

## ***Q: Does Drive Square Simulation System have “forced feedback” to the steering wheel?***

Historically Force Feedback (FF) was designed into many gaming and simulation applications in order to compensate for the limited movement of the motion base or a lack of it.

Since the human body is always in contact with the steering wheel it is a good way to transfer the simulated vibration of the road to the body using the steering wheel. Other alternatives include vibrating back cushions and powerful audio feedback.

FF steering have received widespread acceptance, as both the gaming control and a vibration feedback can be combined into a single cost-effective device.

Yet real driving on the real road produces very little, if any, of forced steering feedback. One of the reasons for that is a heavy dependence on the power steering system, which essentially isolates the driver from the “feeling of the road”. Also – such steering feedback is heavily manufacturer-dependent (“soft” steering of a Buick vs. “hard” steering of Audi). While the difference in the feedback force is significant, it has not shown to adversely affect most driving behaviors.

More important, however, is the ability for the steering wheel to return to the central position. It is essential for making correct turns. Incorrect wheel alignment, as we know, causing car’s steering wheel not to return to the central position, can easily lead to over- or under-steering.

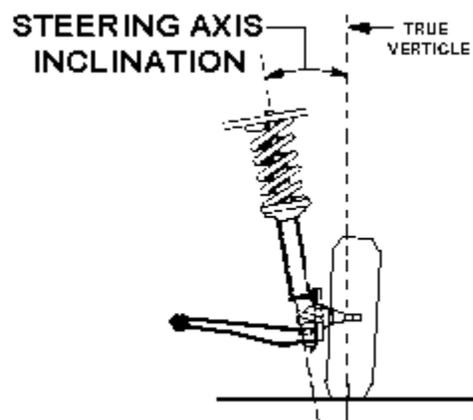
In Drive Square Simulator, the returning force is being produced in exactly the same way as it is being produced in a real car during driving, as the source of this force is the weight of the front of the car itself.

One of the front wheel alignment angles, called Steering Axis Inclination (SAI) is responsible for generating this force during normal driving. Usually SAI is a built-in angle and is not adjustable in the alignment shop.

The effect of the SAI is illustrated in Fig.1.

Turning the steering wheel, results in the car body being slightly pushed up. Then the weight of the vehicle generates the force returning the wheel into the central position. As can be seen from the geometry of this arrangement, such self-centering force is non-linear by nature.

In actual vehicle, the ability of the steering wheel to self-center also depends on the speed of the vehicle. It is most evident at zero or near-zero vehicle speeds.



Since the tires of the vehicle produce a very strong grip with the road surface, such grip force easily overpowers the “returning” force of SAI. This causes the steering wheel to get “stuck” in arbitrary position if the vehicle speed is zero. As the car starts moving, the steering wheel will slowly return to the central position as the tire drag, due to the flexibility of the rubber, permits the wheels to wiggle its way out of the off-centered position.

The design of the steering turntable components of the Drive Square Simulator virtually eliminates the friction between the front tires and the road surface. This unleashes the full effect of SAI, when the car is not moving, and even with power steering being shut off. As a result, however, Drive Square Simulator does not provide speed-dependent self-centering force.

However light vehicle driver errors at near-zero speed (parking maneuvers) are not usually life threatening and are not a part of current research, nor it is a part of the proposed training.

Compared to the other FF steering devices, Drive Square steering generates a substantial self-centering force, which is close to the real-life situations, which is coupled with natural damping effects built into the steering.

Most existing implementations of the FF steering devices have a range of problems associated with it. Most practically available electrical motors do not produce enough torque at near-zero RPM to be able to drive FF steering directly. Many large simulator manufacturers are compensating for this by attaching a motor to a reducing gear. Besides having a backlash, reducing gears introduce a lot of unnatural resistance and a gear noise when the steering wheel needs to be turned quickly. Even with reducing gears, the motor power is normally in the range of 0.5 - 2 HP, which requires substantial power supply and expensive high-power modulation circuits.

Gaming devices of such power are impractical and would be unsafe. In order to reduce power requirement, many gaming FF device manufacturers are artificially reducing the size of the steering wheel itself, which leads to yet another distortion.

This spectrum of implementation problems causes many simulator makers to reduce the spectrum of FF steering effects to almost exclusively the vibration.

Even though the Drive Square Simulator does not have powered FF steering actuators, it produces a very naturalistic haptic feedback to the driver at most simulated speeds, due to the natural self-centering steering action, produced by the vehicle’s own SAI.