
VR Mobile Crane SIMULATOR

Administrator MANUAL

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OVERVIEW

The MCO VR Sim is a training simulator for mobile cranes, including hydraulic boom, lattice boom, side boom, boom truck knuckle boom, and more, and is intended to be used as part of new operator training and existing operator skill honing and recertification. Designed for after conventional classroom or online training, the instructional design exposes trainees to control familiarization, basic operation, a number of operational problem areas that better prepare them for hands on training and control of the real-world equipment, hazard awareness and risk identification, and culminates in preparation for taking and passing the NCCCO Practical Exam.

MAIN FEATURES

Muscle Memory and Control Familiarization. While classroom or online training can explain the core functionality of a mobile crane, a trainee must spend time using the controls to intuitively understand their function. New users are often anxious when learning the controls on the real equipment where the weight and load movement can be unsettling. They tend to use single actions at a time and often in a jarring un-feathered motion which only heightens the anxiety when operating. Trainees using the simulator are much more comfortable to explore, and they are more likely to use controls with less anxiety, use multiple functions at once, and demonstrate proper feathering.

“I did feel confident that more time spent in the simulator would bring my abilities up to snuff. The simulator did a superb job of replicating the experience of operating an actual crane.” – Eric Liga, Journalist “Training to Craning in 60 Minutes”

Virtual Reality and Presence. Virtual Reality, especially with motion, allows for a powerful sense of presence—the intuitive feeling of actually being in the virtual environment. Presence is directly responsible for creating powerful and engaging user experiences, which in turn are responsible for training with exceptional retention.

First Person Point of View. Virtual Reality headsets, with full-motion tracking, allow a true first-person point of view. Trainees can look down, up, and all around themselves, and even take a step and look out the window at their outriggers or tracks. This view is critical for positional awareness of the cab during precise lifts, or in the presence of hazards on the job site. Previous simulators, built using conventional screens, allowed trainees to learn the controls and basic mechanics, but only with a VR headset can trainees precisely control the mobile crane in scenarios that match real world conditions.

Virtual Reality and Motion. To avoid motion sickness, any motion shown visually in the headset must be felt by the trainee through their inner ear. If there is a disconnect between what they see and feel from the headset showing movement without the feel of motion, moderate to severe motion sickness may result. General best practices for VR suggest not to move the point of view, but this is not possible on a mobile crane since the operation by definition moves the operator. To avoid this limitation, the use of physical motion allows the simulator to fully model the accelerations experienced by the operator— giving a physical sense of motion that is synchronized with what the user sees through the headset. This synchronization greatly reduces and even eliminates motion sickness for even the most sensitive individuals.

Besides mitigating motion sickness, the use of motion also improves the sense of presence—trainees actually feel like they are sitting in the crane cab feeling their boom arm deflect or rock the cab under the swing of a heavy load. This experience can be unsettling, but experiencing in the simulator first helps prepare trainees for their first experience on the real world equipment. By being prepared for their first experience, which is typically instructor led training on the actual machine, new operators are less distracted and gain more value from their hands-on training time.

SCENARIO DESIGN

The MCO VR Sim is designed as a learning path course where the trainee must complete sequential scenarios. Each scenario trains or reinforces basic operation skills, as well as rare and hazardous problems operators may encounter in the field. Metrics regarding the trainee's operation are tracked in each scenario. The MCO Apprenticeship Learning Plan is designed for a new operator to complete all the scenarios within approximately 10-15 hours. Scenarios can be revisited.



SCENARIO Type Descriptions

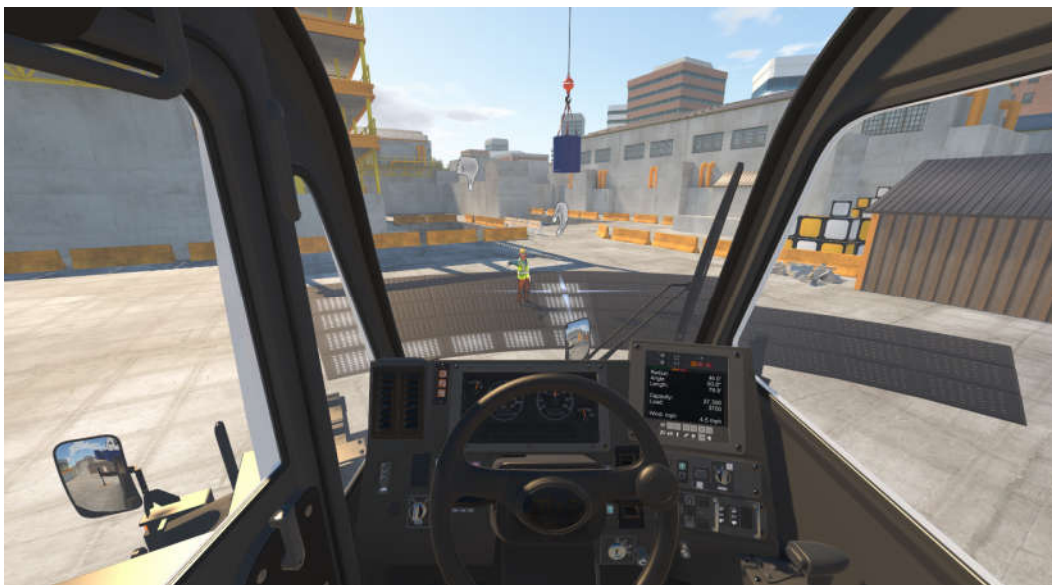
- 1) **Load In Circle.** This teaches the basic function of the crane controls to operate the simulator.



- 2) **Catch the Swing.** This teaches how to take away the swinging motion from a moving load.



- 3) **Signal Person.** This teaches how to precisely follow signal person voice and hand commands.



- 4) **Corridors.** This teaches operators how to navigate loads with precision using multiple functions.



- 5) **Ball in Barrel.** This teaches the operator how to control the swing of the headache ball enough to lower the headache ball into the barrel without tipping it over. Hold for 1 second until barrel opening glows yellow.



- 6) **Hook | Pole.** This teaches precision handling of the headache ball to latch onto a wire-frame object and navigate it to the destination.



- 7) **Lift.** This gives the operator the simulation of a worksite performing a standard lift with supervision.



- 8) **Training Event.** This teaches appropriate resolution steps to both common and rare worksite hazards. On the first occurrence of a training event time slows as the operator receives instructions, then must perform the proper steps and end by clicking on the ignition with the input button (i.e. the “horn”).



- 9) **Wrecking Ball.** This bonus scenario type allows the operator to knock over standing blocks, but at a random moment will require the operator to regain control of the load.



- 10) **Magnet.** This bonus scenario type allows the operator to leisurely pick up blocks using a magnet and stack them to build a high tower.



HARDWARE

HEADSET

VR headsets, with 360 degree positional tracking, allow for true first-person perspective—users are fully aware of their surroundings and intuitively understanding their position in the crane cab. This first-person perspective is required for the user to successfully operate in tight areas, especially with environmental hazards.

The headset also reinforces presence, creating the user feeling of actually standing on the virtual equipment. An experience with strong presence is highly engaging which directly relates to a learning experience with significant long-term retention.

The simulator is compatible the Oculus Rift CV1. Additionally, by using the OpenVR standard, the simulator is compatible with any prospective VR headset option, including the HTC Vive. In the case of the Oculus Rift, the unit is lightweight, comfortable, and designed to work ergonomically with everyone from the 5th percentile female to the 95th percentile male. Glasses and contact lenses are generally compatible without issue. Headsets that incorporate headphones also allow for full 3D positional audio without extra cables or complexity.

CONTROLLER | MOTION BASE

The simulator includes two hardware configurations – Desktop and Motion Base.

The Desktop clamping system is a controller with interchangeable pods that allows the operator to use the joystick/lever controls applicable to the crane being operated. The controllers are built around a common USB control board which have been used and tested on a variety of oilfield, mining, and construction simulators.



The Motion Base is similar to the desktop unit in many ways, but adds a motion platform. The high-speed electric actuators from D-BOX provide motion with high enough response frequency that even the vibration of hydraulic pumps can be modeled. The combined actuators are capable of lifting a platform up to 800 lbs, easily, which allows both the hardware and the potential operator to experience comfortable and realistic amounts of motion.

The actuators have a maximum travel of +/- 3 Inches. The motion base has a default height above the floor which minimizes the potential for pinching.

While in operation, ensure that hands, feet, or any other objects are kept clear of the motion base. Failure to do so may result in damage or injury. A safety light will be active when the simulator unit has power, indicating the area persons should keep clear of.

SETUP

To set up your Oculus Rift and begin using the simulator, perform the following steps.

1. Connect Oculus Rift

- 1) Plug in Oculus Rift Headset
 - Connects via HDMI and USB 3.0 ports (left side of laptop).
- 2) Plug in Oculus Sensor
 - Connects via USB 3.0 port (right side of laptop)
- 3) Clamp Desktop Hardware to Table
 - Connects left module to right module via embedded USB and power cables
- 4) Connect Right Controller Pod to PC via USB
 - Connects via USB 3.0 port (right side of laptop)
- 5) Connect AC Power to Right Controller Pod
 - Standard AC power outlet required

2. Launch Simulator

- 1) Clear Oculus “Health & Safety Warning”
 - Wear Oculus Rift Headset and hover gaze-cursor over warning message box for 2 seconds
- 2) Double-click on “ITI VR Crane Sim”
- 3) Once “Calibrate” appears on screen, use the “Calibrate” button on the inside lever on the controller module (indicated in graphic on screen).
- 4) Once in the simulator, use the “Horn | Select” button on the outside lever on the left controller module, and “Gaze-Cursor” to interact with the virtual environment.

3. Frequent Startup Problems

- Ensure light sensor on headset (located between lenses near top of headset, beside small light) is covered when opening the simulator! Otherwise it will not run.
- Oculus desktop application must be running, but does *not* need to be connected to internet. Minimizing the Oculus desktop application is recommended.

CALIBRATION

The most important piece of running the simulation is to properly calibrate the Headset! If the Headset is not properly calibrated, the virtual and physical assets will be out of synch. This will undermine usability and user comfort.

To calibrate the Headset:

1. Ensure the simulation is running and displaying the “Calibrate Headset” message.
2. Ensure the sensor is properly positioned, facing forward, and level with the ground (do not tilt).
3. Put on the headset and sit at the controls, or hold the headset above the controls and cover the light sensor between the lenses.

If the virtual model is NOT in synch with the physical controller, stop operator and restart the simulator.

We recommend calibrating the headset for every new extended training session (greater than 30 minutes).

Please refer to the **Troubleshooting** section for more information

HEADSET CARE

VR Headsets are precision equipment. Do not drop. Do not place near the edge of a table. Always handle with care! Be aware of cables which can get tangled or become tripping hazards. Do not expose to direct sunlight, especially the lenses.

The lenses in the VR headset may become smudged due to contact with skin or hair. If the view is blurry due to a smudge, gently clean the lenses with the provided cleaners. Do not use any paper-based cleaner, such as paper tissue or paper towel—the cellulose fibers may scratch the lenses. Do not use alcohol or any solvent based cleaners directly on the lenses, as it may damage their coating and result in permanent blurriness.

Current generation VR Headsets have a high resolution per eye but is still limited. Users may note a slight blurriness or “screen door effect” on the screen. If users are able to see the “screen door”, they are likely seeing the headset screen in focus—any further imprecision is a limit of the resolution and technology.

If users note substantial blurriness, especially in a vertical direction, guide them to adjust the headset on their face and perhaps adjust the tension. Likely the headset was tilted or positioned too high.

CLEANING

The headset can be gently cleaned with a damp cloth. Avoid excessive use of harsh chemicals, though a small amount of rubbing alcohol may be used when cleaning the faceplate. Do not get any cleaning chemicals or solvent on the lenses.

GLASSES

Current generation headsets work well with glasses, provided the glasses can fit within the faceplate.

Trainees should “roll” the headset on from below so it slips over their glasses. If not guided on this, they may try to put the headset on from the top where it will get stuck on the top of the glasses.

In general, the headset will try to recreate the optics that the trainee’s eyes would encounter in real life. If they have glasses or contacts, the corrective lenses should work similar to real life. Users that need corrective lenses to see clearly will need such lenses in the headset.

A small number of users with extreme prescriptions, typically involving bifocals, may not be able to experience clear vision with the headset.

OCULUS CV1:

The Oculus CV1 has some unique features:

IPD slider. This slider adjusts the IPD (Interpupillary distance or eye spacing), which can be used to improve the focus for individuals whose eye spacing is significantly different from the adult average of 64 millimetres (2 and 19/32 inches). In general, try to have this slider in the center as most people will have a comfortable experience at the default settings. Persons who have significantly larger or smaller heads, especially children or adolescents, should be instructed to adjust the slider to see if it improves focus for them.



Light Sensor. The Oculus CV1 has a light sensor above the bridge of the nose to ensure that the headset is only active if being worn or mounted on a calibration stand. When the sensor is exposed to light, the headset screens will be black, and any simulation software will be paused.



Velcro Adjustment Straps. The Oculus has a rigid frame with a tracking device at the back of the head to ensure full 360 degree tracking. The tension on this frame can be adjusted with the two sets of Velcro straps. Always make sure the trainees are aware of this adjustment potential and have a comfortable fit with the headset.



KEYBOARD COMMANDS / CONTROLLER FUNCTIONS

Tadano GR-1000XL Administrative Controls

Control the following crane functions using the laptop's keyboard.

Joystick Operation	Keyboard Key	Function
Left Outside Lever	A/D keys	Swing Left/Right
Left Inside Joystick	Y/H keys	Telescope In/Out
Right Inside Lever	R/F keys	Hoist Up/Down
Right Outside Lever	W/S keys	Boom Up/Down
Button – Left Outside Lever	Q key	Horn Select Hold 3sec for Menu
Button – Right Inside Lever	L key	Calibrate
n/a	X key	Toggle Helpful Aids
n/a	T key	Toggle Load Chart

Navigation	Description
NumPad 0 key	Main Menu
NumPad 7 key	Previous Scenario
NumPad 8 key	Restart Scenario
NumPad 9 key	Next Scenario
F3 key	Decrease Clouds
F4 key	Increase Clouds
F5 key	Decrease Wind Speed
F6 key	Increase Wind Speed

Training Event - Proctor	Keyboard Key
Wind Gust	Shift + 1
Winch Failure	Shift + 2
Winch Tangle	Shift + 3
Sling Failure	Shift + 4
Closest Outrigger Failure	Shift + 5
Next Outrigger Failure	Shift + 6
Double Outrigger Failure	Shift + 7
Load Weight Shift	Alt + 2
Fog	Alt + 3
Boom Hydraulic Failure	Alt + 4

Tadano 1000XL Configuration



TROUBLE SHOOTING

If you follow the directions and have the system plugged in as described BEFORE turning it on and have not modified any computer settings or encountered physical damage, it should function reliably and consistently. That said, here are some potential (if rare) problems and the basic steps to resolve them:

POTENTIAL PROBLEM SOURCES

- **Make sure all cables are plugged in before starting the simulator!**
 - If cables are not fully plugged in, headset, controller, audio, and or motion may not work.
 - If cables are not fully plugged in, the computer may be running on battery (laptop only). **If the computer runs on battery**, and the battery runs low, the simulation can potentially enter a state that is **extremely uncomfortable and potentially physically dangerous**.
- Make sure you do not use the mouse/trackpad when the simulation is active.
- Do not close the laptop lid while the simulation is running.
- Do not unplug any cables while the simulation OR COMPUTER are running.
- Be careful about which keys you press while the simulation is running—avoid the keyboard unless administering hotkeys for the current simulation session.
 - For example, pressing the laptop’s “Camera” key above the “ESC” key may take you out of the simulation.
- DO NOT CHANGE ANY SETTINGS!
 - Do not change any settings for Windows, etc.
 - If you take the laptop out of airplane mode, software updates may interrupt the simulation experience.
 - United Rentals and your IT department will identify the best solution for managing updates and the computer, especially when network connectivity is required for LMS support.
- DO NOT TOUCH the sensor(s). Any interference will cause problems with the positional tracking and be EXTREMELY uncomfortable for the user.

BASIC RESOLUTION

If you experience problems with the simulation, the best answer is always to restart. First try restarting the simulator.

PROBLEMS AND SOLUTIONS

The virtual view is out of synch with the physical hardware (the virtual controls are way too high or too low or off center).

- Resolution: Stop the simulation. Recalibrate.

The Simulation doesn't close automatically.

- Resolution: Right click on the icon in the taskbar to exit it. Restart the computer if necessary.

"Calibrate Headset" is not cleared when the calibration button is pressed.

- Resolution: See the above resolution for "Reset Emergency Stop".

The Headset screen is black and the simulation opens on the computer screen.

- Resolution: The Headset is not properly plugged in. Turn off the computer and recheck the wiring.
- If using an Oculus CV1:
 - There will be a white LED on the inside of the headset next to the light sensor, above the nose.
 - If this LED is orange, that means the headset is partially connected.
 - Oculus connections can be diagnosed by going into the Settings -> Devices within the Oculus Home software. This will clearly show which devices are connected.
 - If the Oculus CV1 is fully plugged in, but it shows a black screen and is reported as disconnected within
 - Oculus Home:
 - Gently remove the plastic and foam faceplate by pulling directly back and popping it out of the slot.
 - Check the connection of the cable where it enters the top of the headset.
 - Replace the faceplate, ensuring that it is fully seated.
- **If you are having headset connectivity issues and they are not resolved by confirming that the headset is plugged in, please call for advanced assistance.**

There is no positional tracking.

(When you move the Headset to the side, the view rotates but the virtual position does not move with)

- This can be EXTREMELY nauseating to the user.
- Resolution: The sensor is not plugged in or not calibrated. Turn off the computer and recheck the wiring, or open Oculus Home > Settings > Devices > Sensor > Reset Default View.
- Oculus connections can be diagnosed by going into the Settings -> Devices within the Oculus Home software.
- If the camera is fully plugged in and reported as disconnected, unplug it and plug it into a different USB port.
- **If you are having camera connectivity issues, and they are not resolved by confirming that the camera is plugged in, please call for advanced assistance.**

There is no audio.

- Resolution: The audio settings for the computer have been changed. Is the Windows volume set to zero or mute?
- Resolution (if not using the integrated Oculus headphones): The headphones are unplugged.
- If you are having audio connectivity issues, please consult with IT to ensure that the headphones or headset is the current primary and enabled audio device, and play a sound with the Windows “Test” function.
- **If you are having further audio connectivity issues, please call for advanced assistance.**

The Controller is unresponsive/joysticks don't appear to work.

- Resolution: Is the simulator USB plugged into the laptop?
- Resolution: Is the simulator powered? It will have a blue light when plugged in.
- Resolution: Is the user pressing the foot pedal? The controls will not function unless foot pedal is down.
- **To debug, we can use the Controller Utility. Please call to be walked through this process.**

One of the joysticks or switches no longer functions as it did previously.

- The controller may have experienced physical damage.
- **To debug, we can use the Controller Utility. Please call to be walked through this process.**

Trainee reports the Image is “blurry”.

- The Headset resolution is finite, so there will always be a “screen door” effect and slight blur.
 - If they are specifically noting that the icon or text on the controller is too blurry to read, encourage them to crouch low and get a closer view.
- The finite resolution and people’s personal optics may make reading the controls imperfect—the simulator has been designed to be operational with slightly inconsistent focus.
- Usually a very blurry image means the headset needs to be adjusted on the face (is probably too low or too high) and the strap may be too loose or tight.
- This may also mean that the lens caps are smudged and need a wipe down with the lens cleaning cloth.
- If the trainee has a particularly large or small head (especially with younger users), try having them use the IPD slider to see if changing the eye spacing improves their focus.

The Headset cable is too short/pulls against the user's head:

- There is enough cable for a 7 foot user. If the cable is too short, it is likely tangled.
- Resolution: Adjust the cable, ensure it is not tangled by obstructions.

The simulation runs but there is no motion when the cab moves:

- Resolution: The actuators have no power. Is the simulator plugged in? It will have a blue light when powered.
- **To debug, we can use the D-BOX Test Utility. Please call to be walked through this process.**

The user is nauseas, dizzy, and/or uncomfortable:

- Some mild dizziness or “vertigo” is to be expected, especially if the user is uncomfortable with heights and inexperienced with aerial equipment.
- Mild dizziness is common. Extreme dizziness (motion sickness/simulator sickness) is rare but possible. While we have done everything we can to mitigate Simulator Sickness for most people, if someone is unable to experience the simulator DO NOT push them.
- Some people may need to take a break and experience the simulator in smaller sessions.
- People who are extremely sensitive to motion sickness tend to have the most problems. Younger individuals, persons with previous VR experience, persons with video game experience, or persons with equipment experience tend to have the least problems.
- People with an extreme fear of heights think they will be uncomfortable, but tend to have the most positive experiences.
- DO NOT tell the user they may get sick or prompt them to consider motion sickness—if you tell a user they will be sick, the “nocebo” effect will mean they convince themselves to be so.
- People who operate the simulator extremely aggressively, moving without looking, looking rapidly, bouncing rapidly, driving recklessly, etc., are more likely to encounter motion sickness. In general, the simulator is designed to be used as a real aerial lift, and the conditions where a real lift would make someone uncomfortable are similar inside the simulator. If you notice an extremely aggressive user, encourage them to slow down and operate with more precision and care.
 - Recommend trying with everyone, but always be willing to stop the simulation if asked.

The simulation becomes near unresponsive, updating like a slideshow. The motion platform starts banging in single large impulses.

- THIS IS THE MOST DANGEROUS STATE the simulation can enter!
- This CAN ONLY happen if the laptop is running on battery and has run out of power/entered a low power mode. The laptop has been configured to always run under high performance—do NOT change this setting.
 - Other causes typically require running some conflicting software, such as active virus scanning. DO NOT install any invasive software onto the laptop.
 - ITI will work with your IT department to ensure that the configuration and management of the laptop is optimal. If there are any questions, please call for advanced assistance.
- Resolution:
 - Hit space/emergency stop to terminate the session and freeze the movement.
 - Close the Simulation (hold “ESC” for 3 seconds).
 - Plug in the laptop and ensure there is power before restarting.

There are weird splotches on one of the headset eyes, one eye is dark, one eye is black, or the headset does not show any light or connectivity:

- The headset has likely experienced significant physical trauma and is now damaged.
- **Please call to discuss warranty and replacement.**

The simulation software “crashes”

- **Please call to debug. We may ask for a copy of the current log file. Make note of exactly what was done leading up to the crash.**

The simulation experiences major “glitches”, such as double vision and random green/black/magenta artifacts.

- There is serious problems with the laptop hardware. **Please call to discuss warranty and replacement.**

The laptop does not turn on.

- Resolution: Is it fully plugged in? Is it running but with a blank screen? Try holding the power button for 10 seconds and restarting.
- You may need to consult IT. If the computer has power but cannot be started, there may be a serious problem with the laptop hardware. **Please call to discuss warranty and replacement.**

The simulator makes a loud buzzing noise when Windows plays a sound, such as connecting a USB device.

- Resolution: The actuators have been assigned as the primary speaker within Windows.
 - See resolution steps for troubleshooting missing audio.
 - You may need to get IT to review the audio devices, and ensure that D-BOX remains enabled but is no longer the primary speaker.
 - This issue will only happen if there are significant software modifications to the laptop. Do not change any software on the laptop unless instructed. United Rentals will work with your IT department to ensure that the configuration and management of the laptop is optimal. If there are any questions, please call for advanced assistance.

CONTACT

If you have problems, feedback, suggestions, or any other comments regarding the simulator, please contact our ITI VR Sim Product Manager, Caleb Steinborn for support at 360.225.1100 or caleb@iti.com.