NHTSA Heavy Vehicle Test Track Research

Frank Barickman

Devin Elsasser

National Highway Traffic Safety Administration

SAE®

NHTSA
www.nhtsa.gov

NHTSA Heavy Vehicle Test Track Research

- Stability Control Research
  - Truck-Tractor Stability Control Testing
  - Single Unit Truck Stability Control Testing
- Advanced Technology Research
  - Forward Collision Avoidance Testing

Stability Control Research

NHTSA Test Program

Initial Research

- Evaluate and test the performance of current heavy truck stability control systems
  - Tractor Based Systems
    - Roll Stability Control (RSC)
    - ESC - Yaw Stability Control (YSC) + RSC
  - Trailer Based Systems (no communication with tractor)
    - Roll Stability Control (RSS)
- Understand how these systems perform and their limitations to help estimate potential safety benefits
- Investigate and define test maneuvers that could be used to develop an objective test.

Maneuvers Evaluated

- 150 ft. J-Turn Maneuver
- Single Lane Change and Double Lane Change
- 150 and 200 ft. Constant Radius Maneuver
- High and Low Mu Surface Testing

Initial Results

- Found all levels of ESC/RSC/RSS to be beneficial as compared to the base platform.
- Found tractor based stability systems to be more beneficial than trailer based (i.e. activated sooner and provided interventions to mitigate roll without the trailer based system engaging.)
- Initial decision made to focus on truck tractor stability control and develop a performance test.

Initial Performance Test Focus

RSC – Roll Stability Control for truck tractors

- Develop an “optimized” roll stability performance test that can evaluate roll stability for truck tractors.

NOTE: NHTSA decided this based on preliminary crash statistics that roll stability should be part of any stability control test for truck tractors. Full stability control may be just as important.

RSC Performance Test Development Objectives

- Determine an RSC test maneuver
- Develop a methodology using test maneuver
  - Control trailer (multiple trailers?)
  - Load (CG, Weight, etc.)
  - Driver or Steering controller
  - Outriggers
  - Maneuver speed
- Develop a measure of performance (MOP)
  - Metric (acceleration, roll angle, wheel lift, etc.)

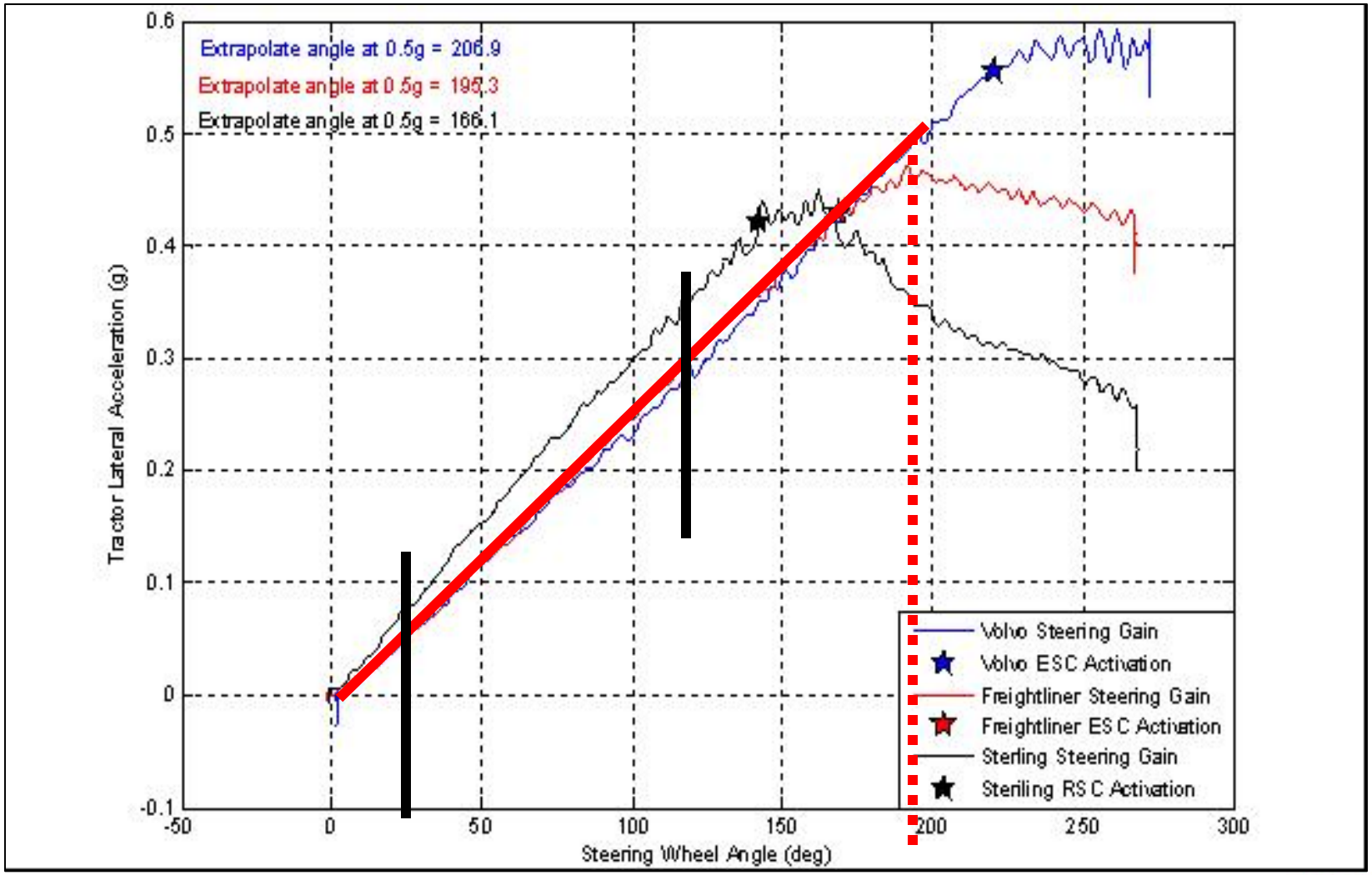
Government and Industry Coordination

- Met with the Truck Manufactures Association, OEM Truck Manufactures, and OE Brake Suppliers
- Regular coordination with FMCSA and PHMSA
- Identified potential RSC test maneuvers
  - Ramp Steer Maneuver (RSM)
  - Roll Stability Control Test (RSCT)
  - Decreasing Radius Test (DRT)
  - Slow Increasing Steer Test (SIS)

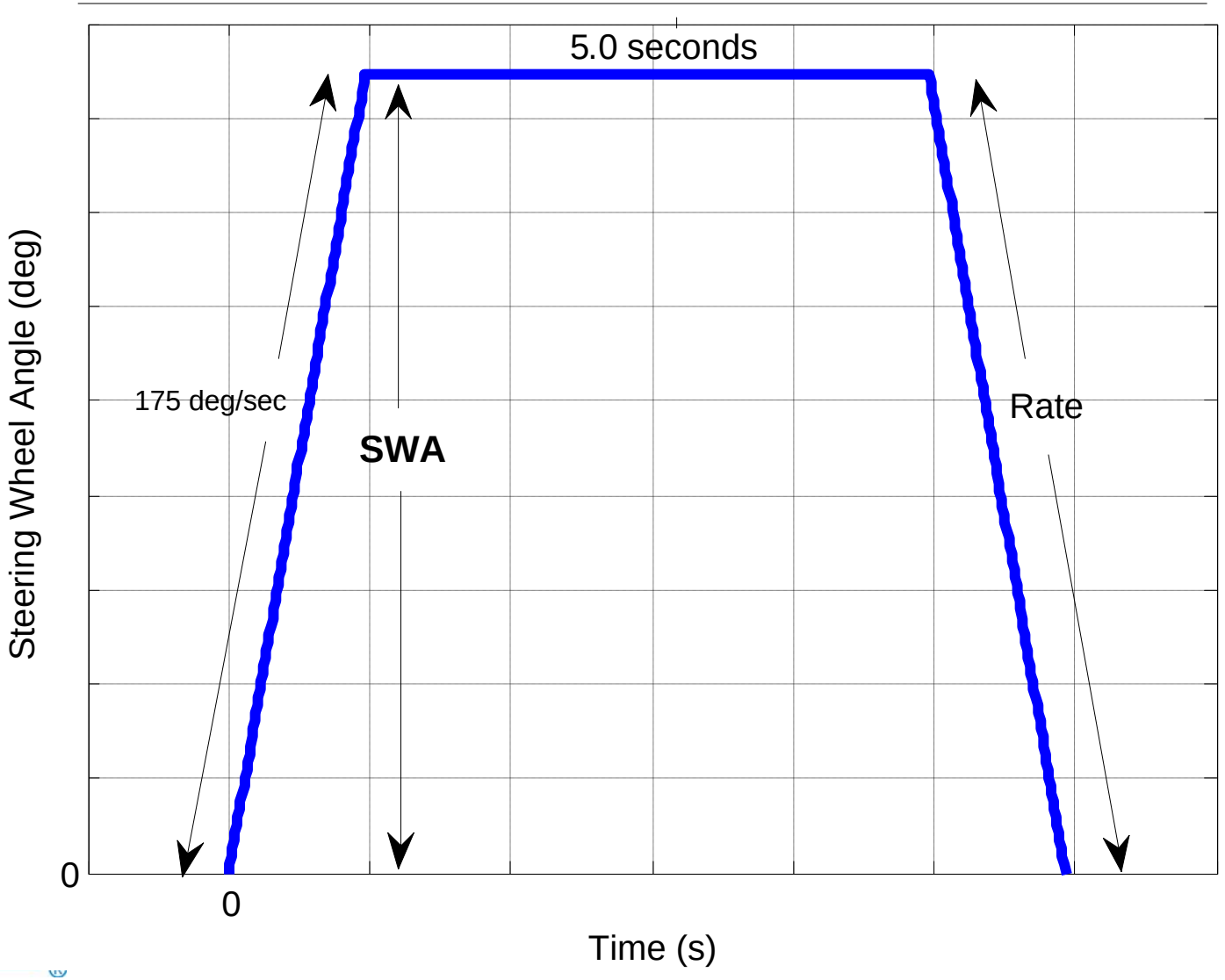
Research Maneuver Decision

- Slow Increasing Steer Maneuver
  - Platform characterization
  - Average steering wheel angle (SWA) at projected 0.5G lateral acceleration
- Ramp Steer Maneuver
  - Tweaked maneuver using ideas from the previously identified maneuvers
  - Use SWA for steering magnitude (from SIS test)
  - Test drop throttle – clutch in
  - Trailer is unbraked

Example of SIS



Ramp Steer Maneuver

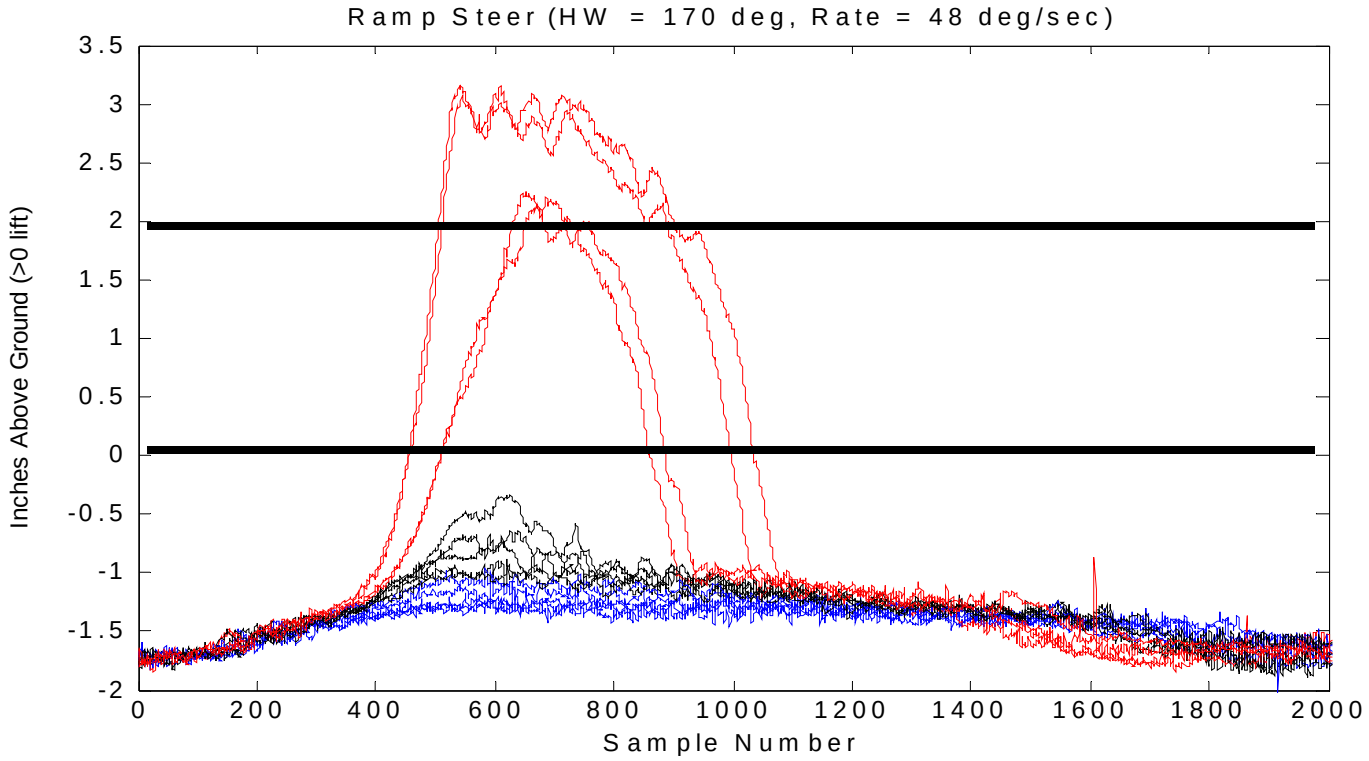


Potential Measures of Performance

- Wheel Lift
- Tractor Lateral Acceleration Ratio (LAR)
- Trailer Lateral Acceleration Ratio (TrlLAR)
- Trailer Roll Angle Ratio (RAR)

Wheel Lift

Considered to be any tractor or trailer wheel lift that occurs during a test that greater then 2.0 inches.



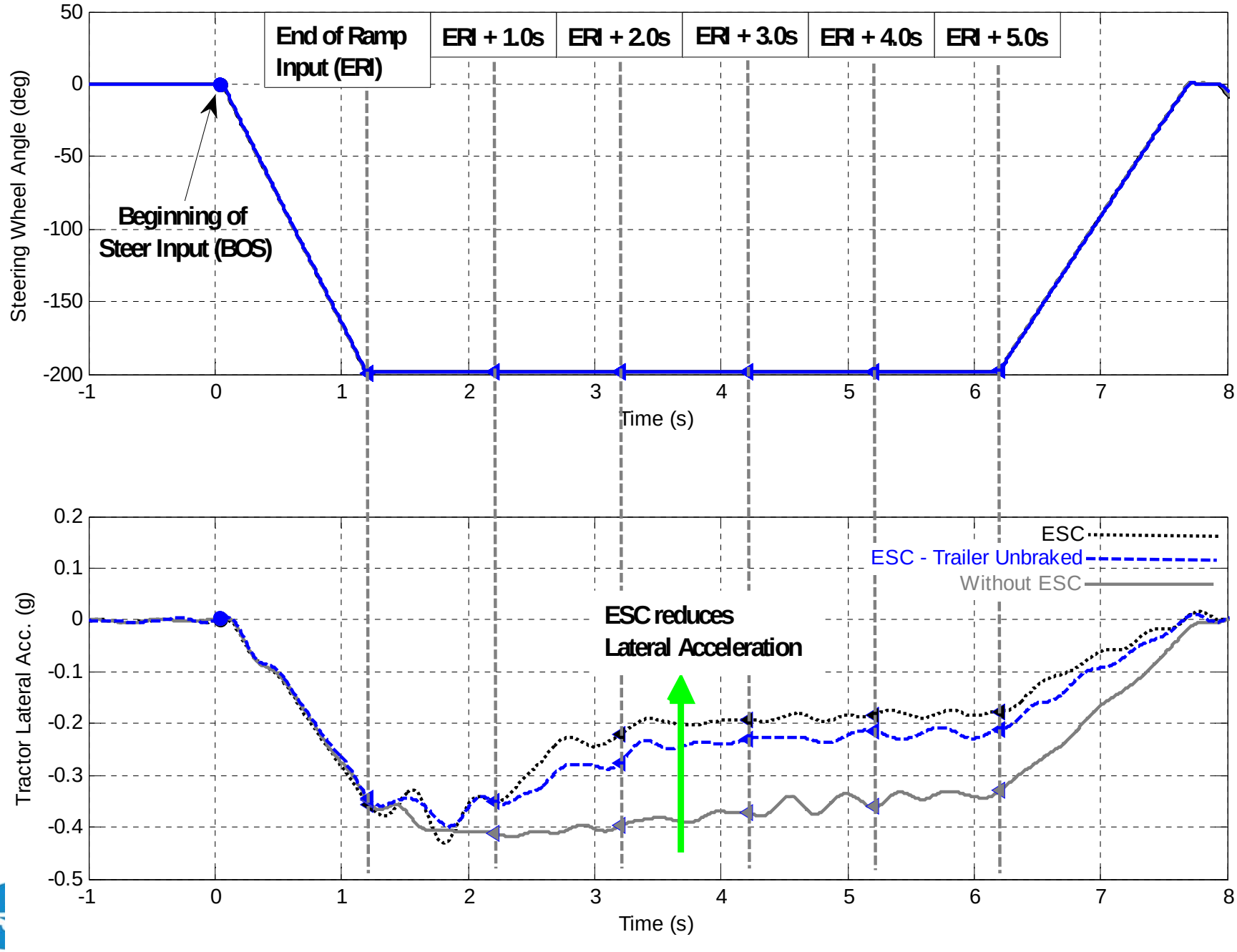
Tractor
Lateral Acceleration Ratio (LAR)

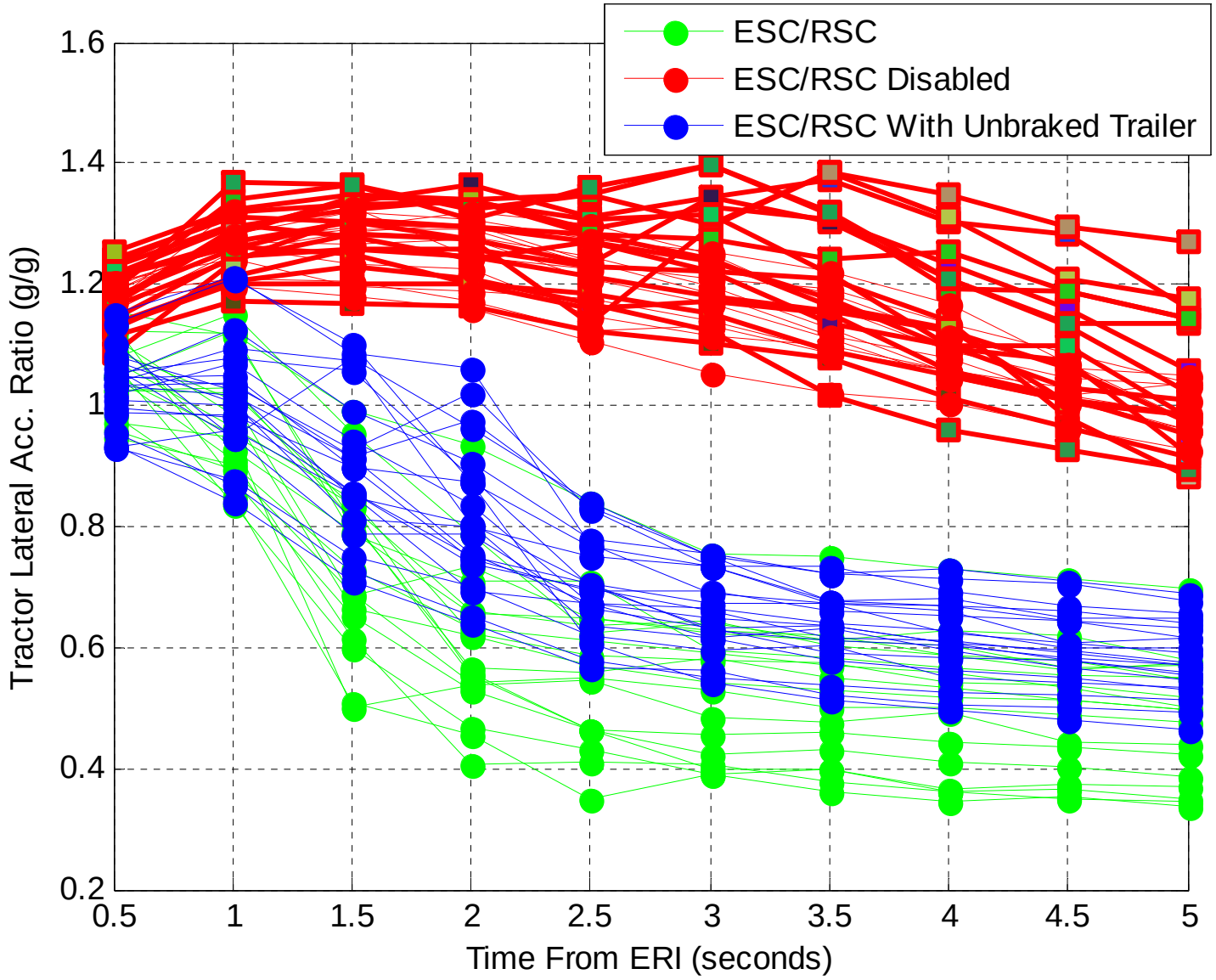
$$\mathbf{LAR} = \frac{Ay_{Tractor}\left(ERI + 1.0, +2.0 \ldots + 5.0\,\mathrm{sec}\right)}{Ay_{Tractor}\left(ERI\right)}$$

Where:

$Ay_{tractor}$ = Lateral Acceleration of the tractor

ERI = End of Ramp Input


End of Ramp Input (ERI)
ERI + 1.0s
ERI + 2.0s
ERI + 3.0s
ERI + 4.0s
ERI + 5.0s
Beginning of Steer Input (BOS)
Steering Wheel Angle (deg)
Time (s)
ESC
ESC - Trailer Unbraked
Without ESC
ESC reduces Lateral Acceleration
Tractor Lateral Acc. (g)
Time (s)


ESC/RSC
ESC/RSC Disabled
ESC/RSC With Unbraked Trailer
Tractor Lateral Acc. Ratio (g/g)
Time From ERI (seconds)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Single Unit Truck and Bus Stability Control Test Track Testing

SUT and Bus Stability Control

Covers a wide range of vehicle applications.

Class 3: 10,001 – 14,000 lbs.

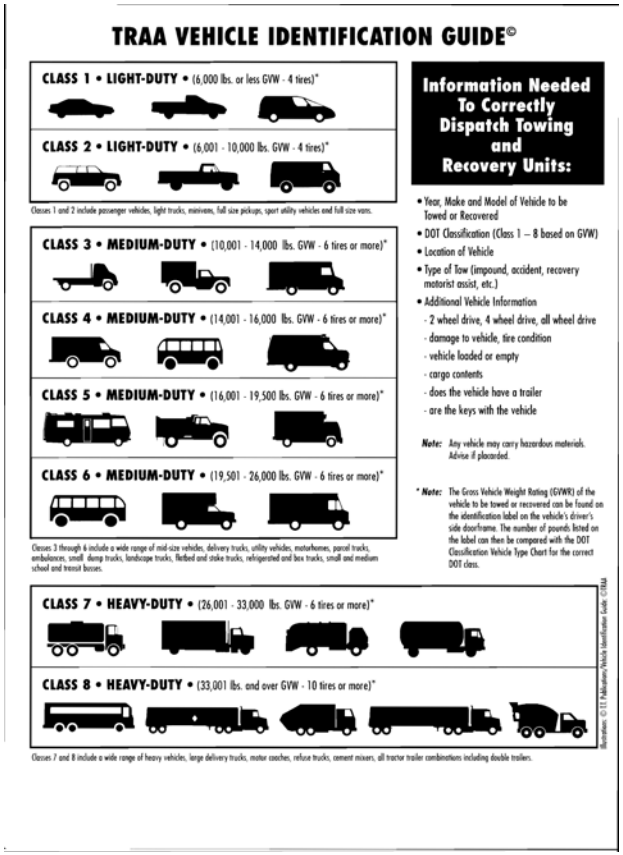
Class 4: 14,001 – 16,000 lbs.

Class 5: 16,001 – 19,500 lbs.

Class 6: 19,501 – 26,000 lbs.

Class 7: 26,000 – 33,000 lbs.

Class 8: 33,001 and over



Objectives of SUT and Bus Track Testing

- Understand the base stability characteristics
- Test a variety of platforms ranging from Class 3 – Class 8 SUTs (including a motorcoach)
- Evaluate SUTs using previously developed test maneuvers
  - SIS, Ramp Steer, Sine with Dwell, Half Sine, Fish hook
  - Base platform in some cases since ESC is not available.

Advanced Technology Research

Forward Collision Warning

- Forward collision warning systems and other technologies are becoming available for both LV and HV platforms.
- NHTSA announced Crash Avoidance NCAP for LV in July 2008
  - NHTSA-2006-26555 (July 2008)

Objectives

- Evaluate the performance of a state-of-the-industry HV FCW system.
- Examine the applicability of objective test procedures developed for light vehicle NCAP.
  - Do the procedures work for the HV platform?
  - What changes need to be made in the method?
- Gather objective data to help understand and define the performance of FCW technology for heavy vehicles.

Objective Tests to be performed

- Subject Vehicle (SV) Encounters a Stopped Principle Other Vehicle (POV)
- Subject Vehicle (SV) Encounters a Decelerating Principle Other Vehicle (POV)
- Subject Vehicle (SV) Encounters a Slower Principle Other Vehicle (POV)

Frequent Truck Pre-Crash Scenarios

LV objective tests correlate well with frequent HV pre-crash scenarios (top 3).

Conflict	Annual # Trucks in Crashes	Relative Frequency
SV encounters Stopped POV	25,444	46%
SV encounters Decelerating POV	12,709	23%
SV encounters a Slower POV	6,942	14%

Volvo IVI FOT Evaluation Report (2007)

Questions?