A MANUAL FOR THE 401CR.

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INTRODUCTION

THE FORCE DYNAMICS 401CR…

…is a high-performance, 4-axis motion base utilizing three ball-screw struts, mounted on a floor allowing for continuous rotation of the platform via slip rings. Computers are on-board, and can 'jump onto' a local wireless network

Its features include low latency and high frequency response, a variety of display options, powerful 5.1 surround sound, and platform geometry designed to achieve maximum motion with minimum parasitic forces, power usage, and footprint.

CONTACT

If you have questions or concerns, Force Dynamics will be happy to help. We can be reached by phone 9 a.m. - 5 p.m. EST, Monday through Friday.

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INTRODUCTION

HOW TO USE THIS MANUAL

This is a pretty simple document, and most likely you'll be fine just reading through. But for completeness' sake, here are some examples of the text formatting conventions used.

Notes enclosed by **(())** marks are advisory:

[[*STRETCHING THE SEAT BELT EXTRA-FAR WILL MAKE LATCHING EASIER.* **]]**

Notes enclosed by **<<>>** marks are mandatory:

<< *PHYSICAL ADJUSTMENTS MUST NEVER BE MADE WHILE MOTION IS ENABLED.* **>>**

Inputs to the Galil smart terminal are shown in their…

…default colors and font:	`:PT*=?`
…and the same for outputs:	`: 1, 1, 1, 0`

Web links and other general typed input are shown as follows:

http://www.force-dynamics.com/dmcsmartterm02.exe

SAFETY FIRST

READ THIS

If you don't read any other section of a manual this summer, read this one. Failure to exercise appropriate safety measures — which include timely and thorough maintenance — can result in damage to profits, things, and people.

It's important.

PLEASE DON'T GET BRAINED BY OUR MOTION PLATFORM

It's not a toy, and it's more powerful than it appears. It is capable of moving much more quickly and much further than it will during normal operation. Stay clear.

> **<< THE PLATFORM AREA MUST BE CLEAR DURING OPERATION. >>**

As long as the main power switch is set to 'on', the platform should be treated as if it might move at any speed, in any direction, at any moment. If you lean on the platform, and it's been left with a car idling in-game, a fender-bender with a miscalculating opponent could deliver a large chunk of unstoppable metal to your jaw.

> **[[THE MOTION SYSTEM IS MUCH STRONGER THAN YOU ARE.]]**

It's easy to become complacent about the 'stay clear' rule when the machine has been operating smoothly for a while, but remember that the simulator doesn't care how long it has been working predictably. The machine has multiple fail-safes, but if there's going to be a failure at all, there's no reason for it not to happen when you're reaching over the top of the platform to grab your phone.

Stay clear while the power is on.

SYSTEM REQUIREMENTS

ELECTRICAL REQUIREMENTS

The 401CR operates on either low voltage, 90 -120 VAC, 50 or 60 Hz, or high voltage, 180 — 240 VAC, 50 or 60 Hz.

With low voltage the circuit must supply 20 amperes RMS; high voltage requires a circuit that can supply 10 amperes RMS.

Line filter ground currents will trip most GFI (ground fault interrupter) breakers. **GFI breakers cannot be used**.

The machine draws current peaks that are four times the RMS for periods of up to two seconds. For this reason the supply circuit must be equipped with a thermal circuit breaker rather than a magnetic breaker.

POWER CORDS

Power is supplied to the 401CR via an IEC 60320 C20 connector located on the floor at the rear of the machine.

MECHANICAL REQUIREMENTS

The static operating weight is 1040 pounds (472 kg) plus the weight of the driver. Under operating conditions, the floor can be expected to carry dynamic loads up to twice this value, with heavy vibrations. These loadings can overwhelm some types of residential floor construction, and damage could result. Seek professional advice if there are any doubts about these issues.

SYSTEM REQUIREMENTS

SAFE OPERATING DISTANCES

The following are the minimum safe operating distances for use of the 401CR. When possible, larger distances are preferable. In all cases, local issues (such as fencing, heavily used public paths, trade show aisles, etc) should be taken into account when setting up the simulator.

USER LIMITATIONS

The size, weight, and age of the driver should be matched to the type of program and/or motion profile being run. Smaller drivers should observe the limitations of the seat belt restraints. Ability to reach all controls is important, as is the ability to understand those controls.

In general, Force Dynamics recommends that users should meet qualifications similar to those for family-entertainment-style go-karts, eg. no pregnant women, no riders with back problems, no riders under X cm tall, etc. Operators should consult local regulations before using the simulator in a public place.

Maximum driver weight for the 401 is 220 pounds (100 kg).

Overloading the unit can lead to the servo motors overheating, and reduced acceleration during vertical moves.

UNPACKING

Our simulators are shipped crated and fully assembled. Once installed in place, they're ready to use. Please refer to the following instructions for unpacking and setup of the 301 and 401.

THE 401CR

1   Remove top and sides of shipping container.

2   Remove plywood shipping clamps from leveling feet under steel floor.

3   Using suitable forklift, remove machine and floor assembly as one unit, using lifting tubes in floor assembly. **Caution: Lift machine by lifting tubes only!**

4   After the simulator is set in place, use caution in removing straps holding up folded floor sections. **Floor sections are heavy!**

5   Remove strap and support bar under nose of machine.

6   After machine is turned on and lifted for the first time, remove white shipping blocks from side struts.

7   Re-zero the simulator after removal of shipping blocks.

UNPACKING

THE 301

1   Remove top and sides of shipping container.

2   Remove four bolts holding machine to base of shipping container.

3   Lift the simulator from base of shipping container with forklift using lifting tubes under bottom of machine. Caution: Lift machine by lifting tubes only!

4   With machine on forklift, install the four rubber isolation feet.

5   After machine is turned on and lifted for the first time, remove white shipping blocks from side struts.

**6**   Re-zero the simulator after removal of shipping blocks.

RECOMMENDED SOFTWARE

While detailed information on all supported (or potentially-supported) software is beyond the scope of this manual, an overview of the most commonly used programs is useful. This guide is not intended to be exhaustive; in this area, the best teacher is experience.

Some information on game operation will be provided, however, that instruction is usually best left to the documentation provided by the game developers themselves. Force Dynamics will provide limited support for game software where practical and where such support is important for operation with its motion platforms, but we cannot be responsible for assistance with day-to-day game operation unless arrangements have been made in advance (e.g., along with custom content development).

Following are overviews of the three main software titles used with our motion platforms: iRacing, Live For Speed, and rFactor.

iRACING
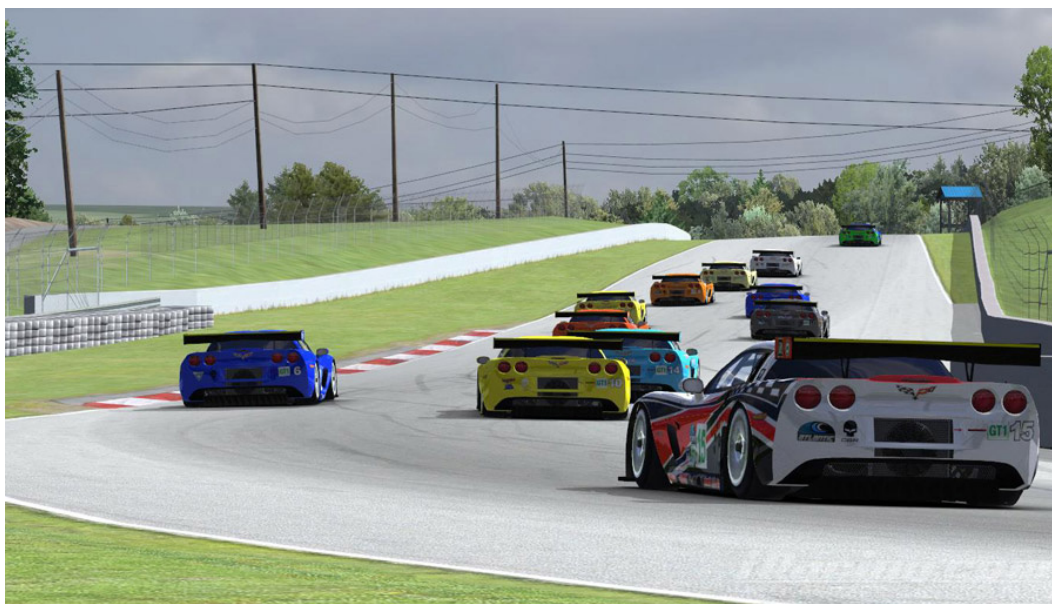
Easily the most realistic of the three, iRacing is a no-compromises simulation top-to-bottom. Tracks are laser-scanned, resulting in surface accuracy which is practically impossible via other means; vehicles are modeled with assistance from manufacturers, and the simulation's tire model — arguably the most important and difficult part of a racing simulation — is excellent and updated frequently.

Solo races against computer-controlled cars won't happen; there aren't any computer-controlled cars against which to race. All competition is done via pre-scheduled internet races with other similarly-skilled opponents, or via similarly-arranged solo time trials. ▶

RECOMMENDED SOFTWARE

▶▶The main negative of iRacing is its requirement for an always-on internet connection; secondarily, its accuracy and (until recently) complete lack of aids to assist new drivers give it a learning curve nearly as steep as the real thing.

One mitigating factor: Unlike real life, you can make as many mistakes as you want without incurring penalties to life, limb, checkbook — or reputation.

But don't celebrate yet — that only applies in practice. In a race against other live opponents, 'agricultural' excursions, course-cuts, and collisions with other vehicles are punished severely by the game's automatic marshals. And adding isult to injury, enough on-track indiscretions will find your license demoted (yes, you need a license for various levels of competition) or even revoked.

Realism has a price.

LIVE FOR SPEED

Called LFS for short, Live For Speed is an independent title created, remarkably enough, by three individuals in the UK and Europe. Responsible respectively for code, graphics, and music and web design, they have triple-handedly produced a renowned simulation which punches far above its weight in developers.

Live For Speed's main claims to fame are a fantastic and incredibly detailed online race matching and statistics system, excellent network performance with large numbers of competitors, a clean and intuitive user interface, and a physics engine which, while not as accurate as iRacing's, uses 'real' modeling for every aspect of output. ▶

RECOMMENDED SOFTWARE

▶ Rather than having sampled engine sounds, for instance, audio is derived from a physical model of the engine and exhaust system; rather than having one system to display tires and one to calculate a 'black box' interaction model, LFS's tire physics are integrated. Pause a car mid-corner in a replay, and you can see the tires's sidewalls stretching inward; abuse a tire enough, and a flabby carcass will join you in the slow plod back to the pit lane.

There are negatives to such an integrated approach, however. A somewhat capricious damage model will occasionally see cars sail off into the wild blue yonder, where they suddenly stick in place mid-flight with a humiliating RETIRED label greeting the unfortunate driver. If you find yourself unlucky enough to be rear-ended by a reckless competitor while entering the pits, you can prepare for a penalty — for speeding in the pit lane.

Quirks aside, LFS's detailed physics engine and low-pressure community make a nice break from the competitiveness of iRacing and rFactor, while retaining an excellent driving model.

RFACTOR

rFactor, while not as polished as Live For Speed or obsessively-realistic as iRacing, has excellent physics, and one standout quality: Extensibility. Both LFS and iRacing are completely closed ecosystems, whereas rFactor allows essentially infinite customizing (the above screenshot is of a sequence Force Dynamics created for Ford's Taurus SHO motion exhibit). rFactor is whatever you want it to be. The same basic engine tests setups for F1 teams, and provides the backbone for the "24 Hours Of Lemons" modification, which features giant mobile fruit — a must for any serious racing enthusiast.

OPERATION

BEFORE STARTUP

Ensure that all cover panels are in place, and that any extraneous loose items are removed from the simulator. Running the machine without covers can result in loose change or other conductive items falling from pockets into the electronics.

>> *PHYSICAL ADJUSTMENTS MUST NEVER BE MADE WHILE MOTION IS ENABLED.* <<

The Driver must…   …be sitting in the seat with the seat belt tightly fastened across the pelvis.

…have the door closed and latched.

…make all steering wheel and foot pedal adjustments before the simulation begins.

The Operator must…   …ensure that all of the safety features of the simulator are functional and have not been disabled.

…not allow more than one person in the simulator at a time.

…check for and remove any loose items from the machine, both seat and base (change, iPhones, pacemakers, etc).

…inform all spectators of the movements of the machine, and ensure that no one is within an unsafe distance.

>> *BARRIERS MUST BE IN PLACE TO PREVENT SPECTATOR ACCESS TO DANGEROUS AREAS.* <<

OPERATION

SAFETY PANELS

The clear safety panels surrounding the cockpit are intended to keep the driver's hands and arms clear from moving parts and pinch points in the mechanism. The operator should stop the simulator if any attempt is made by the driver to defeat this purpose.

DRIVER MECHANICAL ADJUSTMENTS

Seat Belt	Pull the retractable belt from its holder and pass it over your lap and snap it into the buckle protruding from the other side of the seat. It can be overextended to provide extra slack to make the insertion into the buckle easier. The seat belt will self retract to the proper tension.
Wheel	The steering wheel can be adjusted up or down by loosening the two clamping knobs, one on each side of the steering console. The console can then be pivoted up or down to place the wheel in a comfortable position. Re-tighten the clamp knobs securely by hand.

[[*STRETCHING THE SEAT BELT EXTRA-FAR WILL MAKE LATCHING EASIER.*]]

Pedals	The entire pedal housing with all pedals can be moved closer to the seat or further away by means of the release lever protruding from the lower left side of the pedal housing. It can be reached from the seated position, but an assistant may be needed to help slide the assembly to a comfortable position. Depress the individual pedals to ensure they can be fully bottomed out.
	Individual pedals can be moved side to side from the factory settings. Access the pedals by removing the cover from the pedal housing. Pedal assemblies can be relocated by removing the two bolts that secure them from underneath the floor of the pedal housing. The mounting holes are spaced one inch side to side, and determine the amount of sideways adjustment available. Exercise care in moving the assemblies to avoid damaging the wire harnessing.

OPERATION

Driver Door

The door has a latch and interlock switch which are pre-adjusted at the factory, and require no driver adjustments. The driver and/or operator should insure that the door is fully closed and that the latch is engaged before running the simulator.

Pause Button

This button is located on right hand side of the steering box, next to the steering wheel. When pressed it suspends motion in a controlled fashion and returns the machine to home position.

In this case, however, "Pause Button" is a misnomer — the button is used to both pause and restart motion. Motion is restarted in a controlled fashion, as with the suspension of motion.

[[*THE HEEL REST CAN BE UNBOLTED AND REPOSITIONED.*]]

E-Stop Button

This button is located on the steering box to the left of the steering wheel. To actuate, press the button firmly. The E-Stop switch stops the machine immediately and removes power from the motors. It is intended only for emergencies.

To reset the E-Stop (the button remains down when pressed), twist the button clockwise. The button will pop up, restoring power to the circuits. In certain cases it may be necessary to re-zero the simulator after an E-Stop is triggered. **In no case should an internal E-Stop be reset by hand!**

If the internal E-Stop is triggered:

1   Trigger an external E-Stop, either via the remote E-Stop box, or via the shorting plug if no remote E-Stop is available.

2   Reset the on-board E-Stop.

3   Latch the belt and close the door.

4   Reset the external E-Stop, and reactivate the machine. It will return to its home position.

OPERATION

YEESH, ENOUGH ALREADY

I suppose you're going to want to use it now, aren't you?

All right, all right — but first, you should take a look at the glossary. It contains terms and jargon that you'll run into in these instructions, and will almost certainly be useful unless you're already an expert. Once you have an idea what you're getting into, get started…

STARTUP

Here's how to get going.

1 System power

Turn on the power switch on the 401cr's floor. There may be two switches — a larger breaker switch on the right, which should always be on, and a smaller vertical switch on the left, which should be used day-to-day to power the simulator.

Using the large switch to power / unpower the machine may damage the switch over time.

2 Computer power

2005-2015 models: The computers should start automatically; they will take a minute or two to start up. If they don't start on their own, you can use the tiny red buttons on the vertical gray sides of the 'main case'. They're toward the center of the machine compared to the left and right struts, and each is under a small green light which turns on when the computers are on. The left side button is for the game computer, and the right side button is for the control computer.

2015-current models: Newer systems use only one computer. The computer should start automatically; it will take a minute or two to start up. If it doesn't start on their own, you can use the tiny red button on the vertical gray side of the 'main case'. It's toward the center of the machine compared to the right strut, and is under a small green light which turns on when the computers are on.

3 Calibration

2005-2013 models: Go over to the 401 and push each pedal down fully, and turn the wheel fully left and right. It doesn't matter in what order.

This tells the game computer where the pedals and wheel 'start' and 'stop'; if this is not done, the brakes might drag or the throttle might always be on, until someone happens to push them down all the way.

OPERATION

2013-current models: If necessary, center the wheel and press the tiny red button on the left side of the wheel box to reset center position. You can do this at any time, even while a game is running!

4 Sound

2005-2013 models: On the left side of the machine, near the rubber hose, is a little box with a knob and a power button (among others). Turn on the sound with the power button, and turn the knob until it's some amount of the way up. You can control the volume in Windows, and in the games, too, so it might take some experimenting.

2013-current models: Newer systems use a Force Dynamics-built powered subwoofer and Boston Acoustics satellite speakers. These systems don't require you to turn the audio on separately; volume is set in the Windows control panel or from within the games.

5 Start it up

2005-2015 models running ForceControl 4 or earlier: When you're at the desktop of the game computer (which you'll see on the monitor(s)), you can remotely view the control computer. There's an icon on the desktop labeled something similar to 'connect to control computer' or 'view control computer'.

Double click it, and you'll see a window pop up showing the control computer's desktop. Once you can see the desktop, there'll be an icon for ForceControl. Start it up; the machine should click , and more fans should turn on.

With the optional remote station, the remote desktop connection is unnecessary. In this case, the remote monitor is set up in a convenient location externally and plugged into the receiving end of a wireless video transmitter. A second wireless keyboard like that used for the game computer can then be used to operate the control computer as if it were on the desk with the monitor.

2015-current models or those running ForceControl 5: If your system came pre-configured from Force Dynamics, ForceControl will start automatically, and runs on the game computer. If desired, you can use an Android device to control your system remotely; see the ForceControl manual for more information.

6 Home the 401 (if you need to)

2005-2015 models running ForceControl 4 or earlier: You don't need to re-home the 401 if it's level (it doesn't need to be perfectly level,

OPERATION

just reasonably flat to the eye), and within 3 cm or so of the bottom of the strut travel. If you've had a shutdown while the machine is running, though, you'll need to re-home.

First, get out of the simulator, latch the seat belt, and shut the door. Get to a safe position. Now, check 'Active' in ForceControl (on the upper-right), click the 'manual' selector, and click 'Set Manual Mode'.

Now the 'Home' button should be enabled – click it, and the machine will move all the way up and all the way down. It can take a while, and sometimes it will stop at the bottom for a long time. It's not done until it clicks and lets you back out of manual mode! Don't go near it until that happens!

2015-current models or those running ForceControl 5: The simulator will automatically re-find its home when activated for the first time after a cold start. If the machine was powered off unsafely or power was lost while the machine was in operation, this auto-home routine may not completely home the simulator. In this case, follow the instructions in the ForceControl 5 manual to re-home the platform.

7   Pick a preset

ForceControl 4 or earlier: Under 'Scaling' section, you'll see a few sliders that set motion characteristics – but for now, you just need to pick a preset from the drop-down list at the bottom of the window. When you're happy, just leave the window open (and the remote desktop window too, if you want) and 'go back to' the game computer.

ForceControl 5: Select your motion system in the Platform List to the left; then select the Profile tab. At the bottom of the Profile Editor, you'll see a dropdown menu with available presets. See the ForceControl 5 manual for more information.

8   Run a simulation

This part is pretty easy! Click the icon for the game you're interested in, get yourself out on track (or on the runway) and push the green button. You'll lift off (ideally only if you're on the runway, lift off again) and the motion will fade in. You'll want to be still when you activate the motion, since it can be pretty surprising otherwise.

9   When you're done driving (or flying)

Hit the button again. Since the game doesn't know the simulator exists, you could keep on going if you want. If you do not want, exit the game normally. You can start up again, or 'go back to' the control computer to change a preset.

OPERATION

SHUTDOWN

Shutdown is simple, but it's important to shut down the computers in a controlled way. While an unexpected shutdown generally won't harm Windows, it's been known to happen; the greater danger is corruption to game or configuration files that were being used at the time of the shutdown.

A shutdown while the platform is operating (or while it's in its ready position) will require a re-zero, but generally the motion platform itself doesn't care how it's turned off.

Even aside from potential software damage and the re-zero required, however, it's recommended you don't turn off power to the platform while it's in motion. The brakes are applied to all four axes (including the rotation wheel, which has a brake as well as the struts) at once, which can result in a very abrupt stop — worse than any caused by an in-game vehicle crash or jolt. This isn't friendly to the motion platform, and so should be avoided.

1 Shutting down

Make sure the simulator is in its low (home) position with all three struts as short as possible (performing a re-zero if necessary), shut down ForceControl, and press the button or two buttons mentioned above under **Computer Power**. You can also use the start menu on each computer (which we often do) to hibernate them, or to shut them down without having to go walk around the simulator.

Remember the switch? Give the computer(s) time to shut down, then flip the switch you used to start up. All done!

OPERATION

WHAT IF?...

What if I see an Amp Fault error in ForceControl?

There are two things that can cause this. One isn't a big problem and one is.

The first possibility is that there was a really big crash, or a hefty person that the 401 couldn't lift. It will shutdown to protect itself. The best course of action here is to let the rider continue until he finishes, and only then click to exit ForceControl (which turns off the power to the monitors). Help the rider out of the machine, restart ForceControl, and then do steps 3 through 5 from the startup procedure. Now perform a re-zero procedure, and you are good to go!

The second possibility is that there's a serious problem with an amplifier or motor that is preventing the machine from working like it should. If the problem happens multiple times in a row, or if the machine 'zings' up or down the instant you check Active (you will know this when you see it), that might be the issue, and you should get in touch with Force Dynamics for advice. If the machine is at a safe angle, you can keep running riders through by starting ForceControl up and not doing the rotation re-home.

What if the game looks choppy, has strange graphics artifacts like a red or white road or weird sky, or freezes?

The computer might be overheating, causing the graphics card and CPU to 'get tired'. Performing a full shutdown and startup sequence will usually reset everything so it works, but you should check to make sure that things aren't getting too hot. If the top of a desktop computer feels noticeably warm, that is too hot. With on-board computers, you can feel the cases under the floor of the simulator as a quick check, but the best solution is to remove the step which is over the computer and determine the temperature directly.

If you're comfortable with operating a computer's BIOS, there are also several temperature monitors available in the settings there.

If the computers are cool but you are still seeing these problems, get in touch with Force Dynamics for advice.

OPERATION

What if the machine suddenly freezes with a clunk and the fans turn off?

Usually this is because a someone accidentally hit the big red E-Stop button, either in the machine (on the steering box in newer machines; behind each shoulder or behind the right shoulder in older ones) or externally (via a shorting plug or the remote E-Stop box). You can tell if this is the case because a big red E-Stop sign will light in ForceControl.

If the internal E-Stop is triggered:

1   Trigger an external E-Stop, either via the remote E-Stop box, or via the shorting plug if no remote E-Stop is available.

2   Reset the on-board E-Stop.

3   Latch the belt and close the door.

4   Reset the external E-Stop, and reactivate the machine (check 'Active') from the external control computer.

To reset an external E-Stop, rotate the E-Stop button clockwise until it pops back out. The machine will power up again. Check Active and it will return home; now you can resume.

This also might happen because of a power failure – either to the location (which will probably be fairly obvious) or just to the machine's power source (for instance, due to a fuse or breaker blowing). Once you resolve the power situation, you'll need to do a full shutdown and restart. If the machine was up in the air when power was lost, you will need to do a re-zero. If the *entire* machine was up in the air when power was lost, you probably have bigger fish to fry.

FORCECONTROL

Note: As of ForceControl version five, documentation for ForceControl has been moved to a separate manual; see http://**www.force-dynamics.com** for more information.

Most Force Dynamics systems, including all 301s and all 401cr models, can run ForceControl 5. We strongly recommend upgrading if possible; see the ForceControl 5 manual for instructions.

If you need documentation for legacy ForceControl versions, it can be downloaded on our web site separately.

SERVICE AND REPAIR

It is important to familiarize yourself with the proper operation of the simulator before attempting repairs. The maintenance and safety inspection sections should be carefully reviewed, and the simulator should be properly maintained. The person or persons performing this work should be mechanically inclined and have a reasonable understanding of computer hardware and software fault diagnosis.

Failure to follow proper repair procedures can result in serious equipment damage and personal injury.

High voltages and stored charges are present throughout this machine. The dangers of opening enclosures and working on exposed components cannot be over emphasized. Damage to the unit and serious personal injury or death can result.

The simulator must be turned off and unplugged from the wall before performing any disassembly.

SERVICE AND REPAIR

DAILY MAINTENANCE AND SAFETY INSPECTION

In certain operating environments it may be necessary to check dust buildup more frequently, as often as hourly, to prevent heat buildup and possible failure of the sound system and amplifiers.

1

Free Play Inspection

With the machine in home position (home checked) grasp the front of the machine (pedal end) and push side to side with about 5 lbs of pressure. There should be no free play or 'clunk'. If there is free play or clunk, examine the machine as you are shaking it to find out where the free play is originating.

If the free play is caused by the seat support rods it must be corrected before the machine is run.

Any looseness that is observed at any time in the aluminum seat support rods must be immediately corrected.

Other sources of free play are the bearings that connect the strut to the frame. The play can be due to bearing wear. This is not a safety issue but it is a maintenance issue that should be addressed as soon as possible.

The play can also be due to loose trunnion-shaft fixing bolts. The two trunnion-shafts on the bottom of the struts are each fastened to the strut with two bolts. If these bolts are loose, the constant working due to machine motion can cause the bolts to fall out completely. This can result in the strut collapsing causing possible harm to the occupant. These bolts must be tight (22 ft-lbs). Clearance between the strut tube guide rollers and the tube can also cause clunk or free play. More than .2 mm movement of the strut tube relative to the strut body is excessive and requires readjustment of the rollers. This is not a safety issue. (Contact Force Dynamics for instructions.)

SERVICE AND REPAIR

2 Mechanical Inspection

Examine the entire 401 for cracks in metal or plastic parts and for broken or bent components. If these defective items affect the safety of the machine they must be replaced.

Check the belts on the bottom of the struts. A firm finger press on the belt (squeeze both sides together) midway between the pulleys should deflect the belt no more than .060" or 1.5 mm. If the belt is loose, it must be tightened or it will jump teeth and the machine will lose position. In rare instances it could allow the machine to fall, jolting the rider when the simulator strikes the bottom stop.

Inspect the vinyl covered strut safety tethers for signs of cable fray or crimping and cracking.

3 Check Tightness of Bolts

Check the tightness of all bolts, including the following critical bolts:

- Two bolts on top and bottom of five aluminum rods.

- Two bolts at bottom of monitor frames.

- Bolts holding frame (support struts).

- Steering box bolts.

On older machines, if the steering wheel movement is loose, undo the four screws and tighten the steering nut.

Examine the area around the bolts that fasten the aluminum rods to the seat bracket for fatigue cracks. Pay special attention to the rear-most pair.

SERVICE AND REPAIR

100-HOUR MAINTENANCE AND SAFETY INSPECTION

Every 100 hours of operation, the following items should be checked:

1   Detailed Mechanical Inspection

1.1   Support the front of the machine. Remove the strut drive belts and examine for damage. Replace belts that have any tooth damage, cracks in the belt back, or other damage.

1.2   Examine both the screw pulley and the motor pulley for damage or wear.

1.3   Examine the brake (just above the square mounting plate) for wear debris from the brake disk. If any powder or other debris is evident, check the brake for proper torque (18 in-lbs minimum).

1.4   Remove each of the upper strut pivot axles and examine for signs of fretting or cracking in the area of the shaft under outer bearing race. If any cracks are evident the shaft should be replaced (contact Force Dynamics for instructions).

1.5   Check both inner and outer yoke bearings for smooth rotation. A small amount of grease leakage should be expected. If a lot of grease is leaking or the bearing does not turn smoothly replace the bearing (contact Force Dynamics for instructions).

2   Electrical Tests

2.1   Turn the machine on without the control software running. The large fans that cool the motors should not be running.

2.2   Launch the control software. You should hear a relay click and the motor cooling fans should run. ▶

SERVICE AND REPAIR

▶▶ Electrical Tests

2.4   Buckle the seat belt and close the door. The Active checkbox should not be grayed out.

2.5   Activate the 401. The frame surrounding the control software window should change from red to green. The 401 may move slightly and you may be able to hear the brakes release. If the frame color does not turn to green, check to see if the E-Stop is pulled out and the remote E-Stop shorting plug is in place.

2.6   Open the door; the frame should change from green to red and the Active checkbox should be grayed out. If not, then the switch and/or wiring are defective. Do not operate the 401 until the problem is fixed.

2.7   Close the door and disconnect the seat belt; the Active checkbox should be grayed out. If not, then the seat belt switch is shorted. Do not operate the 401 until the problem is fixed.

2.8   Buckle the seat belt. Check Active. The frame should change back to green.

2.9   Press the E-Stop button. The fans should stop, and the frame should turn from green to red. If not, the E-Stop circuit is not operating. Do not operate the 401 until the problem is fixed.

2.10   Uncheck Home. The 401 should move straight up about 9 inches and stop. If it does not, check the seat belt, door, and E-Stop.

2.11   Check Home. The 401 should return to its home or low position.

ADVANCED PROCEDURES

INTRODUCTION

These are advanced procedures. In fact, if these procedures were any more advanced, they'd build domed cities, blast off, and colonize the universe.

Suffice it to say that we advise using caution when performing any of the procedures here. In some cases, messing up will just mean an embarrassing call to Force Dynamics, but in some, damage to property or person could result. Use caution, and if you're unsure, don't try it.

Note that ForceControl 5 can perform many of the functions provided by these procedures (such as changing controller IP addresses, etc). Check the ForceControl 5 manual or contact Force Dynamics if you have any questions.

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STARTING SMART TERMINAL

Starting and using the DMC Smart Terminal, Galil's servo control utility, is necessary for most advanced procedures. This section will tell you how to get it going correctly with the 401CR.

1   Check to make sure nobody is near the machine.

Do a full power-off and power-on.

2   Start ForceControl.

Don't do anything else; just start it.

3   Start DMC SmartTerminal.

There should be an icon on the desktop like this:

If there is none, there should be a link in the start menu under 'Galil'. If not, it's probably not installed. You can download a copy here:

http://www.force-dynamics.com/dmcsmartterm02.exe.

Run the file, being careful to follow the first (confusing) step correctly, and continue to step 4.

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4 Go to Tools → Select Controller.

You should see a screen like the one shown in the next step.

If you just installed the program, however, it probably won't know how to find the controller, and will give you a cryptic error message. If this is the case, dismiss the message, go to Tools → Controller Registration, and click on 'Find Ethernet Controller'. When it's finished, you should be able to restart the Smart Terminal, return to Tools → Select Controller, and continue.

If you have previously changed the IP address of your controller, or if the computer you're using was used to 'talk' to a different simulator, you might see a dialog box asking which controller to use. Pick the controller with the IP you're using — you can find it in ForceControl in the Connection panel, under 'Simulator IP Address'. If you get the wrong one, Smart Terminal will respond with a series of increasingly scary-looking dialog boxes; just keep clicking 'cancel' until you either return to the main screen or Smart Terminal crashes itself. (Hey — go talk to Galil. It's smart, not perfect!) No damage will be done, however. Start over and try a different controller IP address.

[[*TEXT ENTERED IN SMART TERMINAL MUST BE ALL-CAPS.*]]

5 Now that we're connected, the Smart Terminal looks like this:
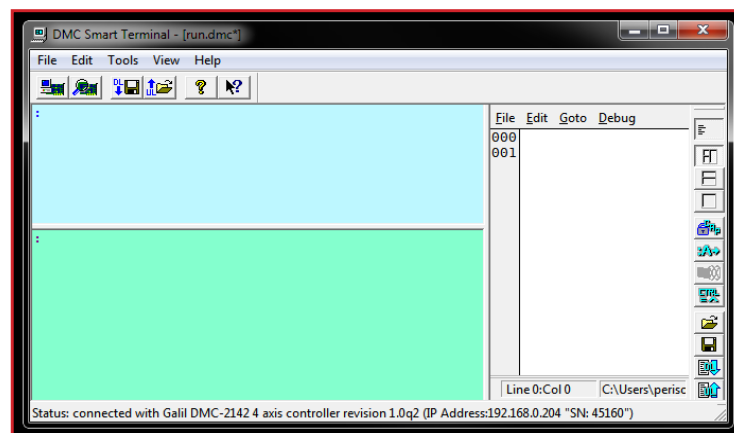
The white frame (right) is for code editing; you don't need to worry about it. The blue frame (upper left) is the input frame; click here and type to make things happen. The output frame (green, lower left) shows responses from the servo controller. It might be full of a bunch of stuff; that's raw output from the simulator, and you don't want it since it slows things to a crawl.

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6   It's time to cancel the program.

Anything you're seeing in that green box is output from a ForceControl helper program that runs on the Galil servo controller. Whether or not the output is showing up, we want to halt the program. In the blue box (from now on, you can assume everything you type is typed there) type

Halt Execution: `: HX`

This Halts the eXecution of the onboard program. This will result in a Net Fault in ForceControl. That's OK.

7   Now, go to Tools → Display Data Record.

You should get a window with this on the lower left:

Axis Data				
X	Y	Z	W	
0	0	0	0	Reference Position
0	0	0	0	Motor Position
0	0	0	0	Position Error
0	0	0	0	Auxiliary Position
0	0	0	0	Velocity
0	0	0	0	Torque
16,962	16,962	16,962	16,962	Analog Input
1	1	1	1	Stop Code

X, Y, Z, and W correspond to the left, back, and right struts, and the rotation axis.

We're going to be interested in three of those:

Reference Position	Where you told the strut to go
Motor Position	Where it really is
Torque	How hard the motor is working

Maximum torque is about **32,000 units as shown in the Data Record**. If any strut is 'pegged' there solidly, e-stop the simulator, do a full power-off, and start over. If it happens repeatedly, there's a chance there's been a hardware failure, so get in touch with Force Dynamics before proceeding.

Now you should be ready to start in on the real work. Go get 'em, Tiger.

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MANUAL RE-ZERO

A manual re-zero can be helpful if your control software is malfunctioning (or your control computer has bitten the dust), if the servo controller's on-board code is missing, or even if the machine is in a particularly uncomfortable-looking position. However, this is one of the more difficult manual operations you can do with our platform. If you're unsure, contact Force Dynamics **before** continuing.

1   Start up Smart Terminal and connect to the simulator…

…as described in **Starting Smart Terminal**. Then, turn everything on:

Main power on:	`:SB7`
Motor power on:	`:SH`

2   From here on in, have a hand on the e-stop.

Now, set-up.

Position tracking:	`:PT1,1,1`
Torque limits:	`:TL*=4.5`

Setting the torque limit to 4.5 (rather than its usual 9.98) is intended to ensure that the machine will move as intended while limiting the strain put on the machine when the struts reach their end stops. However, you should still `AB` (Abort motion), or E-Stop, as soon as the struts touch bottom or top.

Check soft limits forward:	`:FL*=?`
Check soft limits reverse:	`:BL*=?`

'Soft limits' refers to the software limits the servo controller puts on motor movement. If the forward limit is, for example, 20,000 counts, then a command to go to 30,000 counts will result in motor motion only to 20,000 counts. They're sometimes a useful backup in case of other code problems, but in this case we want them turned off. So, if you don't see this:

```
: 2147483647, 2147483647, 2147483647, 2147483647
: -2147483647, -2147483647, -2147483647, -2147483647
```

then… ▶

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▶▶ Reset forward limits: `:FL*=2147483647`
Reset reverse limits: `:BL*=-2147483647`

(You can use any numbers of the same sign as long as they're really big — say, `2147483646`, or `2000000000`, or even `2000000`.)

3   Get ready:

Brakes Off: `:SB1`
                           `:SB2`
                           `:SB3`

Check position tracking mode; it likes to turn off randomly:

`:PT*=?`

…should return: `: 1, 1, 1, 0`

If not, set position tracking mode on again.

4   Now we check to see if everything is working right.

This will move the machine a little bit upward:

Absolute move: `:PA-5000,-5000,-5000`

PA means 'Go to an absolute position'. The numbers in sequence mean Left, Back, and Rear struts. Negative numbers go higher, positive numbers lower; from the bottom, the machine can go to about -180000 (the numbers are in servo counts, which are arbitrary). 5000 counts should be good for a couple of cm or so.

You should now see reference positions of 5000 in the Data Record, and Motor Positions fairly close to that (within ~1000 is OK; more than 2000 is bad).

If all this worked OK, we can do the re-zero.

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5 The re-zero.

This will involve some 'looping', and I have some included extra commands that will take longer, but will make things more clear. It'll be a pain in the neck, but it's much safer than skipping steps.

The most important thing to remember is that we want to move the two longer struts until they are at the level of the shortest strut. This means we must lower the tallest and next-tallest struts, in order, before continuing.

I'm going to incldue steps for all three struts to simplify things. Choose and complete the steps for the two taller struts only!

6 If the left strut is the tallest.

If not, skip to step 7 (If the struts are even now, skip to step 9).

'Run' the following lines over and over. You can start with bigger numbers like 15,000, but as you get to your target, only do 5,000 or so. Use your judgment here depending on how far you have to go.

Move down:	`:PA15000`
Reset position to 0:	`:DP0,0,0`
Reset to position track:	`:PT1,1,1`

7 If the back strut is the tallest.

If not, skip to step 8 (If the struts are even now, skip to step 9).

'Run' the following lines over and over. You can start with bigger numbers like 15,000, but as you get to your target, only do 5,000 or so. Use your judgment here depending on how far you have to go.

Move down:	`:PA,15000`
Reset position to 0:	`:DP0,0,0`
Reset to position track:	`:PT1,1,1`

8 If the right strut is the tallest.

If not, skip to step 9.

'Run' the following lines over and over. You can start with bigger numbers like 15,000, but as you get to your target, only do 5,000 or so. Use your judgment here depending on how far you have to go.

Move down:	`:PA,,15000`
Reset position to 0:	`:DP0,0,0`
Reset to position track:	`:PT1,1,1`

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9 Are the struts even?

How even is 'even'? Within about 2cm either way is fine. Somewhat more is acceptable, and you can even things out more at the bottom if you're comfortable doing so, but more than 4cm will start affecting simulator feel too much to be acceptable.

If the struts are even, you can continue to step 10. Otherwise, return to step 6.

10 Finish up.

Once the struts are all very even, you can do the same thing for all of them at once:

Move down:	`:PA15000,15000,15000`
Reset position to 0:	`:DP0,0,0`
Reset to position track:	`:PT1,1,1`

Move cautiously when you get toward the bottom, and check the torque and error numbers. If you're seeing high torque (>16000) and bigger errors, either call it a day.

If you issue a command and get no movement, and the reference position hasn't changed, check position tracking mode as above. If the machine has stayed in the same place and the torque output has gone way up, e-stop and contact Force Dynamics.

11 Phew — you're done!

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SERVO SYSTEM CHECK

In situations where the status of the servos is unknown, or when you've just installed new electronics or motors, it's a good idea to check the functionality of the servo system manually to ensure that the struts won't 'run away' and cause damage to the system.

<< *THE BELTS MUST BE OFF TO PERFORM A SERVO CHECK.* >>

Please note that you must have front of the machine supported with the belts off, the struts must be blocked up off their lower limits, and you must either have the machine jacked up very slightly to disengage the traction wheel from the floor, or remove the chain from the R-axis drive. Even if you're not checking the R-Axis, a misplaced comma could send your machine on an unintended (and potentially-damaging) carnival ride.

The first step is to check to make sure the limits are off so the controller will let the motors move. In the Data Record window, there should be a section on the left, about 2/3rd of the way down, with limit information — a grid of boxes for the four axes and the forward and reverse limits for each. All of them should have red dots to indicate that the axis is allowed to move in that direction. If not, check to see that the struts are high enough to avoid tripping the lower limits.

Note that the limits are inverted forward/reverse, so the reverse limit will prevent the machine from moving up and the forward limit will prevent it from moving down. We tell the machine to move in a negative direction to move up — this is due to the direction of motor rotation. So, 'forward' limits being triggered (the box being white) means the strut can't move down; 'reverse' limits being triggered means the strut can't move up.

If the machine is propped off the limits and some of the X/Y/Z limits are on (white), then there may be a problem with the limits; contact Force Dynamics.

If not, we can test the servo system.

1 Get ready

First things first: Follow the steps in **Starting Smart Terminal** (Page N). Now, we want to turn on main power to the machine and activate the servos.

Turn on main power:	: SB7
Enable amplifiers:	: SH

You should see red dots in the 'Servos enabled' field in the data record — on the right hand column about half way down.

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2 Turn the brakes off on each axis.

With the brakes on, we can't move the motors, so we set bits one, two, and three, in turn, to release the brakes. Except for early-run machines, the brakes only deactivate after all the bits have been set.

Left strut:	`:SB1`
Back strut:	`:SB2`
Right strut:	`:SB3`

You should have heard a click as you entered `SB3`.

3 Check the servos.

Now we can see whether the servos are really working! If there's a "runaway" problem, when we try this, the servos will just start going full bore in one direction or another. The encoder might or might not show a changing position in this case, but you can hear the motors 'zinging'. In this case, issue:

Abort motion:	`:AB`
Turn off servos:	`:MO`

To test the servos, we want to set the maximum speed, accelerations, and decelerations to something reasonably slow:

Speed, counts/sec:	`:SP*=7000`
Acceleration, counts/sec^2:	`:AC*=20000`
Deceleration, counts/sec^2:	`:DC*=20000`

Now we can tell the servos to move. As you issue these commands, you should see the reference (commanded) position, motor (real) position, and error (difference between the two) change in the grid on the lower left of the data record. We need to turn on point tracking so the servos respond to us, and then tell the servos to move:

Point tracking on:	`:PT1,1,1,1`
Absolute position move:	`:PA5000,5000,5000,5000`

If the error is less than a few hundred counts, the servo system checks out.

If not, double-check your steps again, and, if the issue remains, check to see if the encoder counts run away with the servos (going up or down in number) or if they stay around zero with the errors increasing. Contact Force Dynamics with the results, and we'll help you finish troubleshooting from there.

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CHANGING THE IP ADDRESS

Sometimes it's useful to change the IP address of your simulator. Think of it as your machine's phone number. Each one you talk to has to have its own, just like you can't have two friends with the same mobile number; calling one and having both talk at once could be disastrous.

So, if you want more than one simulator to talk on your network, they — along with all computers — need to have their own unique IP addresses. By default, our machines ship with the address 192.168.0.101, the control computers …102, and the game computers …103. Where multiple machines are shipped at a time, the second simulator will have the address 192.168.0.111, and …112 and …113 for the game and control computers, and so on.

While it's possible to set up a simulator while others are active on the network, it's best not to attempt it, in order to avoid confusion (and possible broken hardware).

Ensure that all other machines that might be on the same network are turned off completely before continuing!

If you ordered more than ten simulators at once, there's no set numbering scheme, but we're probably on-site to help out.

1 Find your simulator.

Hook up the 401cr, start up the Smart Terminal, and it will say there were no controllers found in the database (it stores information about Galil controllers (for you, 401crs) in the Windows registry). Dismiss that dialog, and go to:

Tools → **Controller Registration**

Click **Find Ethernet Controller** (on the right).

Your 401cr will pop up; if it's using our factory set IP address (192.168.0.101) this will show up under **IP Address**. This 'discovery' tool will also find controllers that don't have an address at all, either because they're new or because there's been some foul-up with setup or changing an IP — so you can return to this point if something goes wrong.

Note 1: Sometimes the Smart Terminal will display a dialog box behind the current window. Check the task bar if something seems to not happen when it should.

Note 2: Smart Terminal will often present terrifying-looking errors. Usually the best thing to do is to dismiss them and ignore them. Sometimes, doing this will crash Smart Terminal. Unfortunately, this is normal, too. If Smart Terminal gives you the run-around, just exit, restart, and start fresh.

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2   Add the controller.

Highlight the controller and click OK.

At this point, the Smart Terminal will add that controller to the registry and bounce you back to the main window (perhaps after dismissing some dialogs).

3   Change the IP address.

Now you'll want to go change the IP address of your newly created controller. Go to **Tools → Controller Registration** again, and this time, select bottom-most device that appears in the list on the left.

Now click **Edit Controller Properties** and click on the **Ethernet Parameters** tab.

Now click **Set IP Address**. Another dialog will pop up containing some information about the controller, and some boxes that will let you pick a new address for the controller. You can test the address you pick to make sure it's not taken by something else — we recommend doing this!

A quick note: If you have your computer and 401CR hooked to a LAN that's connected to the internet via a DHCP router, the Terminal might not want to let you change the IP address; it may say something similar to **Network card is connected to a Managed Network**, and not give you options.

To get around this, manually set the IP addresses of your 401 computers, and unplug their connection to the wider world before running Smart Terminal. (It's possible you can trick it by just unplugging, but sometimes this will make Windows computers lose their addresses.)

Now you can assign your 401 its new address using the controls on this dialog, and you should be good to go.

A quick test to see that everything is working is to start up a command prompt and 'ping' the address you selected. Starting the ForceControl software and selecting the new address works pretty well too.

ADVANCED PROCEDURES

GENERAL TROUBLESHOOTING THEORY — GTT401

There are a few basic (despite this being a four-hundred level course) ideas that will give you some hints about how our simulators work and what to look for. However, remember: A little knowledge is a dangerous thing, and passing this course doesn't make you a graduate!

1 Look for the first point of failure.

If all four servos fail to run, the problem is almost certainly not with each servo individually; rather, it is with something that affects all of the servos at once. If I were troubleshooting a total servo failure, I'd look for amplifier power, a problem with the servo interface board, a problem with the Galil firmware or setup, and then a problem with the control board itself.

2 It's probably simple.

The more complex the problem looks, the simpler the cause is. Problem? The left strut only moves up, the door doesn't work, and the rotation wheel runs away! Cause? There's a solder bridge on the interface board shorting the left limit switch line and the door switch to ground, and shorting two quadrature encoder lines together. (This almost certainly wouldn't happen as written; some artistic license was taken.)

Unfortunately, the opposite also happens: Problem? The door sometimes doesn't work. Cause? A nearby fruit vendor's old television has created an EMI node around the interface board, peaking when the machine is rotated North and the fruit vendor is watching *Coronation Street*. (This almost certainly wouldn't happen as written; a fruit vendor would watch *Eastenders*.)

3 Change one thing at a time.

This goes for all troubleshooting, and is a very, very tempting rule to break, even (or especially) when you are quite experienced. Only change one thing, no matter how simple it seems, or even if the second thing isn't related to your troubleshooting. Your sound system is cutting out randomly, and you're checking the cabling. Your buddy asks to swap your long extension cord for his too-short one before you change your latest connector. You start up, and with the new connector, the problem is fixed…

…but it was the extension cord. It was too long, causing the voltage to drop during heavy use, and making the sound system drop out — it's the first thing to fail when the voltage drops. When your friend swapped in the short one, the problem went away. Change one thing at a time!

GENERAL NOTES

This section includes some basic notes on simulator issues that don't fit anywhere else.

3D SETUP

Correct setup is crucial to the quality of 3D in so-equipped simulators. We ship our machines with a baseline 3D setup, but different games and even different cars within games require slightly different setups.

Two controls are used to set up 3D: depth amount and convergence. Depth amount sets the overall effect level of 3D; its default is 100%. A 100% setting will sometimes cause problems in game menus, but if 3D is set up correctly, it is optimal for in-game use.

The most important aspect of 3D setup to remember is that when your eyes relax and lose focus, the double-image you see should match the double-image you see of an object at similar distance in 'real life'.

1   Turn on in-car steering wheel and driver hands

Move the wheel around until you can see a distinguishing feature, like the band circling the top of some wheels, or the knuckles of the driver's hands.

2   Defocus your eyes

Look at a feature on the real steering wheel or your hand, relax your eyes and pay attention to the double-image you see. Your goal is to adjust the convergence setting until the double-image on the screen's steering wheel matches the one in real life.

3   Use the hotkeys

Control-F5 and Control-F6 adjust convergence. There isn't any on-screen confirmation of adjustment, and the first adjustments often take a long time to become visible, so you'll probably want to hold down the keys for a while at first. When you get it right, Control-F7 saves the setting.

4   Look out!

It's very important to remember that it's possible to invert the 3D by moving the convergence too much in one direction. If this happens, you'll still see 3D, but if you hold a finger up and alternate opening/closing your left and right eyes, the finger will move in the opposite direction of similarly-distant onscreen objects. If this happens, check which adjustment direction makes the separation larger, and go in the opposite direction until your reference point 'crosses to the other side'.

GENERAL NOTES

MENU APPEARANCE

With projection and 3D-screen simulators, some menu items can be obscured by the steering wheel. In the absense of memorizing settings, there are two workarounds possible. For 3D-screen simulators with Sony television monitors, pressing the Home button on the remote control will pop up a menu which incidentally shrinks the screen to a smaller box on the upper left; the entire screen is thus visible.

With projection-screen simulators, it's possible to reach up and behind your head to the mirror and tilt it so the image shifts up along the screen. *Please note that caution should be used as the mirror is quite sharp and the edges of the mirror are not shielded!* Be careful to touch only the metal mount plate, and ensure that the retaining bolts are not so tight as to result in twisting of the mirror when it is manipulated.

It is usually possible to set the bolts tight enough to keep the mirror from moving during motion but enable smooth adjustment.

<< *NEVER MOVE THE MIRROR WHILE THE MACHINE IS ACTIVE OR IN MOTION!* >>

DISPLAYS: DISPLAYPORT NO-SHOWS

On machines with triple-head video utilizing a Displayport adapter, monitors and/or the operating system may decide that they are not connected. Often this can be solved by unplugging/replugging the connector at the monitor, but sometimes you'll need to hard-restart the simulator and/or unplug/replug the connector **at the video card**. This is annoying, but thankfully rare.

DISPLAYS: TRIPLE-SCREEN BROKEN

If Eyefinity (ATI's term for its triple-output video method) breaks, you may see a desktop on one or two monitors, or wrongly-ordered, separate desktops on all three. To restore it without rebuilding it in the Catalyst Control Center, right click on the desktop, select 'Catalyst', then select 'Eyefinity' and 'restore'. If those options aren't available, a soft-restart (from the Windows menu) will usually fix the problem.

GENERAL NOTES

COMPUTER RESTART ISSUES (401CR)

If the control or game computers lose power or are shut down / rebooted unexpectedly, Windows may decide that it needs to perform startup repair.

This can be particularly annoying with the control computer in the 401CR: since the control computer in the 401CR is 'headless', it's not possible to see the menu that appears, so it often appears as if it simply hasn't started at all — particularly given that modern power supplies don't run their fans unless absolutely necessary! Unfortunately, Windows usually won't find anything it can fix, since fixing usually isn't required, and there's no way to tell where in the process it is.

A further complication is that sometimes, USB keyboards will refuse to work during Windows' boot menus, leaving you helpless unless you attach a PS2 keyboard. Surely you have one around, right?

Since startup repair can sometimes save one's proverbial bacon, and since it's not a good idea to get into situation which provoke it in the first place, we don't disable this behavior by default. But if you want to, here's how:

1 **Click on the Start menu...**

... and search for 'cmd'.

Right click on **cmd.exe** and select 'Run as administrator':
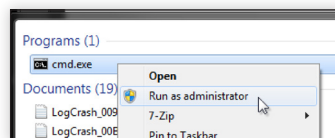
2 When the command prompt is open, type the following at the prompt:

`bcdedit /set {default} bootstatuspolicy ignoreallfailures`

3 If you want to return to normal behavior, do this instead:

`bcdedit /set {default} bootstatuspolicy displayallfailures`
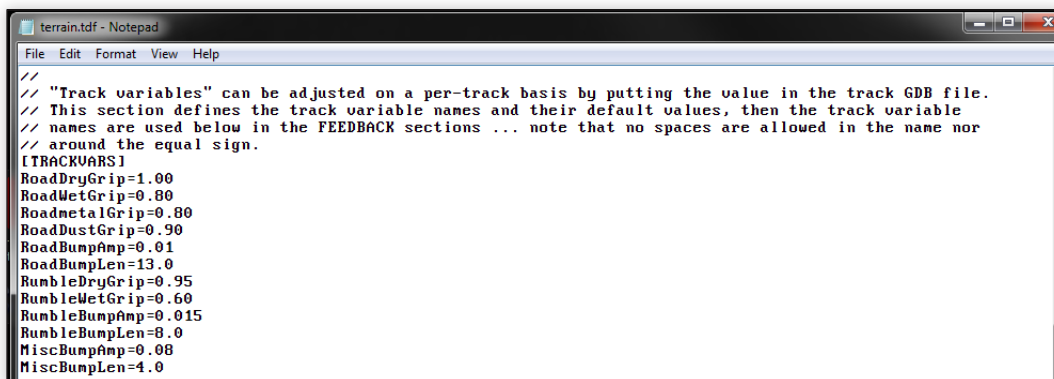
GENERAL NOTES

CONTROLLERS: USB ORDER

Due to the way Windows enumerates USB devices and handles DirectX controllers, it's important to remember that **the way you plug in USB devices will affect how games see them!** So, if your machine has a handbrake and a gate shifter, make sure you keep them plugged in to the same ports consistently, otherwise your games may see the wrong controls.

Likewise, if you suddenly find that none of your controls are working right, a good first step is to make sure Windows has recognized all the devices; if a device 'high on the chain' failed to be recognized for some reason, the axis and button numbers for all of the following devices will show up differently to the games, making it appear as if everything broke at once!

GAMES: RFACTOR BUMPS

Is rFactor ridiculously bumpy? Many rFactor tracks have a procedural bump map specified in their .tdf — Terrain Definition File — that can cause uncomfortable bumpiness in a motion platform. There's also a default **terrain.tdf**, stored in the **rFactor\GameData\Locations** folder, that has several references to this procedural bump map:

The important line here is the one beginning '`RoadBumpAmp`': It sets the amplitude (height) of the repeated bumps the game adds to the road surface. When driving a desk, these bumps just make the car bounce around a little, adding some life to the track surface, but because they're regular rather than random, in a motion platform they can cause horribly uncomfortable oscillations. Set this to zero here (and in the **terrain.tdf** file for individual tracks that have them) and you should have a much smoother ride in rFactor.

Note that this may cause issues for online gameplay and/or hotlap comparisons with those who haven't made the same changes to their tracks, since the bumps do affect grip levels and car performance. For proof of this, try setting the bump amplitude to something like 3 or 4 and watch the sparks fly — just not with motion turned on!

GENERAL NOTES

OTHER HINTS & TIPS

• When adjusting your seating position, choose your seatback angle first (if available) and then move the seat as far back as it will go; only move it forward unless absolutely necessary after tilting the steering wheel to its optimal position. The further back the seat is, and the further back the pedals are, the easier it is for the simulator to move the weight around. The difficulty of lifting and rotating weight increases with the square of its distance from the front struts, so every inch the seat is moved backward can boost performance significantly!

• Driving alone and have a wireless keyboard? You can leave it on the simulator's main cover (with the Force Dynamics logo) while driving, even if you're driving a 401.

• For systems with the Force Dynamics-built Turnbox force feedback wheel, when using iRacing, set the force level to around 125% in ForceTorque, and then set iRacing to use a force strength of about 15, minimum force of 0, damping of 0, and check 'linear mode'. Damping can be set to your taste in ForceTorque, usually between 50 and 125%.

GLOSSARY

Let's get some terminology taken care of. Please note that these definitions are in the context of Force Dynamics' hardware and software system, and may be incorrect, misleading, or too-narrow in other contexts.

While most of the definitions here are broadly accurate, this glossary is intended as an aid to learning and troubleshooting the 401CR, not as a general guide to simulation.

Address	See **IP Address**.
Control Computer:	The computer that runs **ForceControl**. It receives data from the game computer, and tells the **motion simulator** how to move in response. See also **Game Computer**. On newer systems or systems that have been upgraded to ForceControl 5, the Control Computer is no longer used.
Control Software:	**ForceControl**, the application which receives data from the **game computer** and sends control information to the **simulator**.
Controller:	The device that takes commands from **ForceControl** and uses feedback from the **Encoders** to determine the amount of power required to each motor in order to position the struts properly. Our servo controllers are currently manufactured by **Galil**.
Counts:	You can think of counts like ticks of a watch, or degrees. For every count, the **motor** rotates a certain amount — in our case about 1/10,000th of a revolution. The belt and screw ratios mean that an entire revolution moves a strut about an inch — meaning that in theory we can set the length of a strut to within 1/10,000th of an inch. In reality, the give of the belt and other mechanical factors mean that the real resolution isn't nearly so high. In the 301 / 401 family of platforms, about 180,000 counts cover the entire range of strut motion.
Data:	Normally this can refer to quite a few things — quarterly report files, the collective contents of a hard drive, or extremely advanced sci-fi androids, to name a few. For our purposes, it usually refers to information being transmitted via **Ethernet** either from the **game computer** to the **control computer**, or from the control computer to the **simulator**.

GLOSSARY

E-Stop:	Emergency Stop. Hit this red button and power to the important parts of the motion platform — ie, everything that can make it move — is cut completely. Since the **motor brakes** require active intervention to stay off, the machine essentially turns into a large paper weight. It can sometimes be a pain to recover from this, so it's best to avoid it unless — you guessed it — there's an emergency. Unless life, limb, or the health of the simulator are at stake, it's better to use the green button to stop motion.
Emulator:	Relax, Intellectual Property lawyers — this entry is here solely to differentiate the term from **simulator**. A (software) simulator — or simulation — mimics the behavior of a system, usually real-life (analog), with its own set of rules and equations. An emulator, by contrast, is usually of a digital system, and itself simulates the lowest level processes of a digital chip, in order to provide output precisely the same as the original hardware. It is often used for circuit design and embedded software development; less-legitimately, it can be used as a way to 'pretend' to have a video game system, making it easier to illicitly distribute and play game software.
Encoder:	A device located on one end of the **motor** shaft which **counts** the number of revolutions the motor has turned in order to determine the position of the strut. (Actually it counts around ten thousand times per revolution, but it's easier to explain the first way.)
Error:	The difference between the **reference position** and the **motor position**, in **counts**. A large error results in a large (high power) signal being sent to the **amplifier** — either positive or negative — and a small error results in a small signal being sent. (This is an oversimplification — see **PID Loop**).
Ethernet:	This is the communication medium used for our motion systems — the same one you likely use at your office or on your home network (even if you don't know you have one!)
ForceControl:	The software that directly controls the motion of the machine. It receives data from the game telling it how the vehicle is moving. It runs on the **control computer.**
Force Feedback:	A method for 'pushing back' — or feeding back — forces that the **simulation** or **game** generates, mimicking the forces the driver of a real car would feel.

GLOSSARY

Game: Also known as **simulation**. This is the software you see when you're driving (or flying). Examples include Live For Speed (LFS), rFactor, iRacing, and Microsoft Flight Simulator.

Game Computer: The computer that runs the **simulation** you're using – e.g., Live For Speed, iRacing, etc.

Galil: The company which manufactures the servo **controllers** our motion system uses. The part of their system which we use is the controller (think, 'small computer without a case' — Physical, not legal, mind you).

The controller receives information about motor position from the encoder and responds with the torque output necessary to move it to (or keep it at) its target location. We (incorrectly) sometimes use the term 'Galil' to mean, "the computer board that positions the motors".

Green Button: Press this to start or stop motion. Actually, this just puts the simulator in a position where it will respond to motion if any is present. You can start 'motion' while no game is running, and the simulator will still lift to its normal position and wait; you just won't feel anything until there's data coming from the game.

IP Address: The number that identifies a computer (or motion simulator) on your local network. Without correct IP address settings, the simulator may not respond, or the control software may not react to games. Sometimes referred to simply as 'address' — when not discussing where to send fan mail.

Moving Group: The part of the simulator held up by the struts, including the seat, monitors (or projector), wheel, pedals, and so on.

Motion Platform: Usually this refers to your motion system — see 'Simulator'. Sometimes it can refer generically to any piece of hardware used to hold some load — whether or not it includes a person — and lift, rotate, translate, or otherwise move it (usually a relatively small amount) via an attached base.

Motor: This sounds obvious, but for the sake of completeness: The heavy square thing which, via a small belt, drives the struts up or down.

GLOSSARY

Motor Position: The position of the motor, in counts, returned by the encoder. If the motor spins one revolution, the motor position will increase (or decrease) by from one to ten thousand counts, generally, depending on motor and encoder setup.

Network: See 'Ethernet'.

PID Loop: Short for 'Proportional, Integral, Derivative', a PID loop is an algorithm used to accurately control a servo system. A simple proportional system (e.g., "send power of N times the error") would result in endless oscillations.

         Roughly, the PID loop adds terms to rectify this problem — a derivative term to 'damp' the motion and an integral term to push to a final location accurately. Incorrectly setting the PID parameters can result in oscillations, large **error**, sloppy motion, or even in a strut **running away**.

Reference Position: The target position, in **counts**, at which a servo would 'like to be'. If the error — the difference between the motor position and the reference position — is large, a large signal will be sent to the amplifier; if it is small, a small signal will be sent.

Remote Station: The Remote station consists of a wireless keyboard/mouse and a monitor which 'talks' wirelessly with the control computer on simulators with continuous rotation. This enables remote operation of the motion platform without complex slip ring arrangements or limitation of motion range.

Servos: Usually used to refer to the entire system used to create motion, from the amplifiers up to and including the motors. Technically the term means something like, 'a system used to control the position of a load'. It can also be used as a verb somewhat like 'move' — for instance, the Galil command (issued in Smart Terminal) for 'turn on and go somewhere' is SH: 'Servo Here'.

Simulation: See **game**.

Sim: Shorthand for **simulation**, but almost always in the software sense.

Simulator: As opposed to simulation (software), this is the motion platform hardware. AKA 301, 401, 401CR, etc. In the context of games other than driving simulators, such as 'Flight Simulator X', this can refer to software.

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Sound System: The complete unit that provides audio to the occupant of the motion platform. In most pre-2013 simulators, this is a Logitech Z5500; current systems use a custom combination of amplifiers, Force Dynamics-designed subwoofers, and Boston Acoustics satellite speakers.

Steering Box: An informal term used to describe the steering wheel enclosure and associated electronics.

Strut: The complete mechanism used to hold up a part of the simulator and move it around. In our machines, this is a trapezoidal, red unit with a shaft emerging from the top and a large pulley (like the thing in your engine compartment that's impossible to put a belt back on to). Luckily it's quite a bit easier to put a belt back on to our pulleys…

Wheel (and pedals): Jargon used to describe the steering wheel and pedals used in the simulator.

Yaw: Rotation around the vertical axis, akin to what you feel as your car goes around a corner (or what you don't feel as it fails to go around a corner!). Yaw capability — the fourth axis — separates the 401 and the 401CR from the the 301.
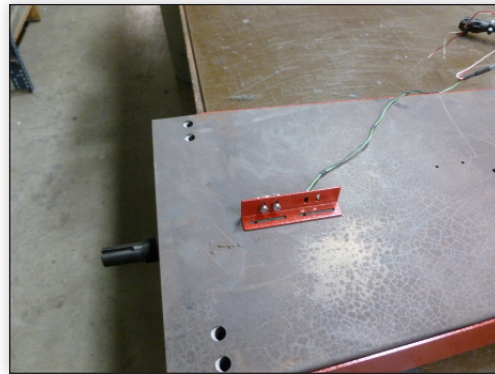
APPENDICES

MECHANICAL LIMIT SWITCHES

The following instructions describe the procedure for checking and adjusting mechanical strut limit switches (on systems which have them).

1   Support moving group

2   Remove drive belt

3   Remove servo motor

4   Remove limit switch cover (photo 1)

5   Show switch vane in slot of cover (photo 4)

6   Switch is adjusted using slots in mounting bracket (photo 6)

7   Check switch with multimeter

8   Adjust switch on strut so the switch closes with the strut raised ~25mm

1 Mockup of strut with limit switch cover

2 Lower limit switch location
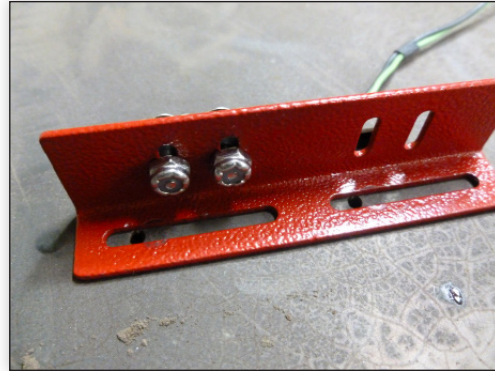

3 Slots in cover for limit switches

4 Switch vane inside strut
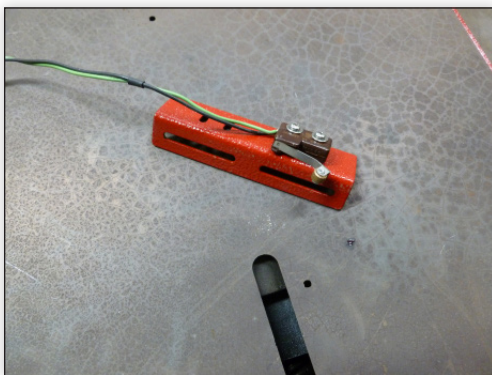
APPENDICES
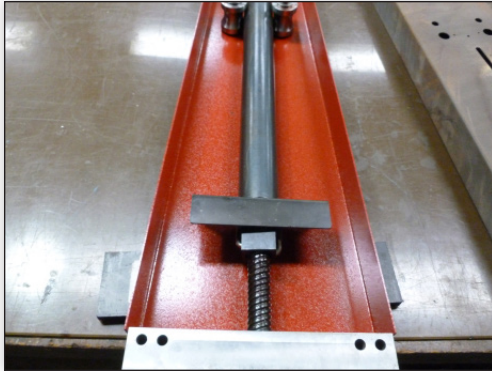
5 Inside of strut

6 Adjustment slots in switch bracket

7 Limit switch on mounting bracket

APPENDICES

USING THE OPTIONAL 401CR TRANSPORT WHEELS

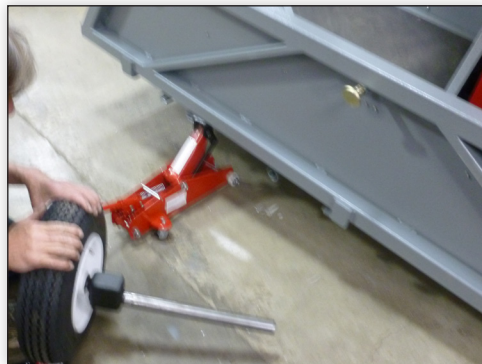Here's how to use the optional transport wheels and custom jack to move your 401cr.

1 Custom Jack

2 Side wheel

3 Front caster

4 Location of jack to install side wheel

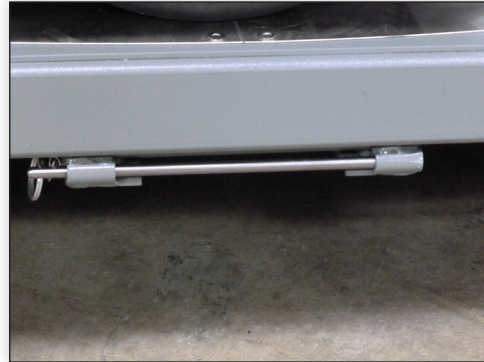**5** 1 side wheel installed

6 Second side installed

APPENDICES

How to use the optional transport wheels and custom jack to move your 401cr (continued).

7 Jack location to install caster

8 Caster mount with lock pin

9 Caster in place

10 Lock pin installed

11 Machine sitting on caster

12 Machine ready to move

APPENDICES

SERVO CONTROLLER FIRMWARE UPGRADE

If you have an older (pre-2013) machine, you may need to upgrade your servo controller's firmware before you can use ForceControl 5. (If this is necessary, ForceControl will inform you when it starts.)

First, you'll need to access the Galil servo controller by removing the center electronics cover from the simulator, and removing the silver cover from the controller (located near the center).

Note that while you will need to have the machine powered on to perform the controller upgrade, you should turn off the system while removing or reinstalling covers or plugging and unplugging wiring!

Once you've uncovered the control board, it should look something like this:
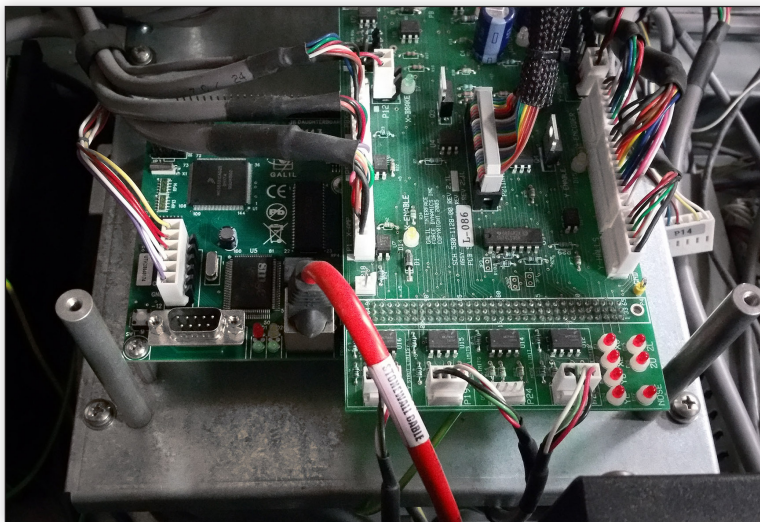
You'll need to make a RS232 (serial) connection to the nine-pin connection on the corner of the Galil board, shown on the lower left of the photo. If your computer was made in this century, you'll probably need a USB to RS232 adapter, and you might need a short female-to-female serial cable, since most USB to RS232 adapters only have a male connector.

Once you've got everything connected and ready to go, turn on the simulator and your computer (if separate). The next step is to download the software and firmware you'll need:

http://www.force-dynamics.com/downloads/galil-firmware-upgrade.zip

 Unpack the file into its own folder, and turn the page to get started.

APPENDICES

1   Install and run GalilTools (the installer is included in the upgrade file).

2   Connect to the controller by clicking the **+** icon. Select the COM port corresponding to your serial adapter (it will probably be the only one available) and choose the highest baud (speed) available.

3   Select Controller > Download Firmware from the menu.

4   Find the included firmware file and click OK.

5   The update will start. Updates may take up to two minutes.

Note: If the terminal can't communicate with the controller, install the upgrade jumper on the Galil board (marked UPGRD) and retry the firmware install as described above.