highlighted in the 'Viewport'.



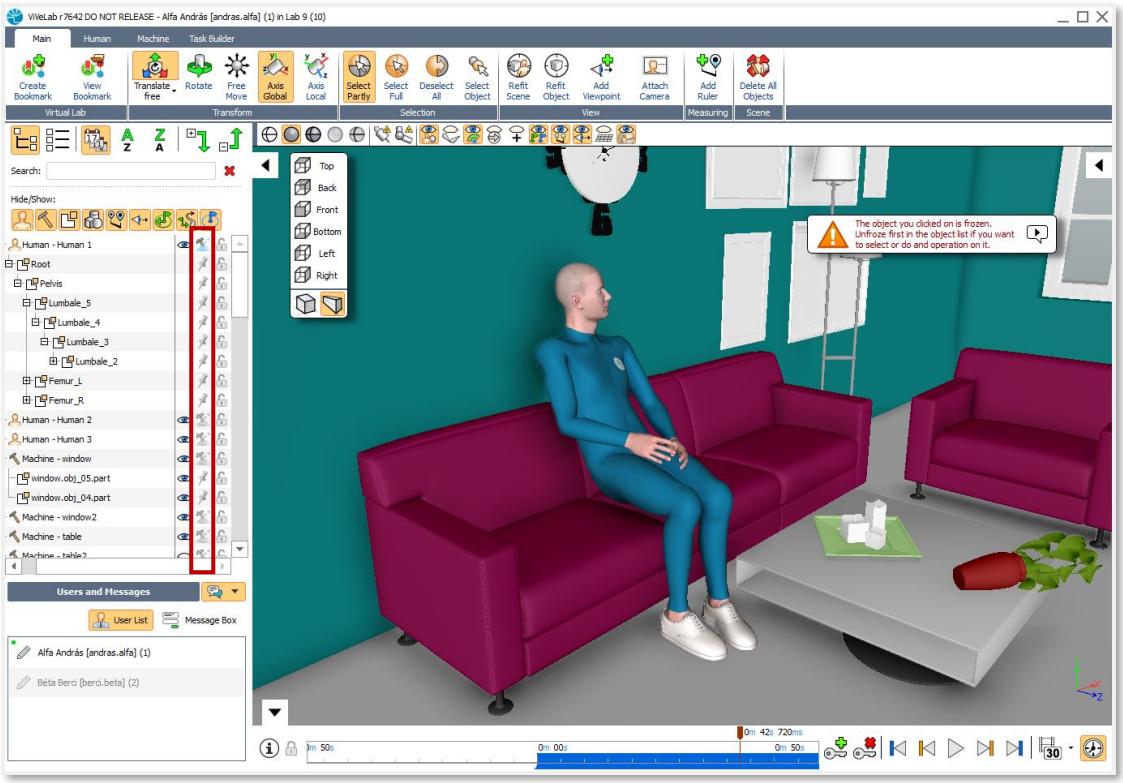
The visibility of each object can be turned on and off by clicking the ‘Visible’ option.



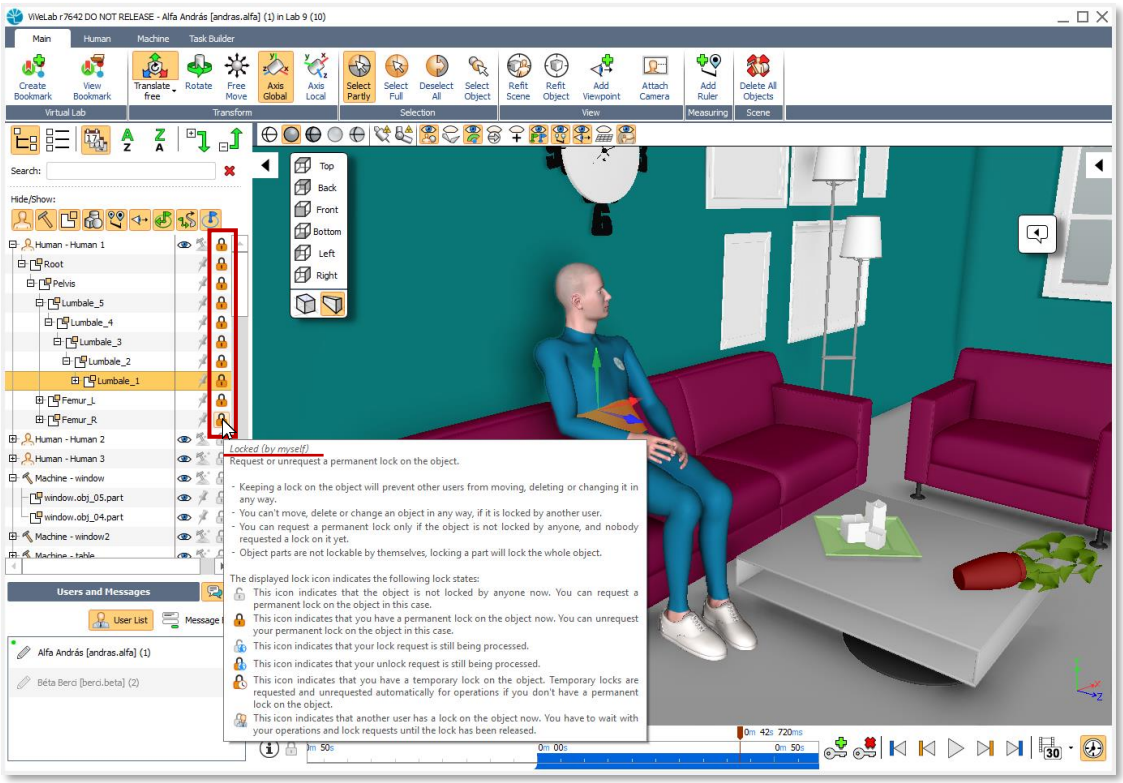
It is possible to pin selected parts of the body in order to fix only the relevant body part in a position.



After selecting the ‘Freeze’ option the object cannot be moved until you unfreeze it (click the icon again).

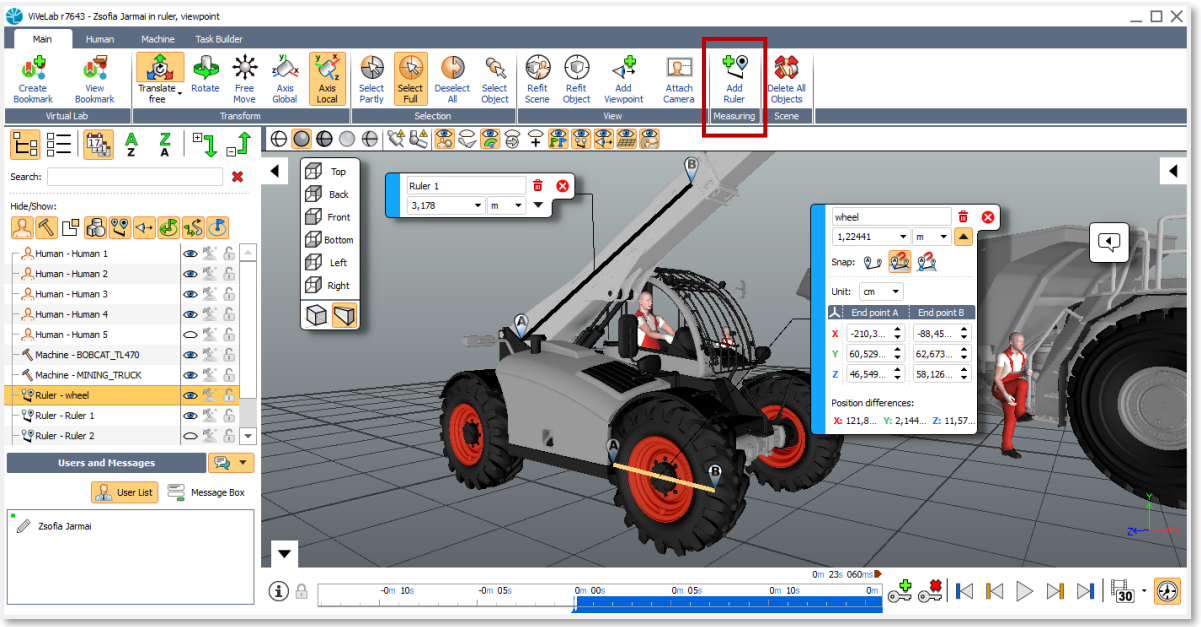


The ‘Lock’ command enables the user to move the selected object while the others in the collaborative environment have no permission to do so. If you hover with the cursor over the ‘Lock’ button it appears in the first row who locked it.

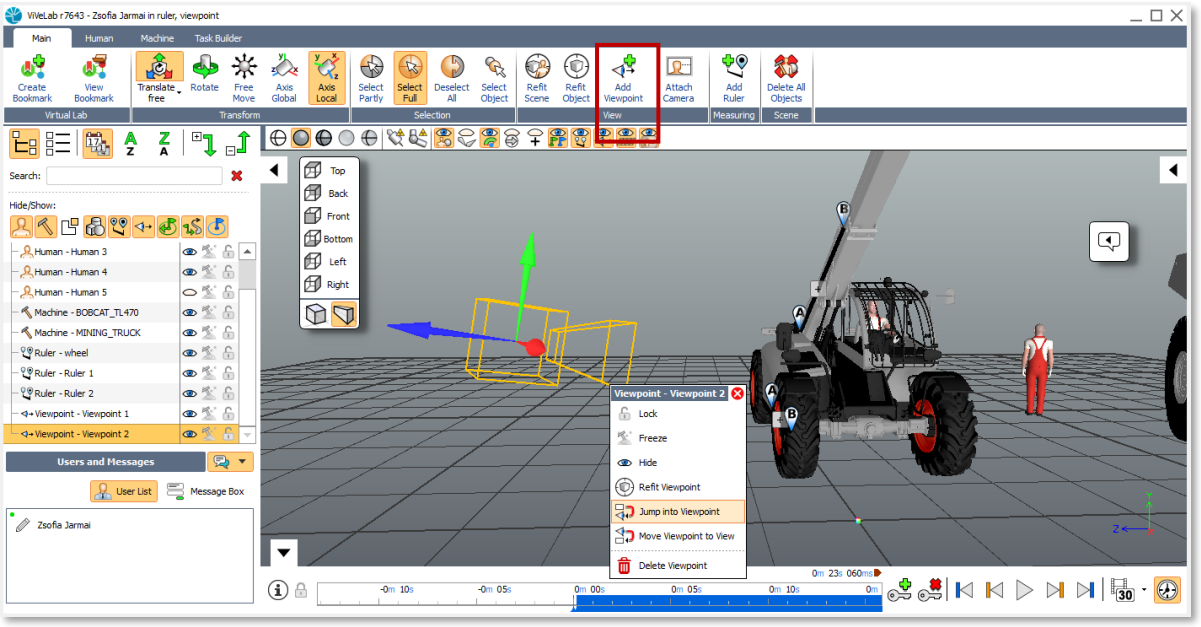


15 RULER, VIEWPOINT

The dimensions and distances in the scene can be measured with the help of rulers. ‘Rulers’ can be created by the **‘Add Ruler’** menu item of the ‘MAIN’ menu. The endpoints of the ‘Ruler’ will snap to the surface of objects. The ruler can be named and its precision and unit of the displayed distance can be defined. If the floating panel of a ‘Ruler’ is closed, it can be reopened by clicking on the ‘+’ sign in the middle of it. Any number of ‘Rulers’ can be created.



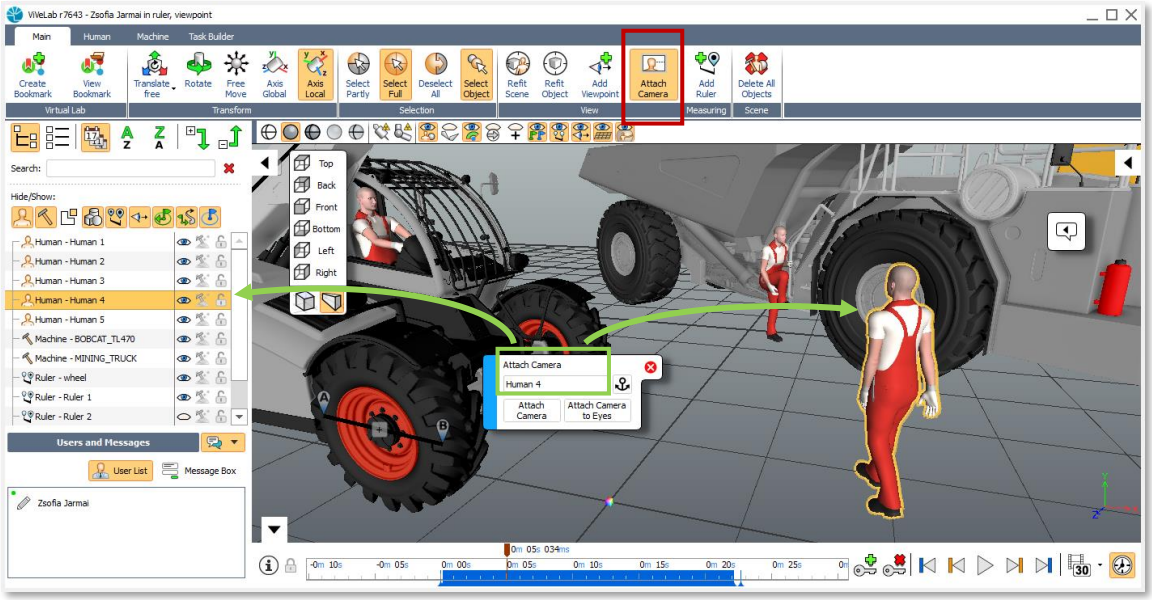
‘Cameras’ can be placed into the scene. By clicking the **‘Add Viewpoint’** menu item in the ‘MAIN’ menu a new camera can be placed into the scene. If a camera is selected in the tree-structure or in the viewport a list of options appear for the right mouse button click. After clicking the ‘Jump into



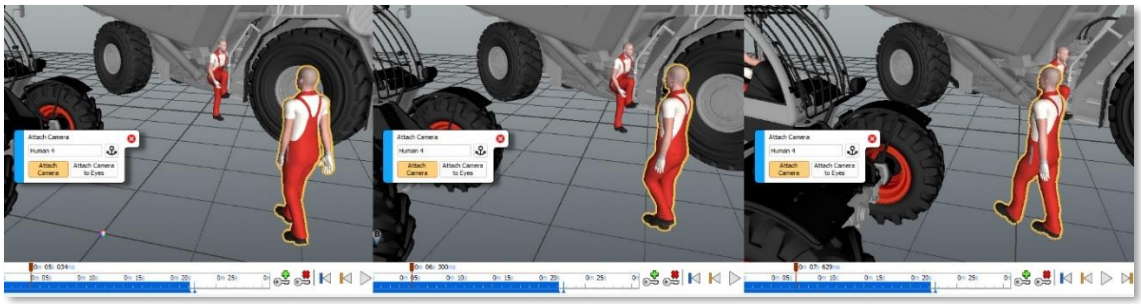
‘Viewpoint’ command the scene will be seen from the chosen ‘Viewpoint’ (through the camera). If you transform the ‘Viewpoint’ its view will change.

16 ATTACH CAMERA

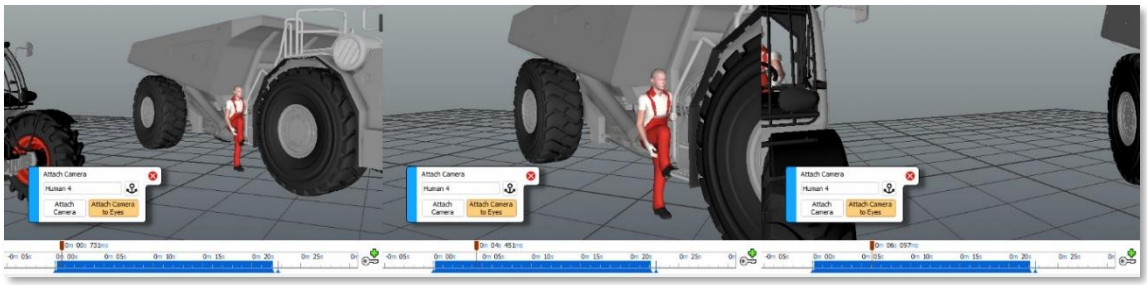
The ’Attach Camera’ feature can be used to make a camera follow an animated human character. A human character can be followed by the camera from a distance or it can be viewed through the eyes of the human character.



In the ‘Attach Camera’ mode the camera is following the selected human character, but it is not rotated. The camera can be moved while in ‘Attach Camera’ mode that changes the camera’s relative position to the character.



In the ‘Attach Camera to Eyes’ mode the camera will be kept in the place of the eyes of the selected human character. In this case the camera cannot be moved.



Only one of the ‘Attach Camera’ or ‘Attach Camera to Eyes’ modes can be active at a time.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