FORCE DYNAMICS

202 Quick Infosheet

CONTENTS

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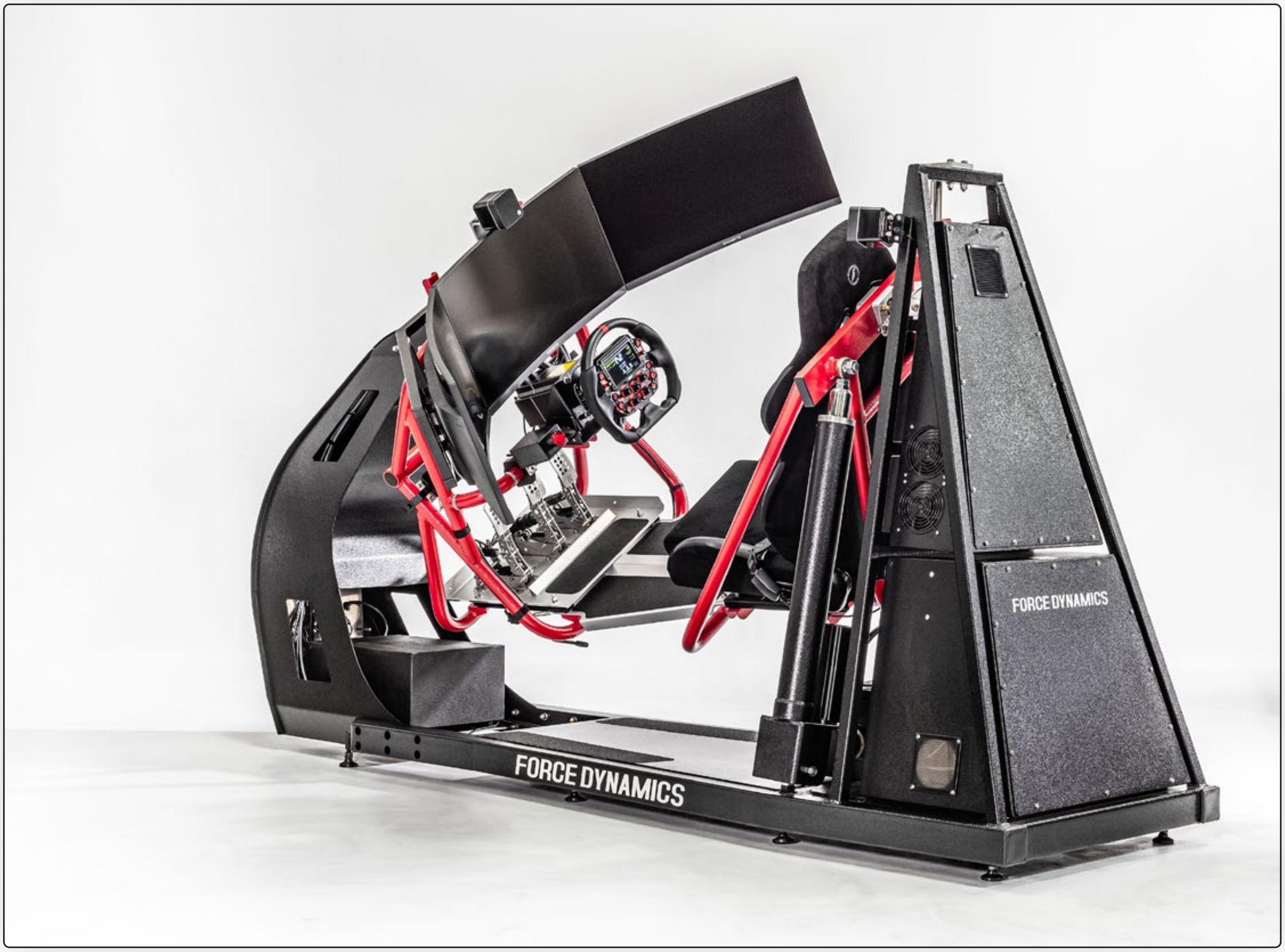
WHAT'S THE 202?

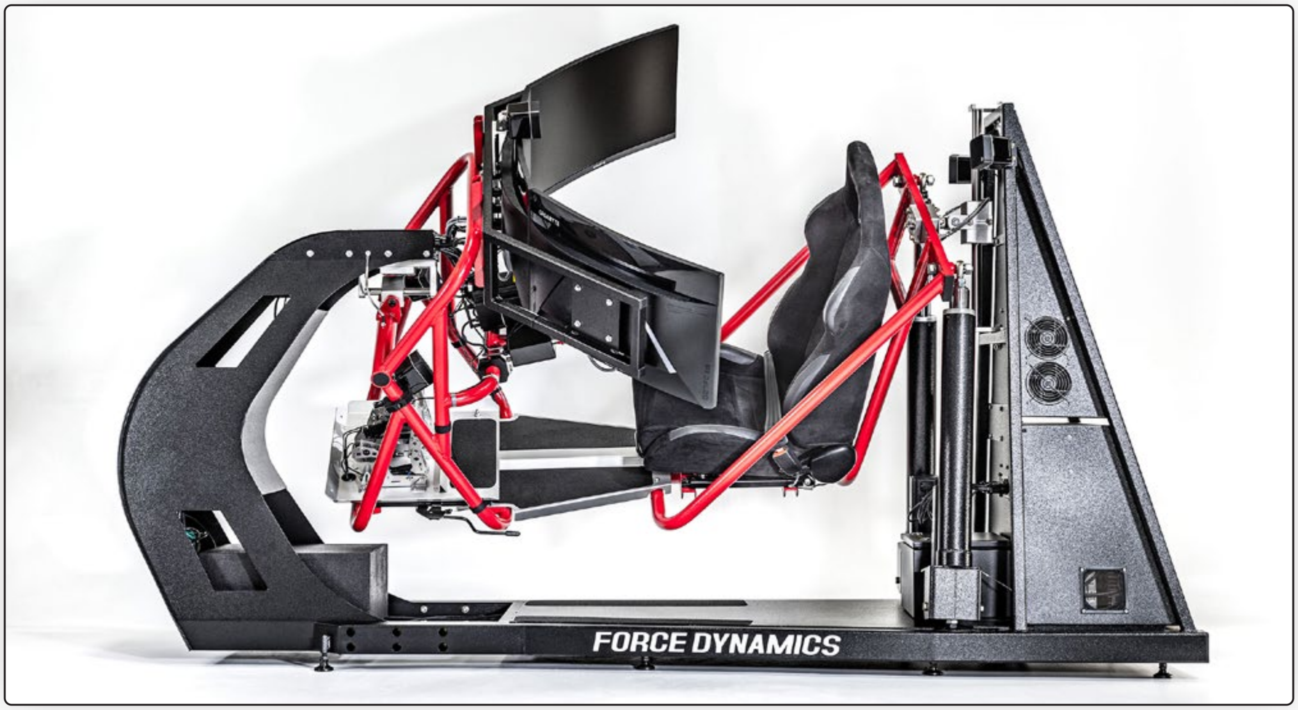
The 202 is designed to maximize driving simulation fidelity and utility in a small, efficient package starting around $29,000 for a bare platform and $39,000 turn-key.

The 202 provides unparalleled dynamic performance — more than 10x that of competitors — and is designed concept-forward to maximize the cues that work best for driving simulation, and to deliver them with superlative quality.



Why Big Motion?

Most other "motion simulators" are actually cueing devices: They bump up and down so you feel road texture, camber changes, and so on. But with small range, low speed, and disconnected monitors, they can't trick your inner ear into thinking you're accelerating, braking, or cornering. The 202 was designed to provide enough motion range so your inner ear triggers your sense of lateral loading as you corner. No competing platform will let you feel changes in your apex speeds consistently, lap after lap. And no other four-post rig, gimbal platform, or seat mover can help you feel every detail of vehicle motion — consistently and correctly — the way the 202's large range allows.



What Are The Specs?

The 202 is a two-actuator, hybrid multi-axis system, using shared geometry with context cueing and an induced surge axis to achieve higher quality simulation than is possible with many other two- and even three- or four-axis simulators.

Roll range of more than ±30 degrees achieves detailed, fine control over lateral load cues, and massively fast accelerations and a head-centered roll point deliver those load cues on time and with unprecedented quality, not just for a system in the 202's price and size category, but relative to the best motion simulators available.

Here's how the 202 stacks up against its competition:

Manufacturer	Model	G-Load Capable?	Screen Capable?	Ready-to-Run Price, USD	Center of Rotation	Range				Velocity				Acceleration			
						Degrees, +/-			Inches	Degrees/Sec			Inches/s	Degrees/s/s			G
						roll	pitch	yaw	heave	roll	pitch	yaw	heave	roll	pitch	yaw	heave
Force Dynamics	202	Y	Y	39,000	Head	>30	7	N/A	15[1]	120	42	N/A	42	>11500	2000	N/A	>5
Qubic Systems	QS-V20	N	N	Est. 40,000[3]	Hips	8.5	5.5	6.1	1.96	35[2]	20[2]	75	8.8[2]	1500	500	900	0.89
Simcraft	Apex3 GT	N	Y	60,000	Chest	25	12.5	25	0	60	60	60	N/A	2400	2400	2400	N/A
Vesaro*	Any	N	N	30,000 to 90,000	Floor	12.2	4.5	N/A	1.5	18.3	6.75	N/A	3.9	1600	590	N/A	1
VRX*	iMotion	N	N	40,000	Floor	12.2	4.5	N/A	1.5	18.3	6.75	N/A	3.9	1600	590	N/A	1
CXC	Motion Pro 2	N	N	75,000	Floor	?	?	N/A	N/A	?	?	N/A	N/A	?	?	N/A	N/A

* D-Box motion   [3] Turnkey in USA   [1] Combined pitch/heave axis   [2] Est. real world

Why Did We Choose This Layout?

Most simulator manufacturers don't build their own actuator or control systems. If you're using low-speed commercial actuators, you're limited to the layouts we commonly see: four-post rigs and seat movers. Those systems can't provide useful g-load information — cueing that helps you drive better.

The 202's layout and actuator design results in dominant dynamic performance, with accelerations and strut velocities 10x most competitors' and accelerations at least 2.5x that of its closest competition. With transient response and actuator acceleration crucial for providing cueing without causing motion sickness, the 202 is in a class of its own not just in performance for its price, but in performance at any price.

For example, compared to D-Box based systems, the 202's pitch and roll accelerations are ten times higher, allowing for dramatically superior portrayal of fine vibrations, sudden impacts, and transients like gear shift shock, wall strikes, curb impacts, and road texture feel. The dynamic performance of the actuators and the static range of the platform is so high that we can cleanly portray combinations of loads (sudden braking plus a curb impact, or brushing against an opponent while cornering) that would saturate and 'lag' actuators in other systems.

In fact, the only system with any dynamic or static specifications superior to the 202, the Simcraft Apex 3 GT, has chassis dimensions almost twice as large, costs twice as much, and still doesn't offer sustained load cueing.

A Virtual Multi-Axis System

While the 202 is nominally a two-axis system, its geometry means that it acts more like a five-axis system. The two axes working in opposition roll the platform, but its ultra-high center of rotation means that the seat moves laterally more than twenty inches. The actual behavior is equivalent to a sway axis on a large 6-DOF system, since roll (cueing lateral load) and sway (doing the same thing) are always actuated together.

When both actuators work together during the center of their travel, the seat moves up and down, providing a large-range heave axis. But toward the end of the travel, under braking or heavy acceleration, the platform pitches around the front axis (delivering acceleration cues) and moves fore and aft: An induced surge axis. The induced surge axis on the 202 is nearly as large as the independent surge axis on systems costing three to four times as much! And, again due to the geometry of the platform, it blends seamlessly with pitch to deliver the same type of loads you'd want with a multiaxis platform.

KEY POINTS

Component Lifetimes

Uptime is a critical consideration for commercial projects, and the 202 has the advantage of being relatively simple both mechanically and electronically. The servo drives and motors used are industrial rather than consumer or custom manufactured to reduce costs, and have been used successfully in the more-demanding 301 and 401cr platforms since 2021.

Generally speaking, the 202 has been deliberately overdesigned to ensure a long commercial operating life. We've used 3/4" rod ends where 5/8 or 1/2 might suffice; thick walled tubing; and precision linear bearings in struts and guide rails.

Component	Calculated MTBF
Actuators	100,000 hours
Front Pivot Assembly	50,000 hours
Rod ends, bushings	50,000+ hours

Replacement Times

Even the most carefully specified system will have problems, so the 202 has been engineered to reduce downtime in the event of component failures. Almost all mechanical parts can be replaced by a tech with minimal experience and tools, and electronic components are plug-and-play swappable. A minimally-expensive set of spares per-location can keep downtime to under an hour in almost all cases.

Estimated repair times for potential failure points and wear items are as follows:

Component	Replacement Time
Actuator & Motor	30 mins
Servo Amplifier	20 mins
Front Pivot Assembly	30 mins
Rod ends, bushings	<30 mins
PC	1 to 2h
Screen (Ultrawide)	20 mins
Satellite speaker	10 mins
Subwoofer	30 mins

WHY US?

Force Dynamics was founded in 2005, and were the first to market with a high-performance, small form factor commercial motion platform that year. In 2008 we were the first to offer a large-range rotation axis with the 401, and in 2010 the first to offer a continuous yaw axis with the 401cr. In 2014 we demonstrated the first inexpensive motion-compensated support for modern VR systems with the Oculus DK1, and have continued with Rift, Rift S, and now HTC Focus 3 support developed in cooperation with HTC.

Since 2005, we've shipped 150+ systems around the world, to commercial clients including Microsoft, Boeing, and Ford Motor Company, and to research universities like UC Berkeley, the University of Virginia, USUHS in Bethesda, and Embry Riddle Aeronautical University.

Many of our earliest systems are in operation after more than 15 years, and are still supported with our latest control software and simulation options.

DETAILED DESIGN RATIONALE

Not everyone is interested in the details of why we chose the 202's specific layout and dynamic performance specifications, but if you are, you've come to the right place!

So, why did we set our priorities the way we did?

First, it's important to consider how motion simulation works. You perceive accelerations via your inner ear, where fluid sloshes around as you accelerate (or tilt) and informs your brain of your rotation or your acceleration. But your brain relies on visual cues to know which is which — whether what your inner ear is telling you is that you're lying on your side, or cornering at 1g. Motion simulation relies on that ambiguity to trick your brain into thinking you're cornering when you're not, by tilting your inner ears to provide the physical "you're cornering!" cue and reinforcing it with visuals to provide the visual "you're cornering!" cue.

So if we rotate your body, but show your eyes that you're level, you'll feel like you're cornering.

With driving simulation, this works great for cornering, because road vehicles take a certain amount of time to transition between, say, cornering hard to the left and cornering hard to the right. Formula cars do it fastest, but even they take a few hundred milliseconds — enough time for a well-designed motion platform to complete the physical rotation it needs to do to model the acceleration change that the car is doing.

Braking and accelerating are a bigger challenge, because the onsets of those forces are quicker — acceleration a little bit, and braking a lot. It's pretty easy to go from zero braking force to full scale within a few milliseconds, but pivoting a whole mechanical apparatus rapidly in that time is difficult and expensive. That axis also takes up more space, because humans aren't spherical. And that extra volume costs money to control and move around.

As a manufacturer, you can respond to this in two ways. You can give up, and make a four-poster or a seat mover — or you can do what we did, which is to maximize the fidelity of the most useful axes while deliberately sacrificing nominal performance on other axes to provide the best possible simulation fidelity in a given package. So, with the 202, our geometry maximizes performance on the roll axis — which is the easiest axis to cue correctly and one of the most important to useful g-load feel — and compromises on the pitch axis, which is tricky to implement at the best of times and carries an outsize cost in terms of power and space required.

Static Performance (Layout)

Reduced Size: The 301 and 401cr are too large to fit through a standard door, and difficult to assemble without expert assistance. The 202 is narrow enough to fit through a standard interior door fully assembled, and is not difficult to disassemble if necessary to allow for manual transport.

High Center Of Rotation: Center of rotation is one of the most critical simulation specs. A low rotation center will cause 'parasitic forces' at head level, swinging your head in the opposite direction of the intended acceleration cue at the start of every movement. Four posters' centers of rotation are literally under their floors, so low that they're almost useless for conveying g-loading information. Some others manage chest-level CoR. The 202 is head level for its primary roll axis and chest level for pitch, providing unparalleled lateral load feel during sustained cornering and allowing us to fully exploit its huge roll range without any parasitics or false cues.

Reduced Servo Load: Weight is the enemy of performance in race cars and in simulators, and with a lower-cost simulator, reducing weight is even more critical. Lifting the entire moving group is expensive and difficult, which is why most manufacturers don't even bother. This disconnects visual from motion, drastically limiting cueing options and motion fidelity. Disconnected displays are a nonstarter for us, so hanging the moving group off a suspended point just behind the display system serves both to raise the center of rotation (compared to a front floor pivot) and to suspend a big chunk of weight (the wheel base, wheel, front audio, pedals, and displays) so its mass doesn't affect the machine's performance.

Layout Benefits

Reduced servo load (as above): Less weight on the servo system means more performance.

Increased performance: Changing accessory loads has little effect on performance with a suspended central pivot. You can put a 50lb wheelbase on the 202 with only the tiniest effect on performance, and even large displays will only affect roll axis performance insofar as they increase polar moment of inertia, rather than constantly loading the servo system.

Reduced wear: Most wiring, displays, audio, and controls will barely move even when the driver is pounding through Eau Rouge or hurtling up a gravel stage on Rally Finland, increasing lifetimes of the most delicate system components.

Context-Cueing: With only two actuators, we don't have fully-separate control over pitch and Z events. But with a carefully-chosen layout, we can provide a compromise position that provides each cue and blend them in software depending on context. In the 202, we use negative pitch for acceleration, but bleed off that pitch cue as braking g-loads are incurred, because that tends to feel more like a vertical movement. As we do that, we blend in vertical cues, so the end result feels much more like a 3-axis (or greater!) system than a 2-axis system.

An effective multi-axis system: Our roll center of rotation is ideal, but the pitch center isn't — as mentioned above. The geometry we chose has an answer for this, though: As the platform lifts and pitches up, it shifts backwards along a slider located on the front pivot axis. Get on the brakes and you shift backwards; get on the throttle and you shift forward.

What's more, the high center of rotation means that where it matters, at the seat of your pants, you move a huge ± 12 inches side to side during cornering: More than all but the largest professional 6DOF platforms!

Dynamic Performance

The 202's layout and actuator design results in dominant dynamic performance, with accelerations and strut velocities up to 20x some competitors' and accelerations at least 2.5x that of its closest competition. With transient response and actuator acceleration crucial for providing cueing without causing motion sickness, the 202 is in a class of its own not just in performance for its price, but in performance at any price.

The only limiting factor on high frequency and transient impact response is in software quality: The 202's custom actuators are capable of extreme accelerations and velocities. Compared to D-Box based systems, for example, the 202's pitch and roll accelerations are ten to twenty times larger, allowing for dramatically superior portrayal of fine vibrations, sudden impacts, and transients like gear shift shock, wall strikes, kerb impacts, and road texture feel. The dynamic performance of the actuators and the static range of the platform is so high that we can cleanly portray combinations of loads (sudden braking plus a kerb impact, or brushing against an opponent while cornering) that would saturate and 'lag' actuators in other systems.

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Why not 6DOF?

6DOF platforms offer, in theory, maximum cueing flexibility. But in practice, they have limitations that make them unsuited for certain applications.

Motion range

The tradeoff for a 6DOF platform is that its axes interact in a complex envelope: Yaw may restrict pitch and Z; Z may restrict roll and yaw. Optimizing cueing for this envelope is difficult or impossible, resulting in systems which are either very large physically or restrict real-world motion drastically compared to paper spec.

Smaller 6-axis systems often end up using a very limited subset of their theoretical motion range, and may not do any real load cueing at all, which can defeat the purpose of having a multi-axis system in the first place.

Illusion of performance

6DOF systems have the spec sheet buzzwords, but when implementing motorsport simulation, they tend to either not deliver continuous loads, or to use their extra axes only to virtually raise the center of rotation. The 202 does all that in hardware. If surge and sway will always be tied to roll and pitch anyway, why spend money to control physically separate axes to do it?

Size

Stewart platforms are fairly large, and will generally take around double the floorplan of a 202.

Reliability

A six-axis platform has the same failure footprint as three two-axis platforms, so all things being equal, a given machine is three times as likely to fail.

Failure modes

Six-axis systems collapse 'unsafe' if an actuator fails; manufacturers are responsible for creating actuators that won't collapse, but if this is done incorrectly there can be issues vs. other geometries where actuator failure can't result in unsafe or hardware-damaging platform collapse. A runaway actuator in the 202 goes "clunk"; a runaway actuator in a hexapod can twist it into a pretzel.

Repairability

In the event of a failure, a six-axis platform is generally going to be more difficult to repair (since the platform must be supported in every direction if a single strut is disconnected), more expensive to repair, and more time consuming to bring back into service than the 202.