DRAFT – Internal Use Only

MOOG Motion Platform User Guide ©2004

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WARNING – The motion platform is not a toy! Great care should be taken when using the motion platform. The motion platform should only be used in conjunction with the chair. Only one person should be in the CAVE space and should remain seated with the seat belt buckled at all times unless in the parked position. When the motion platform is active, a person standing near the motion platform could suffer the loss of a limb or life should sudden movement of the motion platform occur. It is advisable that two people are present at all times when the MOOG is in use.

WARNING – If you have not been given approval to use the MOOG system, then you are not allowed to use it. You must be checked out and cleared on the use of the MOOG prior to any usage. Your CAVE privileges could be suspended or even terminated if you do not comply. Please contact the UVAG/CVEV system administrator (email: uvag-admin@snoid.sv.vt.edu or phone: 540-231-2054) if you would like to use the MOOG.

WARNING – Do NOT use the MOOG motion platform in an unsafe manner. Your CAVE privileges could be suspended or even terminated if you do not comply. If you have questions or concerns, please contact the UVAG/CVEV system administrator (email: uvag-admin@snoid.sv.vt.edu or phone: 540-231-2054)

WARNING – Do NOT try to climb down to the CAVE Hole through the opening in the floor. It may take more time, but it is much safer to get the key to the CAVE Hole and walk down the stairs and go through the doors. Your CAVE privileges could be suspended or even terminated if you do not comply. If you have questions or concerns, please contact the UVAG/CVEV system administrator (email: uvag-admin@snoid.sv.vt.edu or phone: 540-231-2054)

Overview

The Virginia Tech CAVE has a motion platform hidden beneath the floor. The MOOG 6DOF2000E Motion System with serial interface is a motion platform with 6 degrees of freedom as shown in Figure 1.

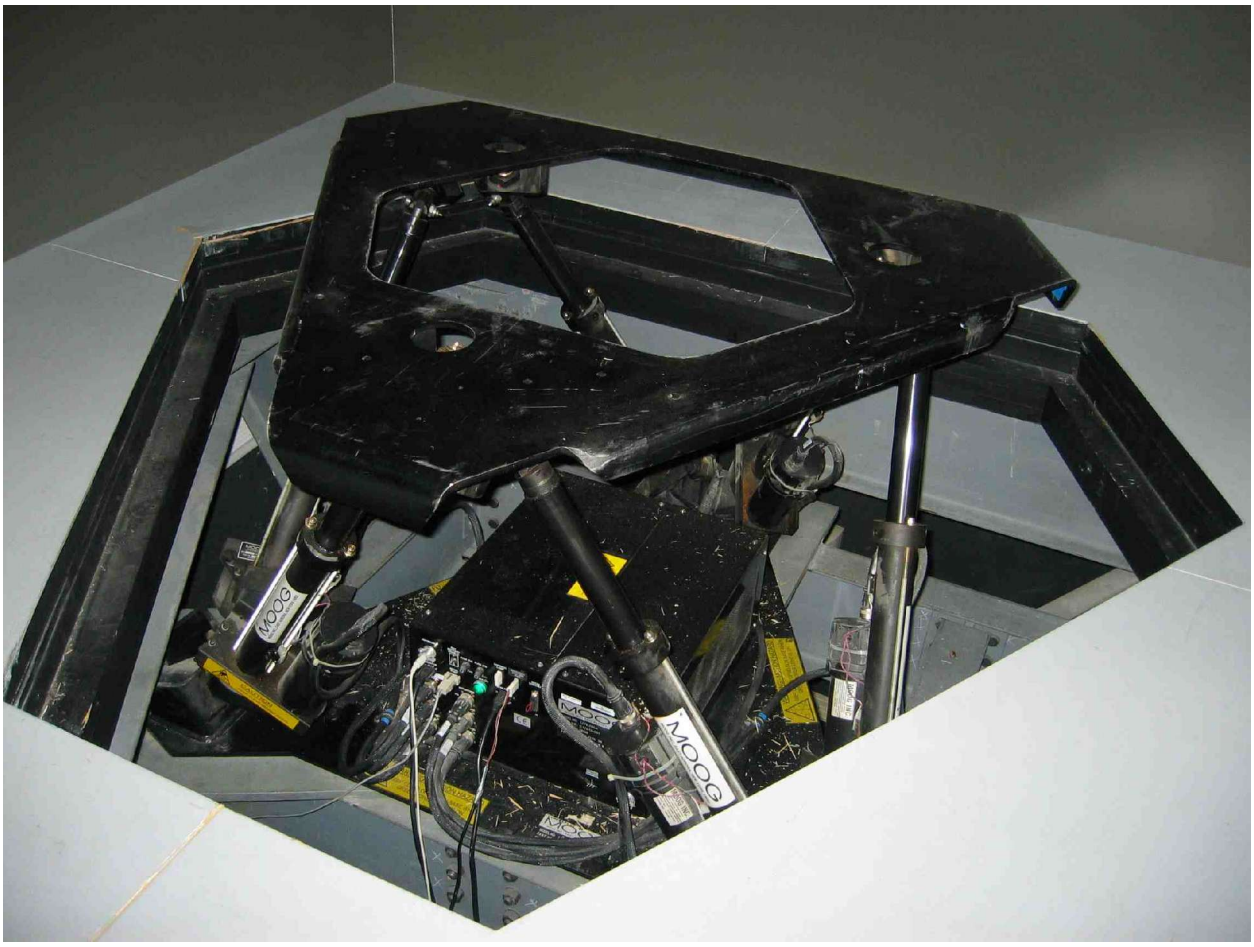


Figure 1. The MOOG motion platform and control panel.

The motion platform is supported by 2 beams specially designed to support it. There is a room beneath the motion platform from which you can access the MOOG motion platform and all of its controls. It is important to inspect the beams and their supports occassionally. If there are signs of cracks or if nuts and bolts appear to have become loose you should refrain from using the motion platform and contact the system administrator.

There is a control panel (Figure 1) and a motion control system display below the motion

platform. The motion control system display provides useful information for diagnosing problems with the motion platform.

This guide will explain how to set up and use the MOOG Motion Platform. The MOOG is now supported by all recent versions of DTK (2.3.2 is the most recent version) for both the SGI/IRIX and Linux platforms in the Virginia Tech CAVE.

The DTK and MOOG libraries, as well as the hoverCraft demo were all written by Lance Arsenault. The MOOG library requires DTK and the hoverCraft demo requires both the DTK and MOOG libraries. I only made minor modifications to allow the MOOG library and hoverCraft demo to work with DTK-2.3.2 for SGI and Linux platforms.

A procedure list is provided at the end of this document.

Conventions Used in this Document

Command line prompts are denoted by a $ followed by a space and then the command to enter on the command line prompt. As an example, if you were going to check your current working directory using the pwd command, it would be denoted as follows:

```
$ pwd
```

implying that you should type “pwd” followed by pressing the enter key.

Preparation

> **WARNING –** Do NOT remove the serial adapters from the SGI or Linux box. The RJ-45 cable can be easily removed from the adapter the same as an ethernet cable. Also, do NOT plug ethernet cables into the adapters or the RJ-45 cable used for the MOOG into an ethernet port or you could damage the hardware.

SGI Onyx/IRIX

To use the MOOG on cave.sv.vt.edu, enter the computer room and verify that the RJ-45 cable is plugged into the RJ-45/9-pin serial adapter located at tty73 (/dev/tty4d73) port on the back of the SGI Onyx as shown in Figure 2. If it is not plugged in, it should be removed from the Linux box.

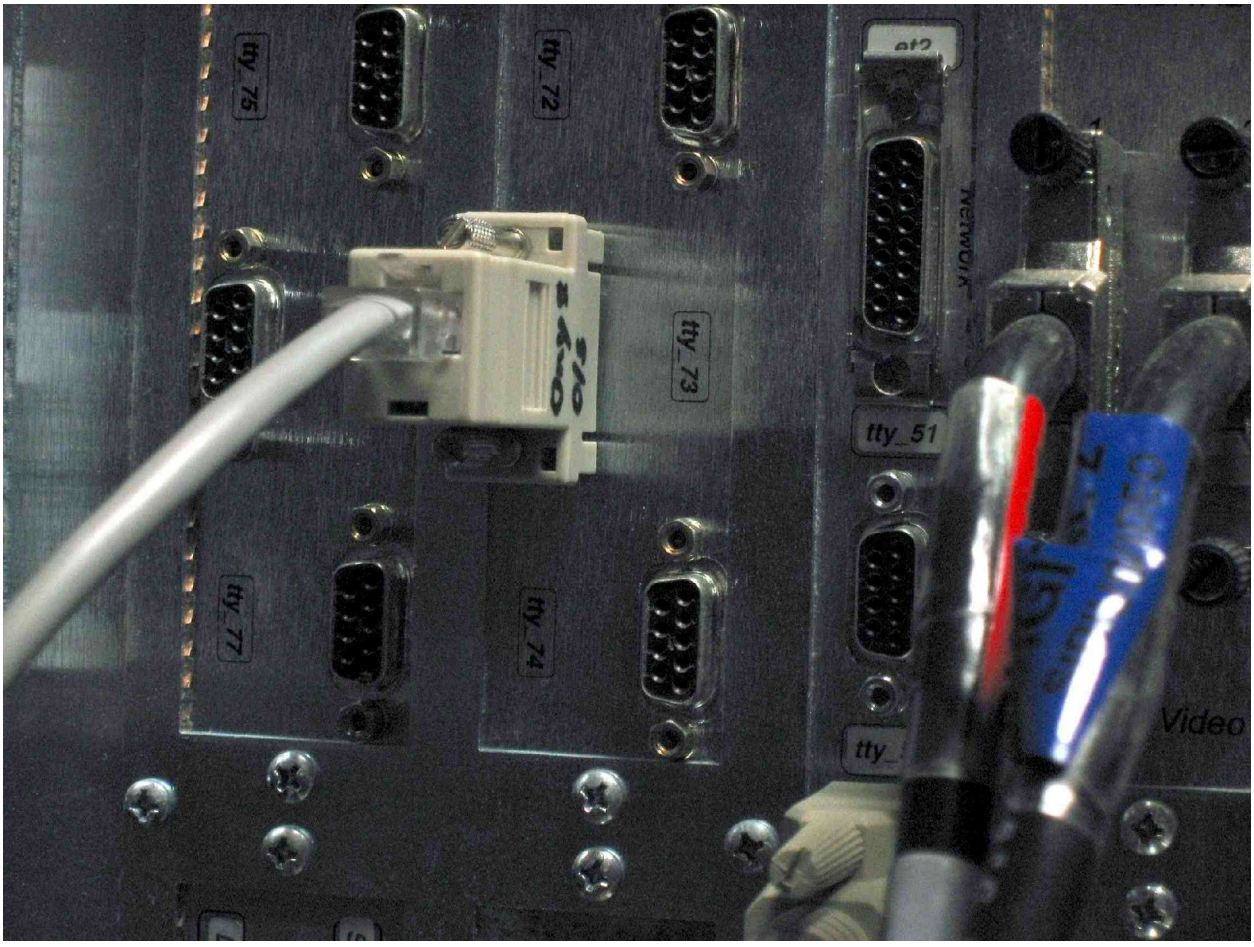


Figure 2. The RJ-45 adapter on the SGI Onyx

Start the MOOG service by running

```
$ dtk-server moog -d
```

Skip to “Using the moog-gui Application” section below.

DADS (Linux cluster)/Linux

To use the MOOG on the DADS system, enter the computer room and verify that the RJ-45 is plugged into the RJ-45/9-pin serial adapter located on the RS-422/RS-485 multi-port serial PCI card on the back of hammer.sv.vt.edu as shown in Figure 3. If it is not plugged in, it should be removed from the the SGI Onyx machine and plugged in to the left most port (/dev/ttyS4).

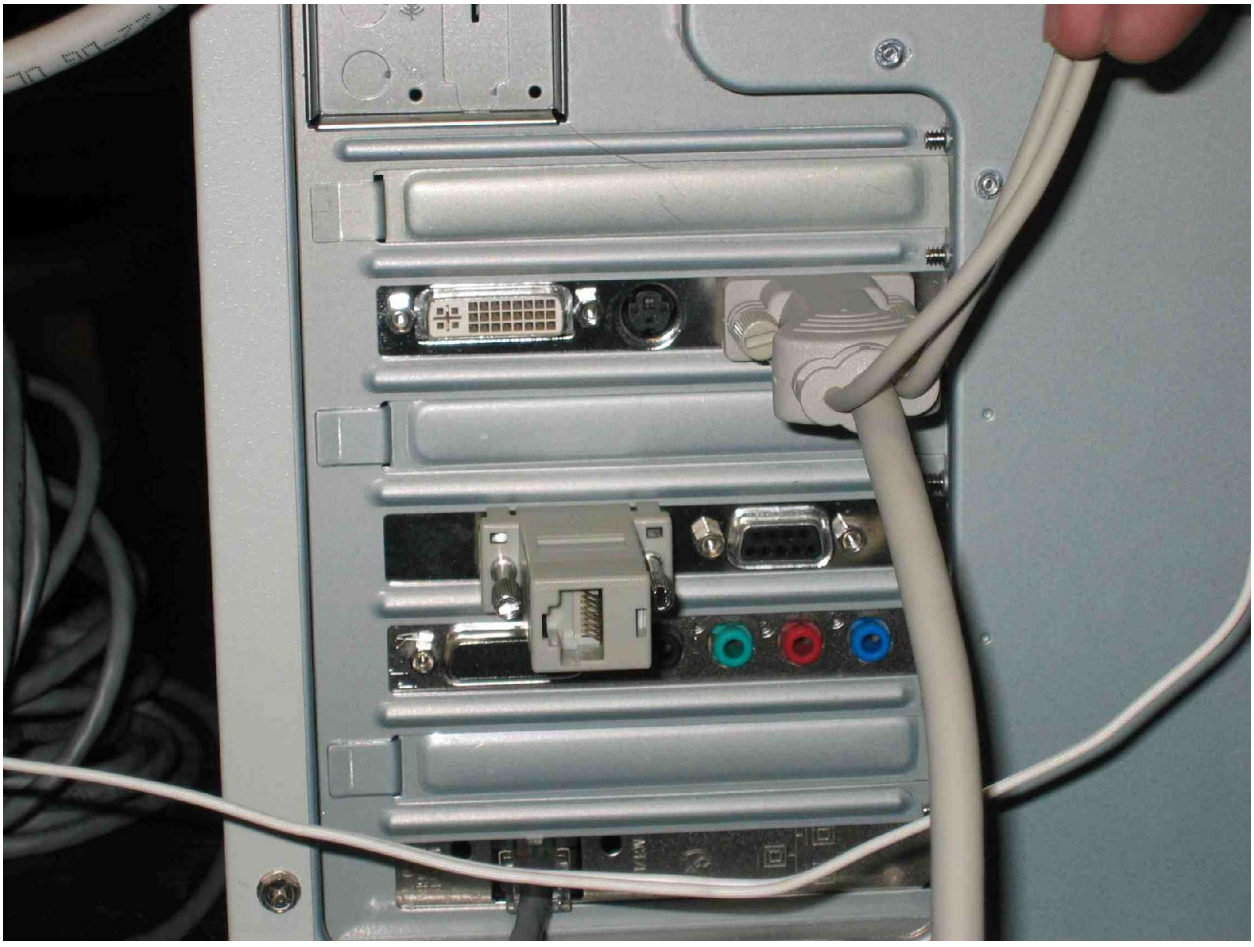


Figure 3. The RJ-45 adapter on the Linux box hammer.sv.vt.edu

Once the MOOG serial cable has been plugged into the correct machine you can run the moog

service on hammer. There are several ways to do this, the simplest being to log into hammer and run the service.

```
$ dtk-server moog -d
```

Using the moog-gui Application

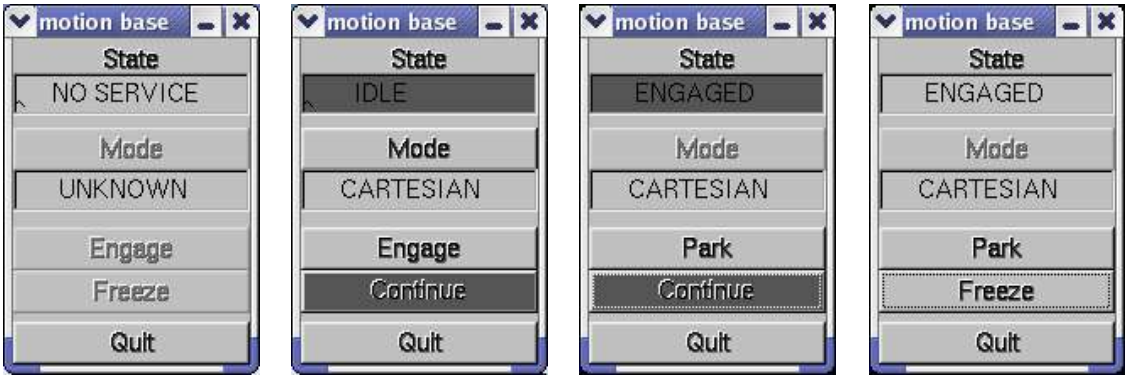
> **Important** – Always use the Cartesian mode during preparation of the MOOG motion platform. Never use the Actuator mode during preparation or you could damage the MOOG, flooring, or screens.

Run the moog-gui application

```
$ moog-gui
```

The moog-gui program brings up a window showing the current state along with several options. If the moog service has not been started or the service errored out, the moog-gui state will be shown as NO SERVICE as shown in Figure 4(a). All buttons are dimmed and no action can be taken when the service is not available.

If the service is running properly the state will be shown as IDLE as in Figure 4(b). The Mode, Engage, and Continue buttons will be available. Pressing the Mode button will toggle between Cartesian and Actuator modes. Always choose Cartesian mode.



(a) (b) (c) (d)

Figure 4. (a) moog-gui with NO SERVICE.
(b) moog-gui with IDLE state.
(c) moog-gui with Engaged state.
(d) moog-gui with Engaged state and Continue button pressed

When the Engage button is pressed the current state will change to Standby. It may take up to a minute for the Standby state to change. The motion platform should then raise approximately 4 inches and the state will change to Engaged as shown in Figure 4(c). If the Continue button is visible then the motion platform will not respond to commands changing its position. Pressing

the Continue button, it will be replaced by a Freeze button as shown in Figure 4(d) and the platform will then allow movement of the motion platform. Pressing the Park button will lower the motion platform to its home position, the state will return to IDLE, and the Park button will be replaced by the Engage button as in Figure 4(b).

The motion control system display is useful when troubleshooting MOOG motion platform problems. Figure 5(a) shows the motion control system display in IDLE state. Figure 5(b) shows STANDBY state. Figure 5(c) shows ENGAGED state. Figure 5(d) shows the motion control system display in ENGAGED state and the motion platform has been moved to some arbitrary location.

Figure 5. (a) The motion control system display in IDLE state.

Figure 5. (b) The motion control system display in STANDBY state.

Figure 5. (c) The motion control system display in ENGAGED state,

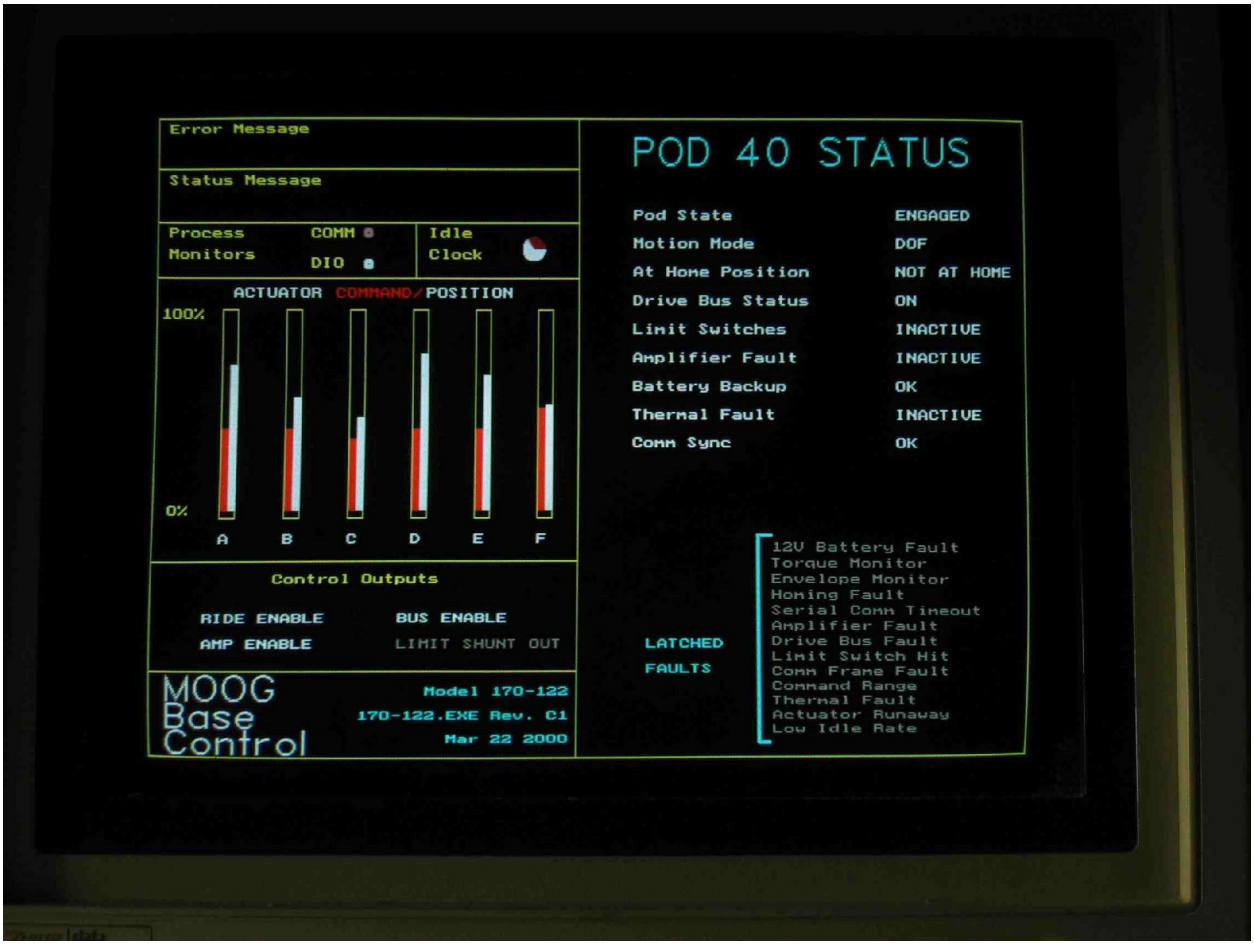


Figure 5. (d) The motion control system display in ENGAGED state and moved from initial ENGAGED position.

Removing the MOOG Cover

The motion platform is hidden by a hexagonal cover flush with the floor of the CAVE which can be seen in Figure 6 if you look closely at the floor around the base of the tripod. To use the motion platform this cover must be removed. A description of the procedure to remove the cover follows.

There is a box covered in black felt approximately 6 feet high on the left side of the CAVE. You should place both the wand and the head tracker in this box while installing and uninstalling the MOOG cover and chair.

Figure 6. The hexagonal motion platform cover.

There are two wheeled beams which are used to remove the MOOG cover. The longer beam should be placed toward the back of the CAVE away from the MOOG cover as shown in Figure 7. Be very careful while placing the wheeled beams in the CAVE as it is possible to tear the

CAVE screen material. The shorter wheeled beam should be placed near the front of the CAVE away from the MOOG cover.

Pressing the Engage button within the moog-gui application will raise the motion platform cover approximately 4 inches as shown in Figure 7. Verify that the mode was properly set to Cartesian and not Actuator. Use dtk-floatSliders to increase the height of the motion platform.

```
$ dtk-floatSliders /tmp/dtkSharedMem/moog/position
```

The default position of the sliders is portrayed in Figure 8. If any of the sliders are non-zero except for the 3rd slider, please park the motion platform from the moog-gui application and verify that all steps have been followed correctly. Be sure to only use the slider controlling the height (should be the 3rd from the top) otherwise you could cause damage to the motion platform, the flooring, or even the screens.

Figure 7. Placement of the long beam used to hold the motion platform cover.

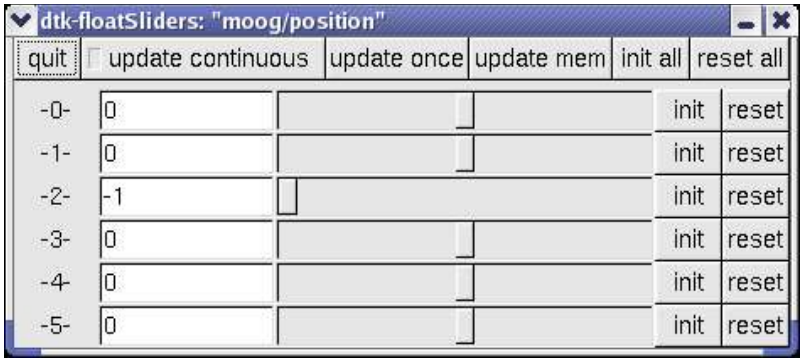


Figure 8. Default position of dtk-floatSliders for moog/position.

In the moog-gui window, press the Continue button to allow adjustment of the motion platform. The Continue button will change to Freeze to show that movement of the motion platform is now possible. Using the slider bar (should be 3rd from the top) to control the height of the MOOG cover, slowly adjust the height to be between 0.7 and 1.0 units (high enough to allow the beams to be moved under the cover and allow the pegs to be inserted). Press the Freeze button to prevent movement of the MOOG.

Use the four wooden pegs to lock the MOOG cover to the wheeled beams. There are holes in the arms of the wheeled beams which match up to holes in the motion platform cover as shown in Figure 9.

(a) (b)

Figure 9. (a) Holes in the motion platform cover and arms of the wheeled beams
(b) The wheeled beam with peg inserted through the holes.

Once all of the pegs have been inserted the motion platform can be lowered slowly and carefully to verify that the motion platform has cleared the motion platform floor cover and won't cause damage to the flooring or the beams. In the moog-gui window click the Continue button to allow movement of the MOOG. Use the slider bar (should be 3rd from the top) to slowly adjust the height to -1.0 units (the minimum height possible). Then hit the Freeze button to prevent movement of the motion platform. Slowly and carefully roll the MOOG cover out of the CAVE making sure not to hit the screens. It is best to angle the wheels before moving it as the wheels do not easily adjust to the direction of desired travel when the cover is attached.

After the MOOG cover has been removed from the CAVE, it should be rolled toward the door and propped up against the wall as shown in Figure 10. Be very careful to avoid the projector while propping the cover up. Unfortunately there is no easy way to move the MOOG chair around the MOOG cover if they are both laying flat on the floor.

Figure 10. The motion platform cover propped up next to CAVE entrance.

Installing the MOOG Chair

Looking at the chair and its wheeled carrier you will see a latch at the back with a large bolt which should be resting in a hole in the back of the chair platform. This latch must be latched into the hole before any movement occurs as shown in Figure 11(a). If the latch is not in place it is possible that the chair could fall off of the carrier during movement.

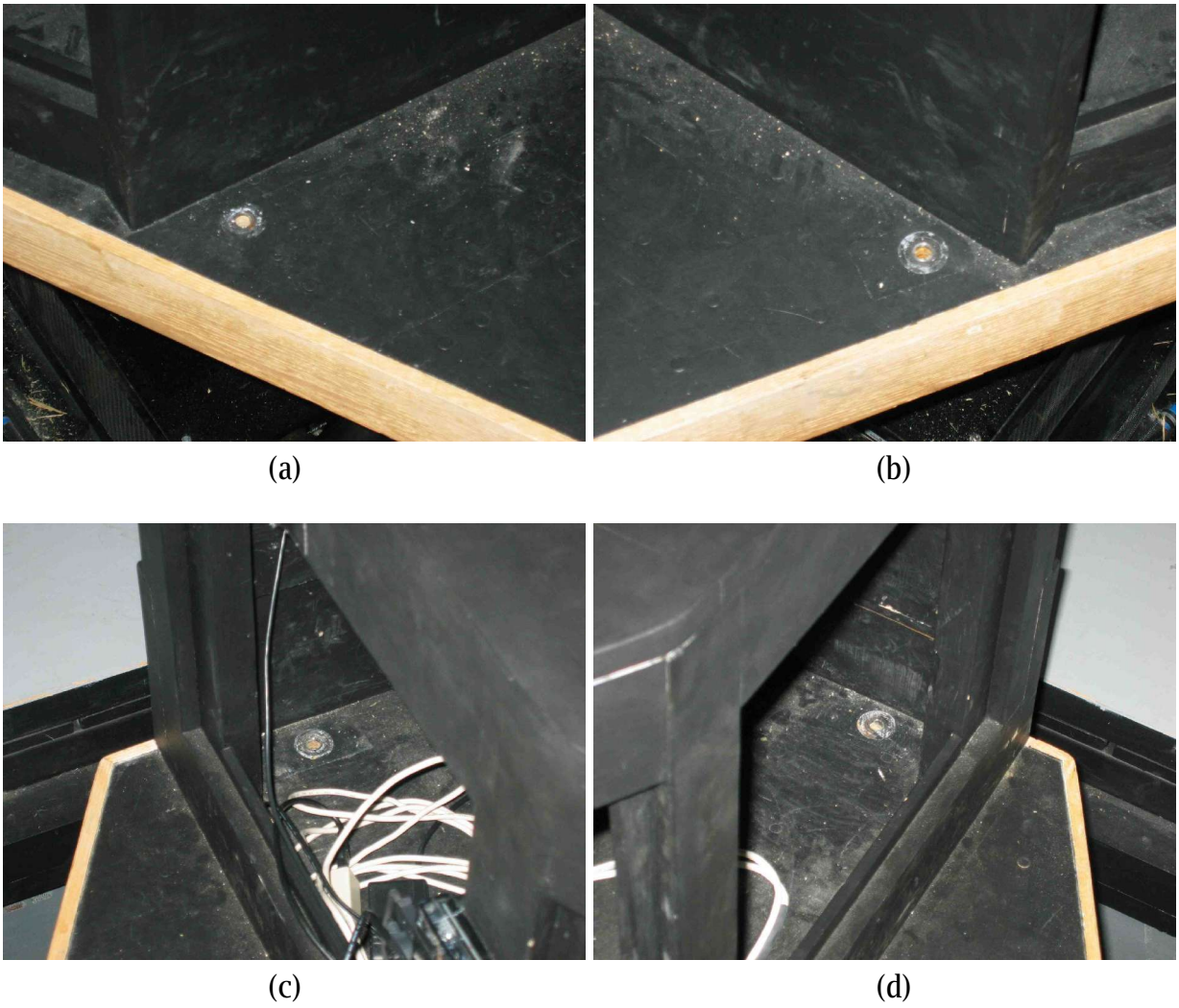
(a) (b)

Figure 11. (a) MOOG chair carrier latched to chair.
(b) MOOG chair carrier unlatched from chair.

Roll the chair into the CAVE with the arms facing the front wall. Try to place the chair above the motion platform with as much accuracy as possible. Click on the Continue button and very slowly raise the height of the motion platform until it just starts to raise the chair (between 0.5 and 1.0 inches). With some force you may need to adjust the chair to make certain it is seated properly on the motion platform. Once you are satisfied that the chair is seated properly, unlatch the carrier from the chair, as shown in Figure 11(b) and use the sliders to raise the chair to its highest limit. Click the Freeze button to prevent movement of the motion platform. Slowly and carefully roll the chair carrier out of the CAVE.

Figure 12. Tools needed to secure the chair to motion platform.

There are 4 holes through the chair base which match up with holes in the motion platform. To install the chair securely you will need the tools shown in Figure 12. These include a wrench, a ratchet set, a hammer, 4 bolts, 4 lock washers, 4 large washers, and 4 nuts. The ratchet set can be found in the tool chest to the right of the entrance to the CAVE room. The remainder of the items are in the tin bucket which usually sits atop the tool chest.



(a) (b)

(c) (d)

Figure 13. The holes used to bolt the chair assembly to the motion platform.
(a) rear left (b) rear right (c) front left (d) front right

There are 2 holes easily visible on the base behind the chair as shown in Figure 13(a) and (b). The other 2 holes are located on either side of the chair in the space underneath the chair arms as shown in Figure 13(c) and (d). Verify they are aligned before proceeding. Use the bolts, washers and nuts to bolt the chair to the motion platform. The bolts should be inserted from the top of the chair through the lock washers and through the holes. If they do not slide through easily to sit flush with the chair base, you can use a hammer to lightly tap the the bolts through. The large washers should be inserted from the bottom and the nuts tightened from the bottom. Be certain to thread the nuts after inserting the washer from below. Use the wrench to hold the nuts from the bottom and the ratchet to tighten from the top. All four bolts should be securely tightened before use of the motion platform with the chair. The forces generated by the motion platform are sufficient to throw the chair off the motion platform or cause damage to the chair or bolts if not

securely fastened.

Using the MOOG Chair Joysticks

There are two joysticks installed on the MOOG chair. The left is a Microsoft SideWinder 2 joystick and the right is a Logitech WingMan joystick. Both use a USB 1.1 interface. They are plugged into a USB 1.1 hub attached to the left side of the MOOG chair. A USB active extension cable is used to attach the hub to the machine io.sv.vt.edu. The hub should only be connected to a machine which does NOT support USB 2.0 as these machines will not properly recognize the hub.

After the hub has been connected to io.sv.vt.edu, you should ssh into io. Each service is required to be on a separate TCP port. The default port used is 34219. Before calling the additional services, you need to set the new TCP port to be used. The easiest way is to set DTK_PORT to NONE so long as there is a dtk-server service using the default TCP port.

To use the SideWinder 2 joystick start the sideWinder2Joystick service.

```
$ export DTK_PORT=NONE
$ dtk-server sideWinder2Joystick -d
```

The sideWinder2Joystick service creates 4 shared memory segments in the /tmp/dtkSharedMem/sideWinder2 directory.

The shared memory segments created by the sideWinder2Joystick service are

```
sideWinder2/joystick
sideWinder2/throttle
sideWinder2/hat
sideWinder2/buttons
```

To use the WingMan joystick start the wingManJoystick service.

```
$ export DTK_PORT=NONE
$ dtk-server wingManJoystick -d
```

The wingManJoystick service creates 4 shared memory segments in the /tmp/dtkSharedMem/wingMan directory.

The shared memory segments created for the wingManJoystick service are

```
wingMan/joystick
wingMan/throttle
```

wingMan/hat
wingMan/buttons

Configuring DTK Shared Memory

SGI Onyx/IRIX

For the Onyx box cave.sv.vt.edu you only need to connect shared memory for the joystick shared memory segments you will require. There are 4 shared memory segments associated with both joystick services as listed in Table 1.

Shared Memory Segment	***Size***	***Byte Size***
joystick	3 floats	12
throttle	1 float	4
hat	2 chars	2
buttons	1 char	1

Table 1. Shared memory segments common to both joysticks

To use the shared memory segments on the SGI Onyx, you must first create the shared memory segments locally and then connect to the remote shared memory segments. You only need to do this for the shared memory segments that you will need.

To create the joystick shared memory segment (replace joystickname with either wingMan or sideWinder2 depending on which shared memory segments you will need from each joystick),

```
$ dtk-getSharedMem 12 joystickname/joystick
$ dtk-connectRemoteSharedMem joystickname/joystick io joystickname/joystick

$ dtk-getSharedMem 4 joystickname/throttle
$ dtk-connectRemoteSharedMem joystickname/throttle io joystickname/throttle

$ dtk-getSharedMem 12 joystickname/hat
$ dtk-connectRemoteSharedMem joystickname/hat io joystickname/hat

$ dtk-getSharedMem 12 joystickname/buttons
$ dtk-connectRemoteSharedMem joystickname/buttons io joystickname/buttons
```

The moog shared memory segments are local to the SGI Onyx box (cave.sv.vt.edu) so there is no need to set them up as remote shared memory.

DADS (Linux cluster)/Linux

For the DADS system you need to connect shared memory for the joystick shared memory segments you will require as well as moog shared memory segments and any other shared memory segments used by the demo or application you are going to run. There are 4 shared memory segments associated with both joystick services as listed in Table 1 above (SGI Onyx/IRIX section). There are 4 shared memory segments associated with the moog service as listed in Table 2 which need to be shared with all of the DADS machines.

Shared Memory Segment	***Size***	***Byte Size***
moog/command	1 char	1
moog/state	2 ints	8
moog/position	6 floats	24
moog/sent	6 floats	24

Table 2. Shared memory segments for moog service

To use the shared memory segments on the DADS system, you must first create the shared memory segments locally and then connect to the remote shared memory segments. You only need to do this for the shared memory segments that you will need.

To create the joystick shared memory segment (replace joystickname with either wingMan or sideWinder2 depending on which shared memory segments you will need from each joystick),

```
$ dtk-getSharedMem 12 joystickname/joystick
$ dtk-connectRemoteSharedMem joystickname/joystick io

$ dtk-getSharedMem 4 joystickname/throttle
$ dtk-connectRemoteSharedMem joystickname/throttle io

$ dtk-getSharedMem 12 joystickname/hat
$ dtk-connectRemoteSharedMem joystickname/hat io

$ dtk-getSharedMem 12 joystickname/buttons
$ dtk-connectRemoteSharedMem joystickname/buttons io
```

The moog shared memory segments will need to be remotely shared between the console and all of the DADS machines. The following list of dtk shared memory commands should be run on all of the machines.

```
$ dtk-getSharedMem 1 moog/command
```

```
$ dtk-connectRemoteSharedMem moog/command hammer

$ dtk-getSharedMem 8 moog/state
$ dtk-connectRemoteSharedMem moog/state hammer

$ dtk-getSharedMem 24 moog/position
$ dtk-connectRemoteSharedMem moog/position hammer

$ dtk-getSharedMem 24 moog/sent
$ dtk-connectRemoteSharedMem moog/sent hammer
```

MOOG Demo – hoverCraft

The hoverCraft demo is a combination of several programs. The render program renders PerformerTown on the display(s). The motionCue program move the chair in response to changes in movement/acceleration. The vehicleDynDrive and vehicleDynFly programs are each used for navigation. The joyRide program is used in conjunction with either of the navigation programs to give greater response, and extreme sensitivity to the controls (sort of like riding a bull – if it gets too much for you just let go of the joysticks and the ride should calm down). Only one of these navigation programs should be used in conjunction with the render and motionCue programs.

Prepare the CAVE for the MOOG chair as described above whether on the SGI Onyx (cave.sv.vt.edu) or on the DADS system. Only after the chair has been securely bolted to the motion platform should these programs be run. The moog should be parked and remain in an idle state until the passenger has boarder and buckled themselves in securely.

For the SGI/Onyx the shared memory will be local, so there is no need to worry about the shared memory. For the DADS system you will need to remotely connect the shared memory to each of the DADS machines.

```
$ dtk-getSharedMem 24 hoverCraft/motionBase_gr
$ dtk-connectRemoteSharedMem hoverCraft/motionBase_gr console

$ dtk-getSharedMem 24 hoverCraft/vehicle_gr
$ dtk-connectRemoteSharedMem hoverCraft/vehicle_gr console

$ dtk-getSharedMem 72 hoverCraft/vehicleDyn
$ dtk-connectRemoteSharedMem hoverCraft/vehicleDyn console
```

The hoverCraft/motionBase_gr shared memory segment is used by the motionCue program. The hoverCraft/vehicle_gr and hoverCraft/vehicleDyn shared memory segments are used by the navigation programs.

For the SGI, only the shared memory for the sideWinder2 and wingMan need to be remotely connected. For the DADS system the sideWinder2, wingMan, moog, and hoverCraft shared memory segments need to be remotely connected to all of the DADS machines. After all shared memory segments have been remotely connected as necessary, you can run the programs. WIth the moog in a parked state (idle), run the hoverCraft programs.

```
$ render
$ motionCue
```

$ vehicleDynDrive or vehicleDynFly

and for those with a sense of adventure

$ joyRide

The basic controls for the hoverCraft demo are shown in Table 3.

	Left Joystick	***Right Joystick***
Forward	* Decrease elevation	Accelerate
Backward	* Increase elevation	Decelerate
Left	Turn left	Strafe left
Right	Turn right	Strafe right

Table 3. Basic controls for vehicleDynDrive and vehicleDynFly navigations.
* Indicates that this control is not supported by vehicleDynDrive.

For safety reasons it is best that another person be present to engage and park the MOOG chair.

Have fun! Figure 14 shows a person experiencing the hoverCraft demo sitting in the MOOG chair.

Figure 14. Someone having fun with the motion platform in the CAVE.

Uninstalling the MOOG Chair

You must exit out of every program that is accessing MOOG shared memory. You do not want anything affecting moog shared memory while in close proximity. This would be very hazardous and could result in loss of limb or even loss of life if a sudden change in the shared memory segment were to occur.

You should use the dtk-floatSliders to reset all shared memory segments to 0 and then raise the chair to its highest position using the 3rd slider from the top as shown in Figure 15. Press the Freeze button in the moog-gui program. You may now remove all of the bolts holding the chair to the motion platform. You should use the wrench to hold the nut from the bottom while untightening the bolt from the top. Be sure to hold the wrench near the nut so you can hold the nut and washer up once it is unfastened. If you drop the nuts, bolts, or washers you will have to retrieve them. If you fail to do so, you may lose your CAVE privelages.

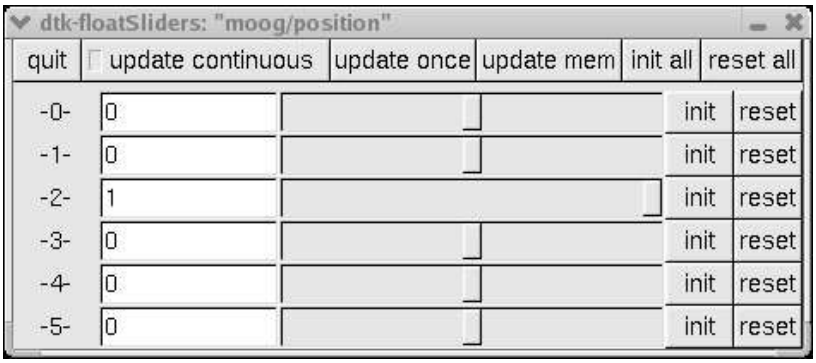


Figure 15. Position of dtk-floatSliders when installing and uninstalling the MOOG chair.

Once the chair has been loosened, slide the chair carrier into the CAVE and place just behind and beneath the chair. Press the Continue button and lower the chair until it is just above the flanges on the arms of the chair carrier (about an inch below the top of the arms). Push the chair carrier forward until the arms touch the sides of the chair. Slowly lower the chair until some of its weight is resting on the flanges of the chair carrier arms. You should now latch the chair carrier to the chair as shown in Figure 16 below. Once latched, you should lower the motion platform to its lowest position and click the Freeze button. Roll the chair and carrier out of the CAVE space and back to its original location in the back of the CAVE room.

(a) (b)

Figure 16. (a) MOOG chair carrier unlatched from chair.
(b) MOOG chair carrier latched to chair.

Replacing the MOOG Cover

Lay the motion platform cover flat on the floor with the wheeled beams still attached. Roll the motion platofrm cover into the CAVE with the longer wheeled beam to the rear of the CAVE space. Position the motion platform cover above the motion platform with as much accuracy as possible. Press the Continue button in the moog-gui application. Slowly raise the motion platform until it starts to lift the motion platform cover. You will need to use some force to verify that the motion platform cover is seated properly on the motion platform.

Once the motion platform cover is seated on the motion platform, raise the motion platform to reduce the weight on the wheeled beams and remove the 4 pegs. Roll the short wheeled beam out of the CAVE. Roll the longer wheeled beam away from the motion platform cover so that it will not impede its movement when it is lowered into the floor. Slowly lower the motion platform to its lowest position insuring that the motion platform cover will clear the edges of the hole in the floor. Once it has been lowered completely, click the Park button in the moog-gui application and the motion platform cover should be lowered flush with the floor.

You should now exit the dtk-floatSliders and moog-gui programs. You should also kill the dtk-server MOOG service on whichever machine it was started on.

Carefully remove both the short and long wheeled beams from the CAVE space and return them to their original location near the MOOG chair.

Procedure List

1. Plug RJ-45 cable into SGI Onyx (cave.sv.vt.edu) or Linux box (hammer.sv.vt.edu) depending on the system you wish to use.
2. Start DTK moog service on the respective machine.
3. Run the moog-gui application from the respective machine.
4. Set moog-gui mode to Cartesian.
5. Use dtk-floatSliders to adjust the height (3rd slider from top) during removal/replacement of motion platform cover and installation/uninstallation of MOOG chair.
6. Remove the motion platform cover – use the wheeled beams.
7. Install the MOOG chair – be sure to securely bolt the chair to the motion platform using all 4 holes in the base of the chair.
8. Run MOOG-enabled applications to use the motion platform.
9. Uninstall MOOG chair – use the chair carrier and be sure to latch the carrier to the chair.
10. Replace motion platform cover – use the wheeled beams.