FACT SHEET

Module 4.1 Drivers Can Affect Vehicle Balance

A driver uses the feeling of motion consistently to judge acceleration, deceleration, and loss of traction. The only other sense used more to operate a vehicle safely is vision.

Vehicle balance refers to the distribution of the weight of the vehicle on the tires as they meet the ground. This down force of the tire patch to the roadway is affected by tire pressure and the suspension geometry. The ideal tire patch size and balance for a vehicle is only reached when the vehicle is still. As soon as motion occurs, changes to the vehicle balance or weight on the tire patches changes. Acceleration, deceleration, cornering, or a combination of these actions causes a transfer of weight from one point of the vehicle to another. If there is no acceleration or deceleration, the vehicle is traveling at a constant speed or stopped, the suspension is set on center and the steering and traction condition is considered to be in balance.

Maintaining Vehicle Balance

Maintaining vehicle balance results from:

- steering wheel balance;
- body position which allows the feet, legs, arms and hands to maintain a stable seat position to obtain a feeling of vehicle movement (kinesthetic feedback); and
- balance maintained through precise movements of steering, smooth and progressive acceleration, and controlled brake application.

Maintaining vehicle balance results from the driver's reaction to the vehicle's suspension set and its center of weight transfer. Basically the weight of a vehicle can be concentrated on one of five points on the chassis:

- the front of the chassis (over the front tire patches),
- the rear of the chassis (over the rear tire patches),
- the center of the chassis (distributed equally over the front and rear tire patches) based on speed changes,
- to the right of center (right two tire patches), or
- the left of center (left two tire patches) based on steering or surface changes.

The magnitude of these weight changes and the driver's ability to maintain control of the vehicle is influenced by the rate of acceleration, brake application, steering input, surface traction, or combinations of these factors.

When driving newer model cars, the distance the steering wheel must be moved to perform most maneuvers is substantially less than was required with most cars during the 1980s and many models in the early 1990s. The number of steering wheel turns to move the tires lock to lock, has in most cases been reduced from four to five turns to two to three turns. The lock-to-lock configuration reduction is a result of smaller steering wheel sizes and rack and pinion steering geometry changes.

Steering too quickly in combination with sudden brake application may have contributed to crashes when a driver loses control and leaves the roadway, often in a roll-over. The use of hand-over-hand steering is limited and hand-to-hand (push-pull) steering is now preferred. When moving at slow speeds with limited line of sight vision, such as perpendicular parking, or during very fast action, such as traction loss recovery, hand-over-hand is still recommended. Since drivers operate different types of vehicles, it is important to know all four steering wheel control maneuvers.

Seating Position

In order to establish vehicle balance and improve visual searching, drivers need to sit in a comfortable, erect position squarely behind the steering wheel. Adjust seat height so that the top of the steering wheel is in line with

the top of the shoulders. The top of the wheel should never be more than one inch higher than the top of the shoulders. Vehicles without power seats and/or adjustable steering columns or tilt steering wheels, may require some drivers to use a wedge-shaped driver's cushion.

Proper distance from the steering wheel can be determined by extending the arm straight forward and adjusting the position of the seat, forward or back, until the top of the steering wheel is in line with the wrist joint. Drivers under five feet five inches in height or with short legs may need to use brake and accelerator pedal extensions. All drivers need to be able to

- comfortably reach and operate the pedals;
- maintain a distance of 10 inches between their body and the steering wheel to reduce the chance of injury in the event of air bag inflation; and
- adjust the head restraint so that the top is no higher than the top of the ears.

Changing Vehicle Balance from Side to Side (Roll)
Sudden steering, acceleration, or braking actions can affect vehicle balance from side to side.

Steering Movements
Weight or center of mass shifts to the left or right side of a vehicle depending on speed, traction and the amount of steering input. Occupants may or may not feel forward movement toward the corner of the vehicle opposite the direction of the turn.

Brake and Steering Combinations
Depending on the degree of steering and braking, braking may improve traction, such as in trail braking through a turn, when performed at an appropriate speed. However, applying the brakes when cornering at too high a speed has little effect relative to slowing the vehicle, but may have a highly noticeable effect of producing traction loss due to severe weight shift.

Changing Vehicle Balance from Front to Rear (Pitch)
Sudden steering, acceleration, or braking action can affect vehicle balance from front to rear. When acceleration is applied, weight or center of mass is transferred toward the rear of the vehicle. If acceleration is sudden and hard there is a noticeable drop of the rear of the vehicle and occupants feel the rear of the vehicle dropping down

Releasing Brake
Simply releasing pressure from the brake pedal results in a shift of weight to the rear.

Covering Accelerator
Covering the accelerator provides a smooth transition from brake release to progressive acceleration. It is similar to trail braking in that speed and vehicle balance are maintained prior to braking.

Light Accelerator Pressure
Light accelerator pressure maintains weight balance while maintaining slow forward motion or allowing speed to slow gradually with minimal weight shift.

Progressive Accelerator Pressure
Ease steering control and improve rear wheel traction when moving out of a turn or curve with firm, steady acceleration to increase speed. This gradually shifts vehicle balance to the rear suspension.

Thrust Accelerator Pressure
A firm push or thrust of the accelerator is used to shift more weight to the rear wheels for traction or to make a shift to a lower gear in a vehicle with an automatic transmission for increased rate of acceleration. This action is sometimes needed when passing and making lane change maneuvers in higher speed traffic situations.

Changing Vehicle Load from Rear to Front (Pitch)
Sudden steering, acceleration, or braking actions can affect vehicle balance from rear to front. When brakes are applied, weight or center of mass is transferred to the front of the vehicle. If braking is hard, there is a noticeable

drop of the hood and rise of the rear of the vehicle and occupants feel forward movement. The most efficient way to slow or stop a vehicle is to brake while traveling in a straight line. This allows the braking force to have an evenly distributed effect on all four wheels.

The ability to apply the correct pressure to the brake pedal is learned through experience and practice. However, each vehicle has a somewhat different "feel" with which a driver must become familiar. Apply too little pressure and the vehicle will not stop at the desired location or within the distance available. Apply too much pressure and the brakes may lock up, and traction and directional control may be lost.

The key to a good braking technique is to stabilize the foot and control brake pressure with the forces of the ankle and toes rather than thigh muscles. Place the heel of the foot on the floor in front of the brake pedal so that the ball of the foot makes contact with the pedal.

This position enables drivers to use the toes to make fine adjustments to pedal pressure and to pivot the foot more smoothly back and forth between the brake and accelerator. This also allows the driver to rest the right side of the foot against the center console or center hump for better control of speed while their foot is on the accelerator.

Releasing Accelerator
Simply releasing pressure on the accelerator results in a shift of weight to the front. The affect on the reduction in speed tends to be more noticeable in vehicles with rear wheel drive than in front wheel drive vehicles equipped with transaxles.

Cover Brake
Covering the brake provides a smooth transition from acceleration to braking. It is similar to trail braking in that speed and vehicle balance are maintained prior to braking.

Controlled Braking (Squeeze On)
Braking is done with sufficient brake pressure to slow the vehicle, while maintaining balance and avoiding traction loss to the front or rear wheels. It is important to remember that directional control (steering) becomes more difficult when using hard braking. **Benefits:** Nice smooth, non-jerky stops.

Threshold Braking
Threshold braking is used to maximize braking by lifting (unloading) the rear suspension, and lowering (loading) the front suspension. This provides maximum traction to the front tires for braking just short of lock up. If lock up occurs, steering control is regained by releasing brake pressure very slightly (2-3 degrees). As with controlled braking, control of the brake pedal is best maintained if the heel is on the floor. **Benefits:** Keeps the vehicle balanced while in a turn and provides more traction for steering.

Trail Braking (Squeeze Off)
Trail braking is used to maintain speed and balance of the vehicle when steering is required prior to turning at an intersection or in a curve. This technique is often used in combination with or at the end of controlled or threshold braking. This action keeps the vehicle load on the front tires. **Benefits:** Helps maintain vehicle balance and traction control when entering a turn without stopping.

EFFECT OF STEERING ON BALANCE

Steering Wheel Control
In order to maximize vehicle control, steering control helps avoid sudden movements and minimize steering wheel reversals.

Hand Position
Place the left hand between 7 and 9 o'clock and the right hand between 3 and 5 o'clock with the upper arms resting against the rib cage. This will improve steering stability by lowering the body's center of gravity and

reducing unintended steering wheel reversals. With a more natural seating position, it also encourages keeping both hands on the wheel and reduces upper and lower back pain often associated with long trips.

The driver's grip of the steering wheel should be firm but gentle. Grip the steering wheel by the outside rim. For greater sensitivity to information communicated by the vehicle, use fingers instead of palms and keep thumbs up along the face of the steering wheel. Never turn the wheel while gripping it from the inside of the rim with the hand facing outward.

Steering Techniques

To steer when going straight and when turning, use both hands—one pushing; the other pulling. In general, when backing and turning, use one hand. Four steering maneuvers permit a driver to maintain steering control: hand to hand, hand over hand, one hand steer and limited evasive steer

1. Hand to Hand Steering

Sometimes referred to as Push/Pull/Feed Steering but should not be confused with shuffle steering. Hand to hand steering permits the driver to make steering inputs ranging from very minor (one to two degree), to gross adjustments (up to a half turn of the wheel) while keeping both hands on the wheel for precision adjustments.

When turning through a slight curve, both hands will typically retain their original grip on the wheel, making only slight finger or wrist adjustments as necessary to maintain path of travel. However, when moving through a turn, the hands may move up to 165 degrees (neither hand moves beyond the 6 or 12 o'clock positions). Depending on whether the driver initiates the turn by pulling the wheel down from the 3 or 9 o'clock position toward 6 o'clock, or pushing the wheel up from the 5 or 7 o'clock position toward 12 o'clock, the opposite hand slides up or down as appropriate to provide additional input or to stabilize steering. The process is reversed to return to a straight path. The wheel is not allowed to slip through the fingers to straighten when coming out of a turn and both hands are always on the wheel to make adjustments as necessary.

Hand to hand steering is particularly well suited for precision maneuvers, steering through curves, intersection entry and exit, and front wheel traction loss control (vehicle understeer).

2. Hand Over Hand Steering

Hand over hand steering is particularly well suited when speed of the steering movement is critical such as skid recovery in a rear wheel traction loss (vehicle oversteer). When used to control or recover from a skid, it is important to hold the wheel so that it allows the driver to use the upper left third of the wheel when steering to the left and the upper right third when turning right. This procedure allows for maximum movement of the wheel with driver's knowledge of its neutral position.

Hand over hand steering is also useful when maneuvering in a space with limited sightlines, such as perpendicular parking in a congested shopping center. When using hand over hand steering, quick movements of the hands are recommended on entry to the maneuver, with smooth slow movements when returning the wheel upon completion of the maneuver. Drivers should be aware that employing hand over hand steering under all conditions does expose one to some additional risk of injury to arms, hands, and/or face in the event of a crash that results in air bag inflation. Use of hand over hand as the primary steering technique raises the risk of off-road crash occurrences.

3. Limited Evasive Steering

Whether performed at low or high speed, a quick turn results in a shift of weight of the center of mass to the left or right side of the vehicle. Speed of travel and steering input have a direct influence on the level (increase) of weight transferred to the front corner opposite the direction of the turn with a reduction in weight to the rear, particularly on the side in the direction of the turn.

When an error has been committed and closure is occurring at higher speeds, the quickness and amount of steering input needed to make a 12 foot lane change is critical. This sudden steering input coupled with higher speed of travel, unless dampened by a smooth, rapid, limited steering effort is capable of generating sufficient weight transfer to cause a loss of control.

The important points to remember are:

- In an evasive action, limited steering input of no more than 180 degrees (touch of the arms) must be quick and smooth with limited return steering to maintain vehicle balance.
- At higher speeds, the driver may control brake prior to initiating the steering action to transfer weight to the front wheels but must come off the brake or trail brake while steering for avoidance. As the speed increases, less steering input is needed to move the vehicle to the left or right.
- Keep in mind that if the vehicle is ABS equipped, stay with the brake while performing the limited steering inputs.
- The initial steering input moves the front of the car while the second input to the touch of arms moves the rear of the vehicle. It is critical to move the wheel back to the neutral position to stabilize the vehicle within the lane.

4. One- Hand Steering

Movement of the steering wheel with one hand is recommended only for backing maneuvers which do not require full left or right turns or when operating information, safety, or comfort devices. Backing and steering with one hand requires shifting one's hip and seat position so the driver's head can be turned to see past the head restraint. To improve balance, the driver's right arm is often draped over the back of the seat. Visual checks to the front should be made prior to starting the backing maneuver. The left hand grips the steering wheel near the top and is moved in the direction the driver wishes the rear of the vehicle go. The left hand at the bottom may be used to back a trailer. Sharp turns while backing may require the use of both hands. Since it is more difficult to maintain steering control when backing, all reverse movements should be made at slow speed.