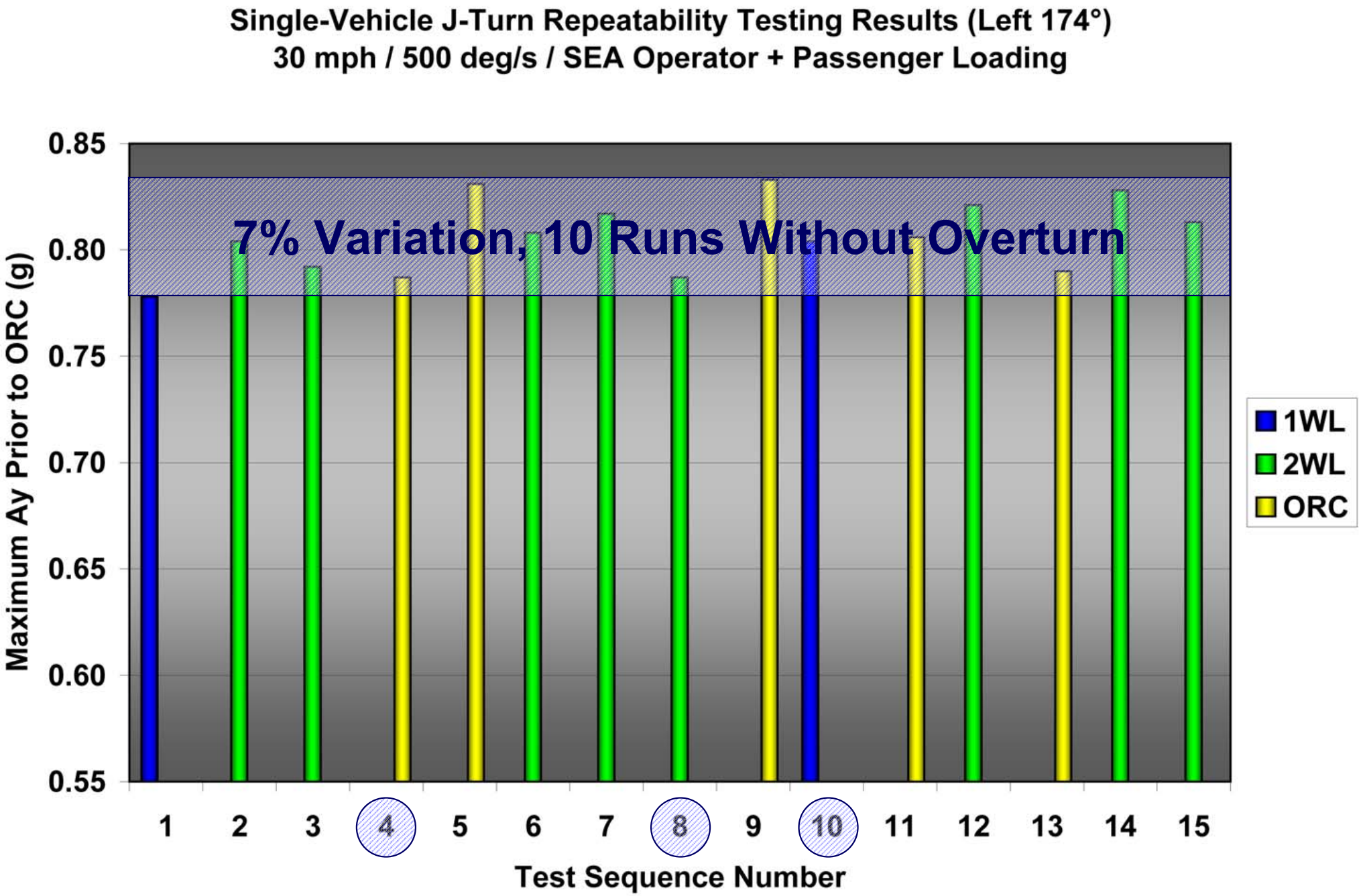
ROHVA / CPSC
Technical Discussion

July 19, 2012

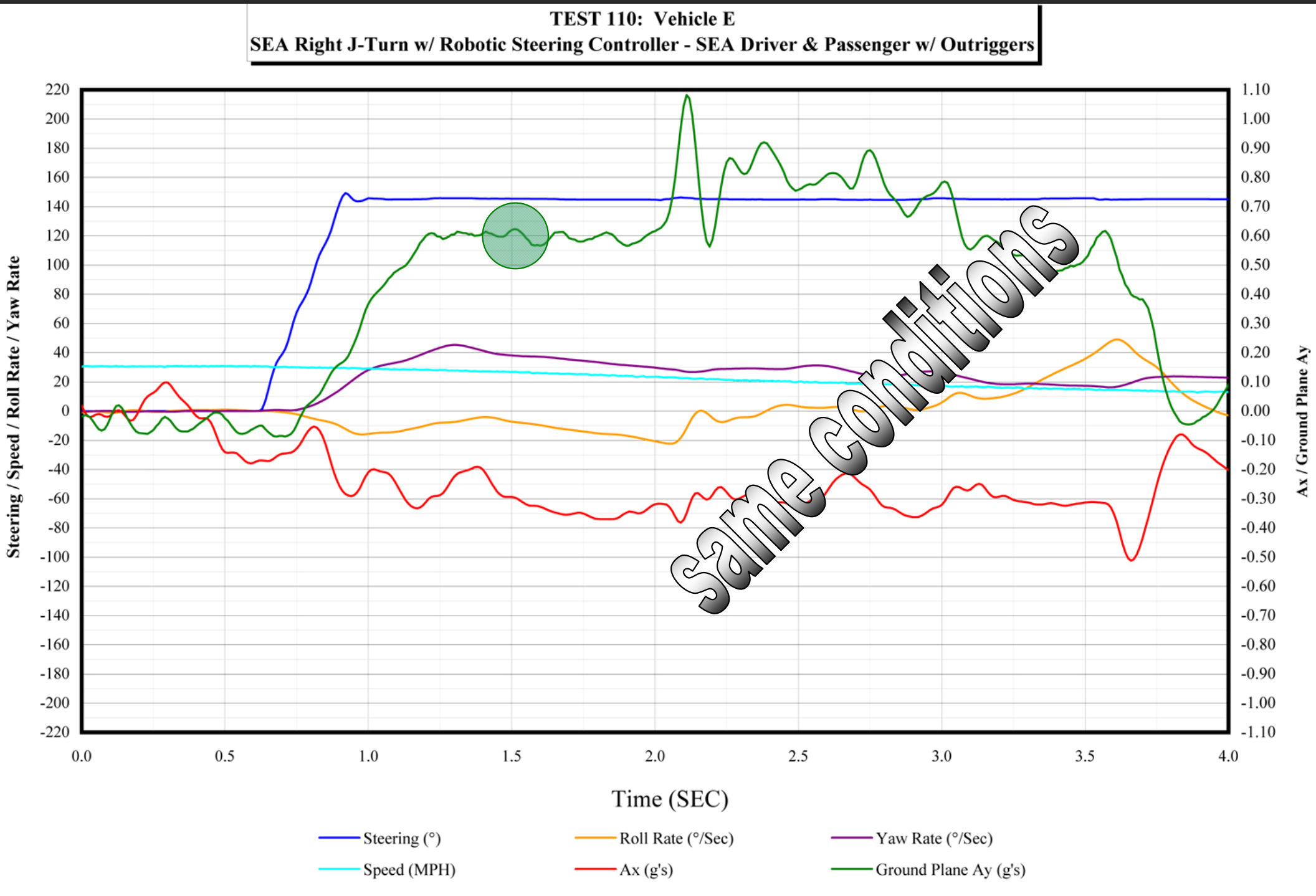
Carr Engineering, Inc.

Single-Vehicle J-Turn Repeatability Study

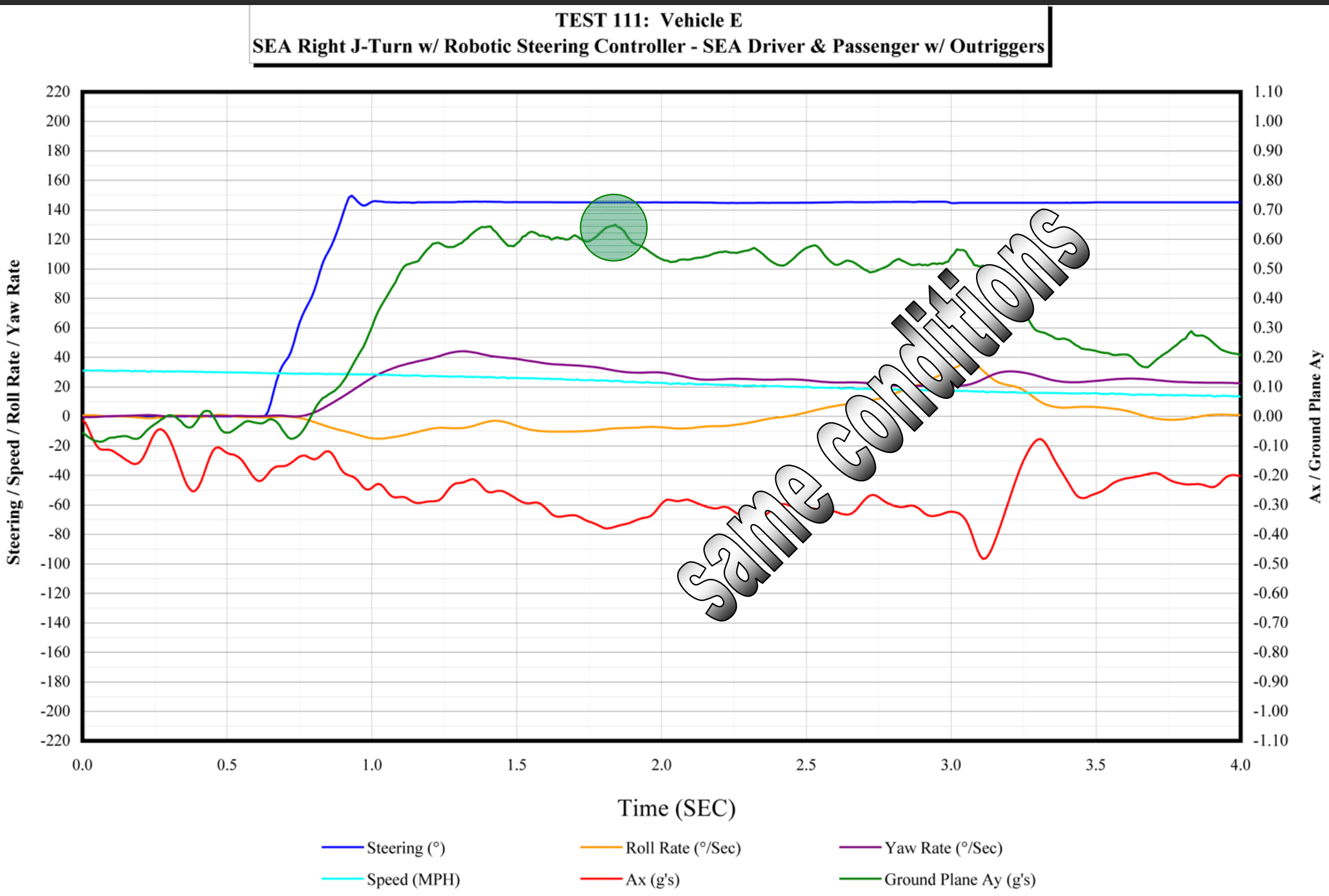
Vehicle E


Single-Vehicle J-Turn Repeatability Testing Results (Left 174°)
30 mph / 500 deg/s / SEA Operator + Passenger Loading
7% Variation, 10 Runs Without Overturn
Maximum Ay Prior to ORC (g)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
1WL
2WL
ORC
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Test Sequence Number

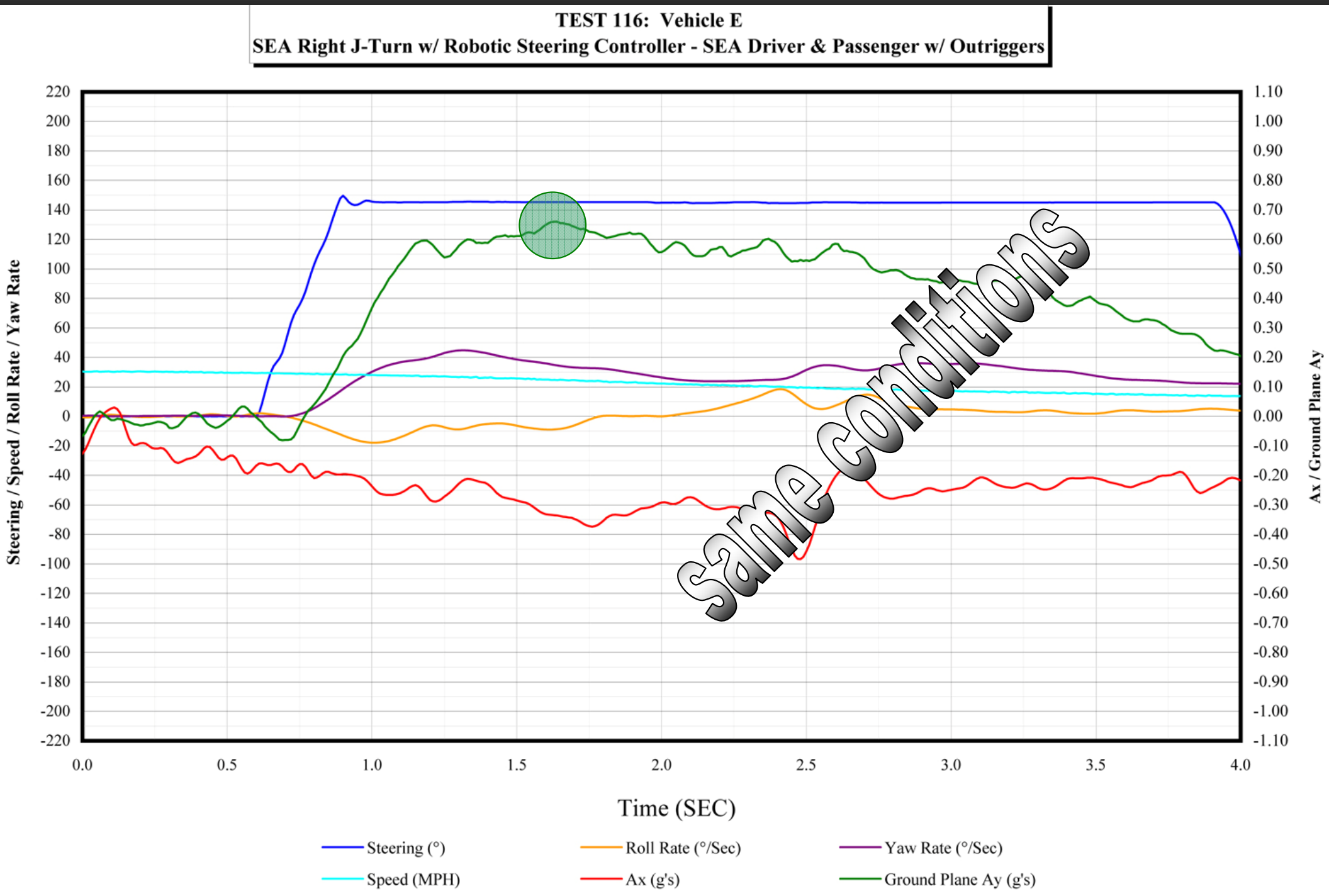
0.623 g w/ Outrigger Contact



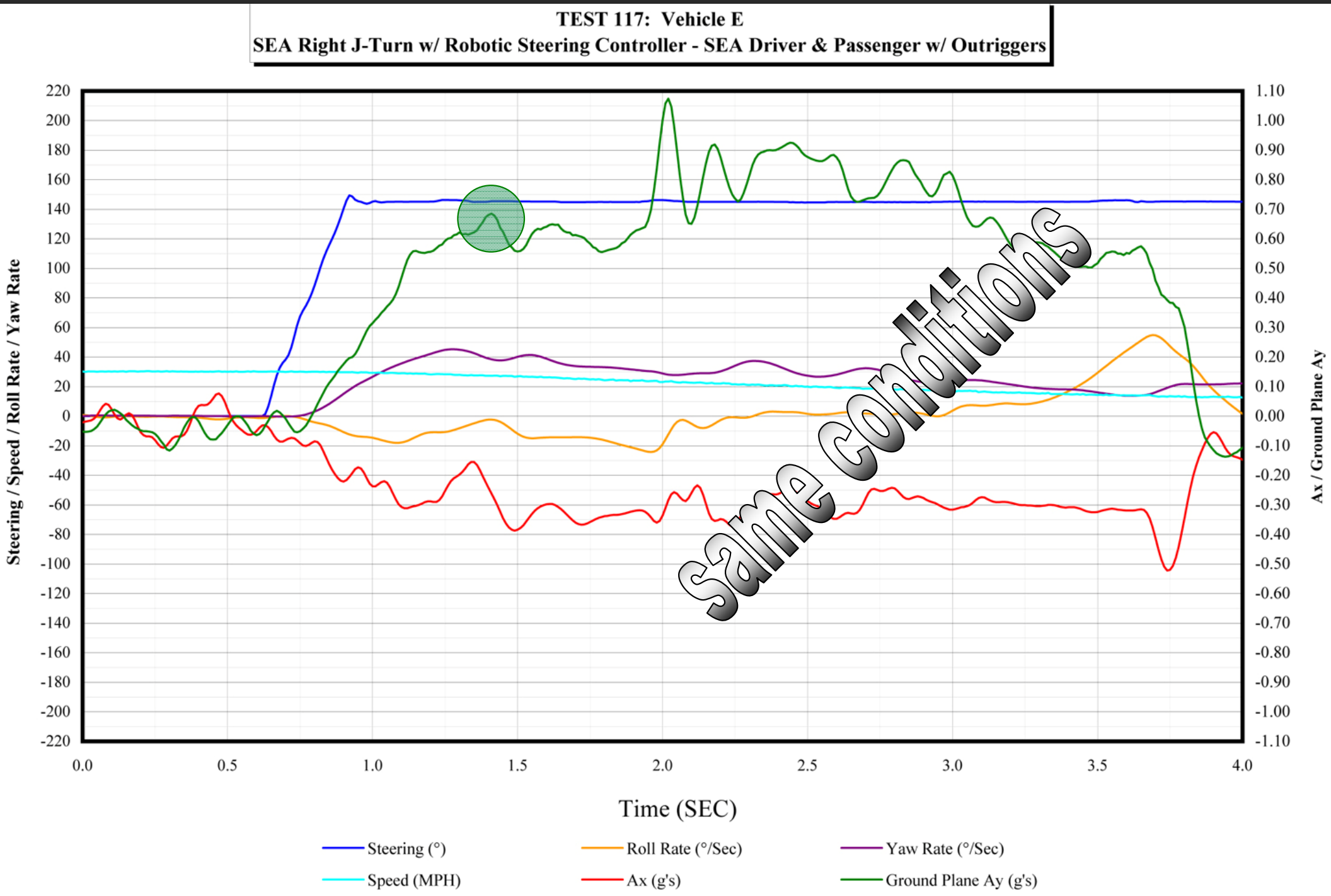
0.649 g w/ Two-Wheel Lift



0.660 g w/ One-Wheel Lift

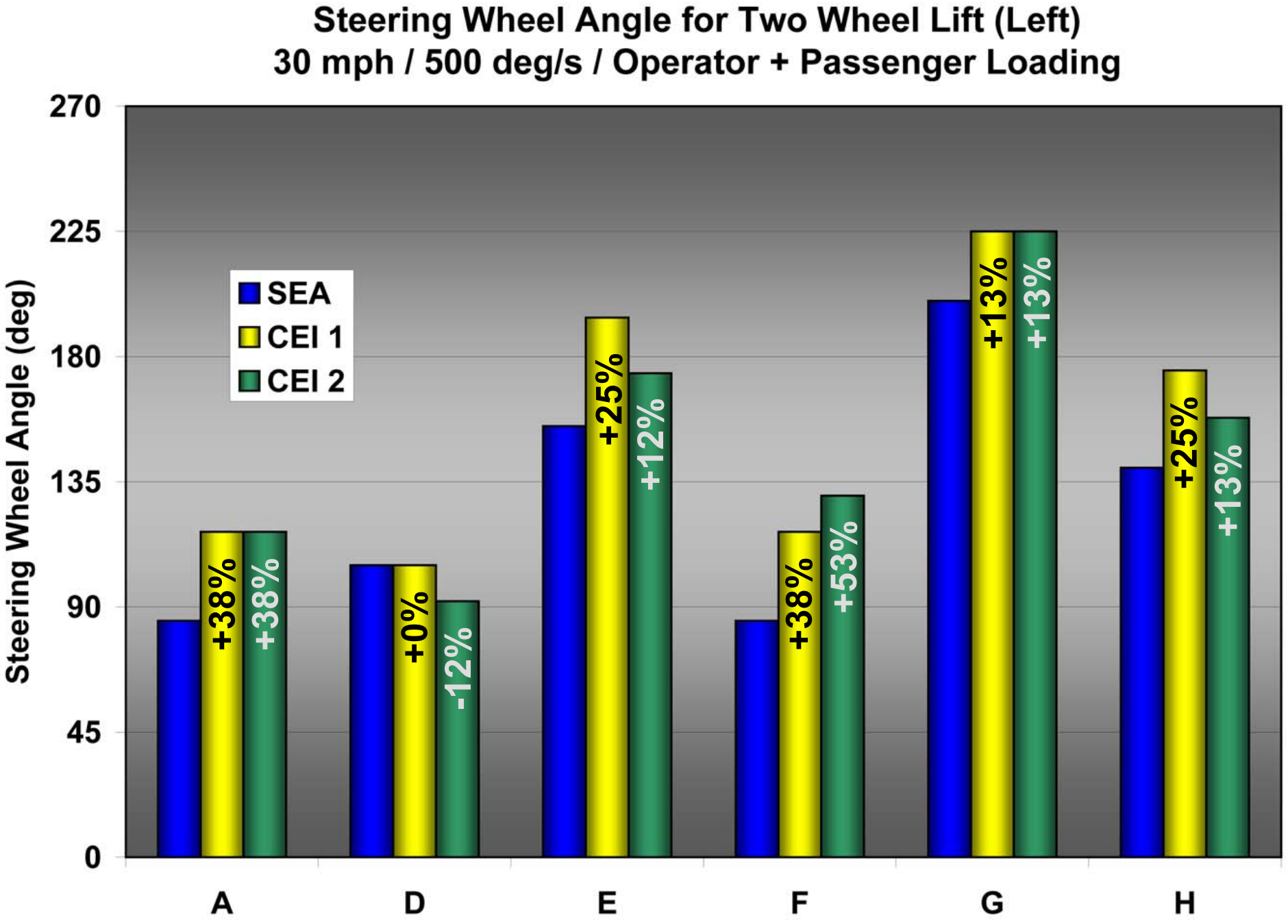


0.685 g w/ Outrigger Contact

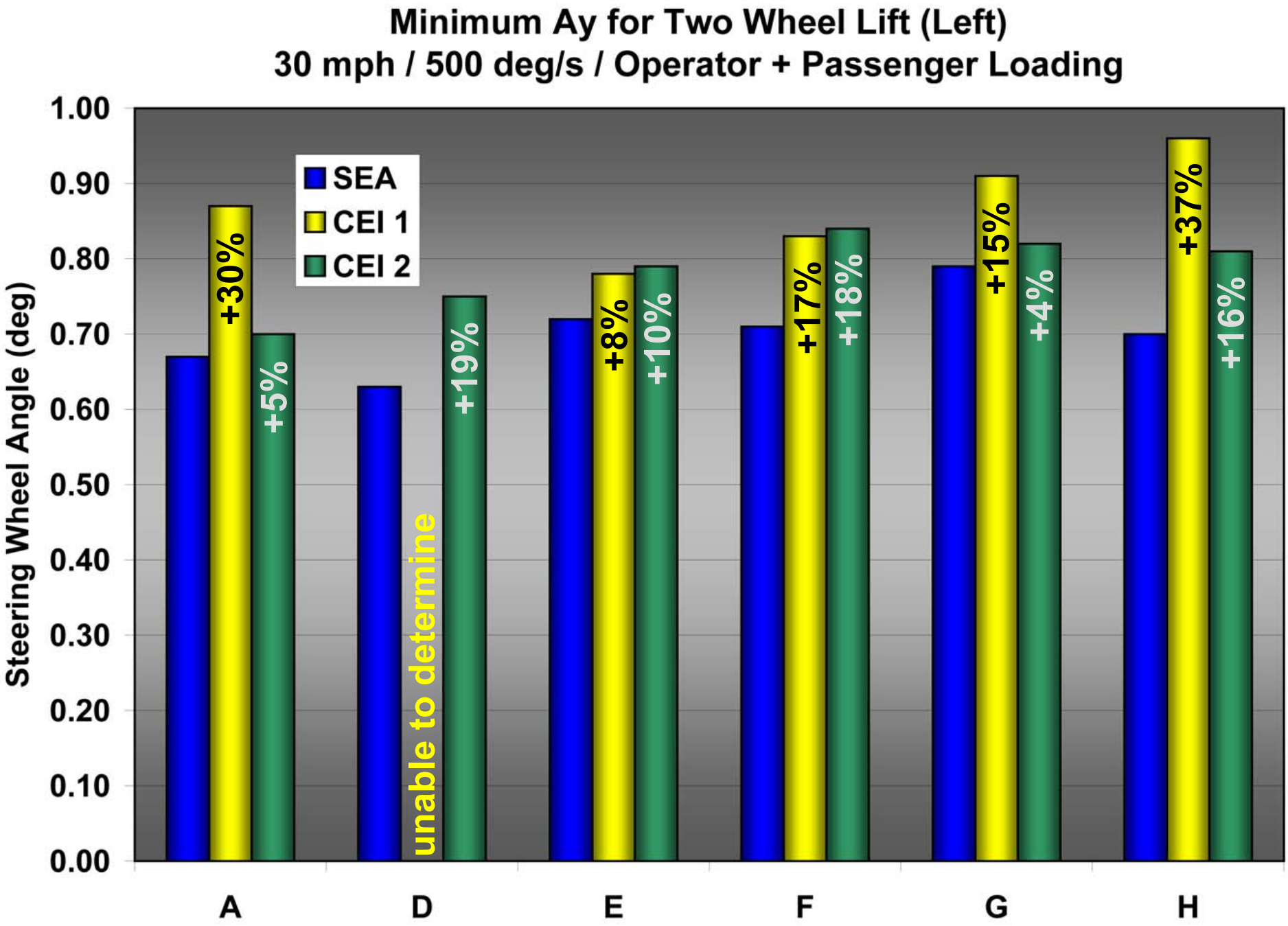


Multi-Vehicle J-Turn Repeatability Study

SWA Results and Analysis



Ay Results and Analysis



CPSC Responses to ROHVA Questions

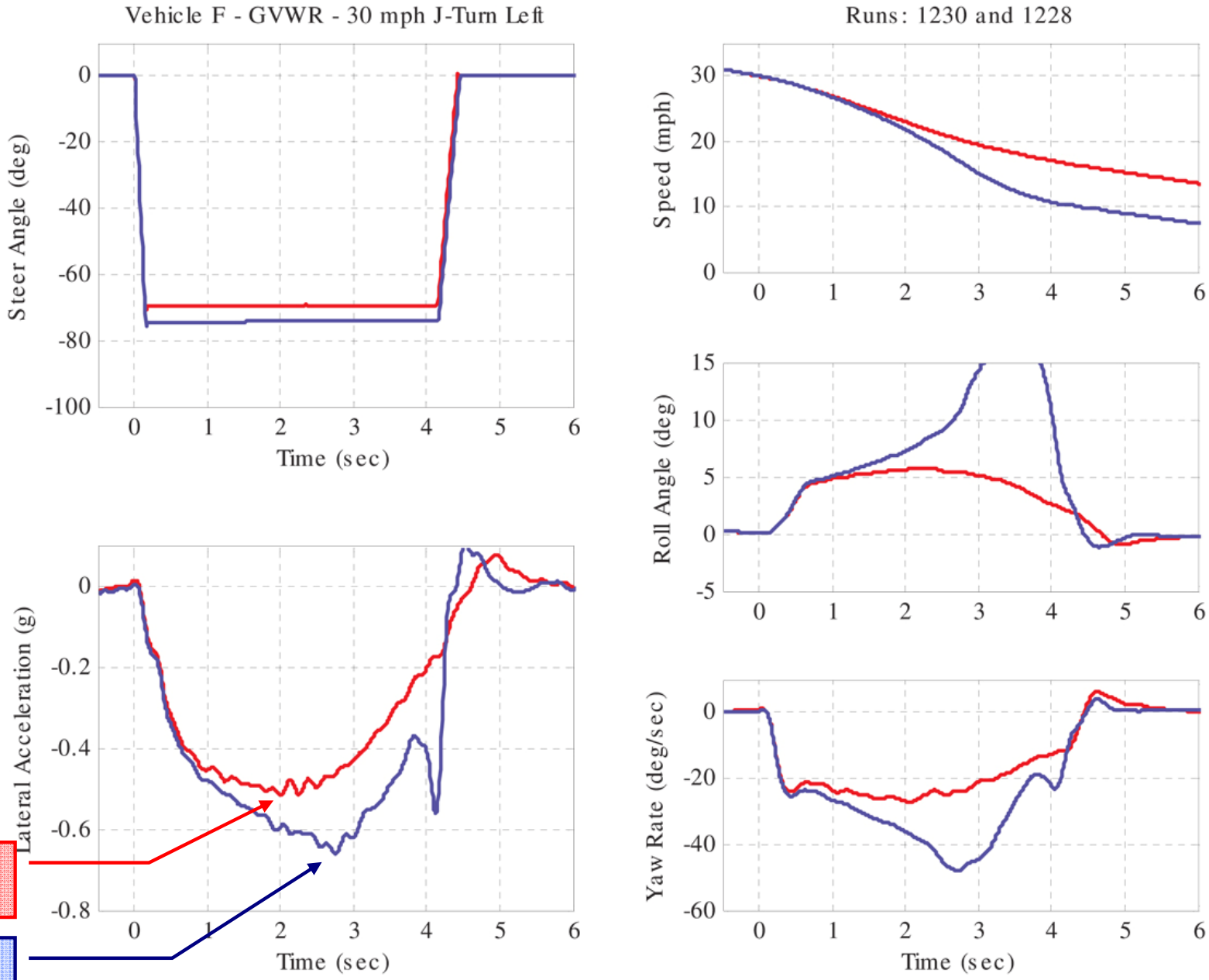
ROHVA Question 4

- **Q: A review of the dropped throttle J-turn testing for which results are presented in Appendix E of both the April and August 2011 SEA Reports indicates that data from several tests may not have been included in the original Reports. In addition to the runs numbered 116 and 117, 1128 and 1129, and 1326 and 1328, were there any other tests performed where a vehicle (or vehicles) in the operator and passenger loading configuration showed an Ay variability of 0.03 g or greater between runs when tested in the same direction? If so, please list the machine(s) by identifying letter and provide the test results for all such runs.**

CPSC Response – Question 4

- **A: In Section 4.5 of the April 2011 report SEA states: "...the blue lines are the tests with the minimum steering that resulted in tip-up and the red lines are the tests with the maximum steering that did not result in tip-up." There are no tests with intermediate steering or severity between these two. These blue and red lines are shown for all vehicles in both the right and left steer directions.**

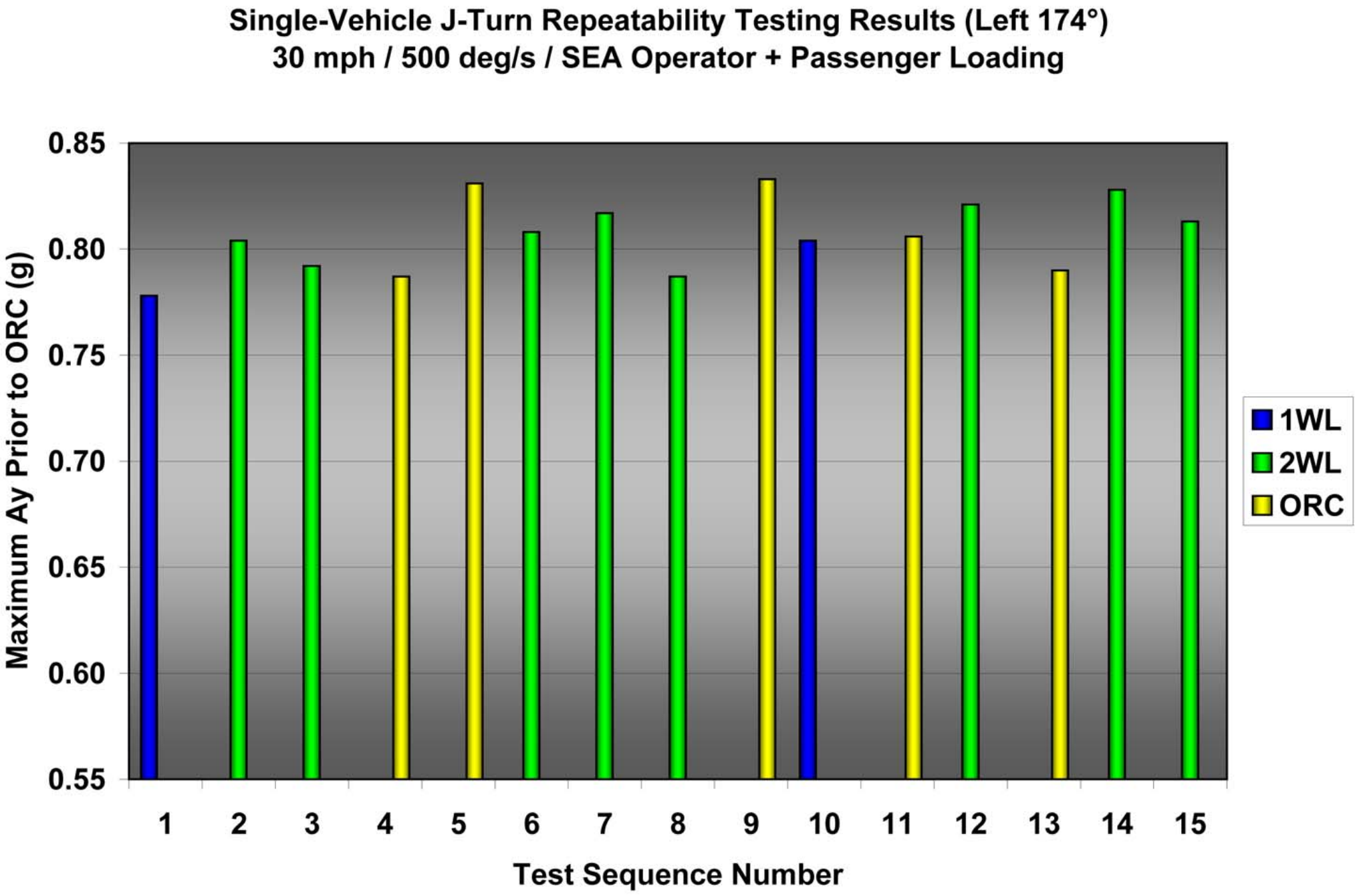
SEA Data – Vehicle F



0.51 g

0.65 g

Vehicle E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0.60
0.55
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Test Sequence Number
1WL
2WL
ORC

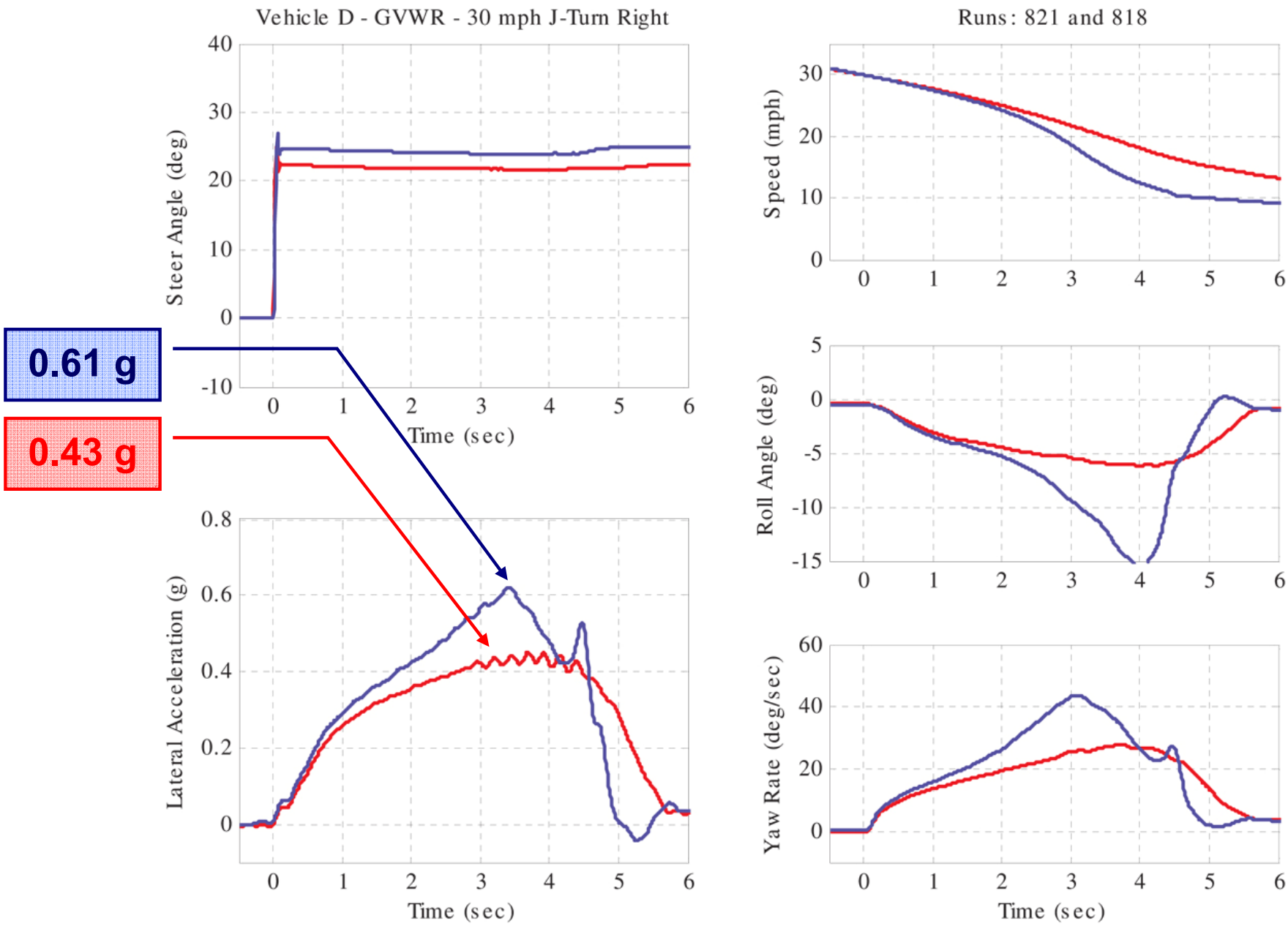
ROHVA Question 6

- **Q: From page 12 of the SEA report, ROHVA understands that "…tip-up events are considered those that produced significant two-wheel lift and in almost all cases outrigger contact." Please identify the number of drop throttle J-Turn tests performed by SEA where 2-wheel lift was observed without outrigger contact. Please provide this data, by machine, for both loading conditions tested. If the precise number of runs cannot be provided, please provide an approximate anecdotal answer rounding to the nearest 10%.**

CPSC Response – Question 6

- **The statement "For this testing, tip-up events are considered those that produced significant two-wheel lift and in almost all cases outrigger contact," is describing that the lateral threshold testing of these vehicles resulted in two-wheel lift that would have continued into a 90 degree rollover if the outrigger did not prevent the rollover event from occurring. Therefore, to determine the minimum lateral acceleration required to induce rollover, the tests were repeated at smaller and smaller steer angles until the vehicle exhibited just enough two-wheel lift to measure that minimum lateral acceleration but not enough to make outrigger contact (and thereby incorrectly measure the lateral acceleration caused by outrigger impact with the ground). 100% of the J-Turn tests that measured the minimum lateral acceleration of the vehicle at rollover threshold exhibited 2-wheel lift without outrigger contact since by definition that was how the value was measured.**

SEA Data – Vehicle D

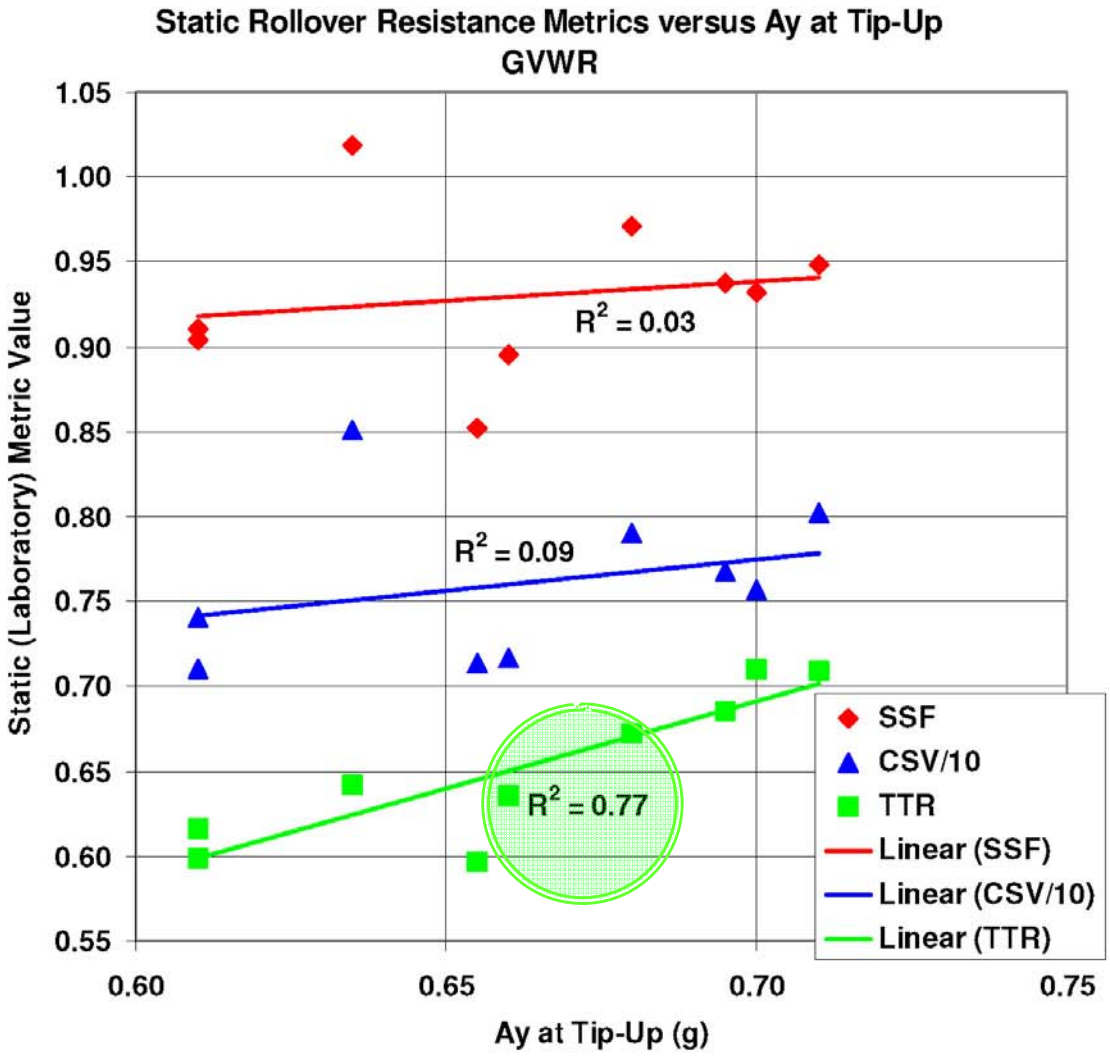


SEA Data – Vehicle D

Maximum Lateral Accelerations During Dropped Throttle J-Turns Vehicle D – GVWR Loading						
	Right Steer Maneuvers		Left Steer Maneuvers		Average of Right and Left Maneuvers	
Percentage of Steering Required for Two Wheel Lift (%)	Steering Angle (deg)	Lateral Accel. (g)	Steering Angle (deg)	Lateral Accel. (g)	Steering Angle (deg)	Lateral Accel. (g)
0.0	0.0	0.00	0.0	0.00	0.0	0.000
25.0	6.3	0.09	-6.9	-0.10	6.6	0.095
50.0	12.5	0.17	-13.8	-0.21	13.1	0.190
75.0	18.8	0.26	-20.6	-0.37	19.7	0.315
87.5	21.9	0.48	-24.1	-0.54	23.0	0.510
100.0	25.0	0.61	-27.5	-0.61	26.3	0.610

Understeer Correlation Study

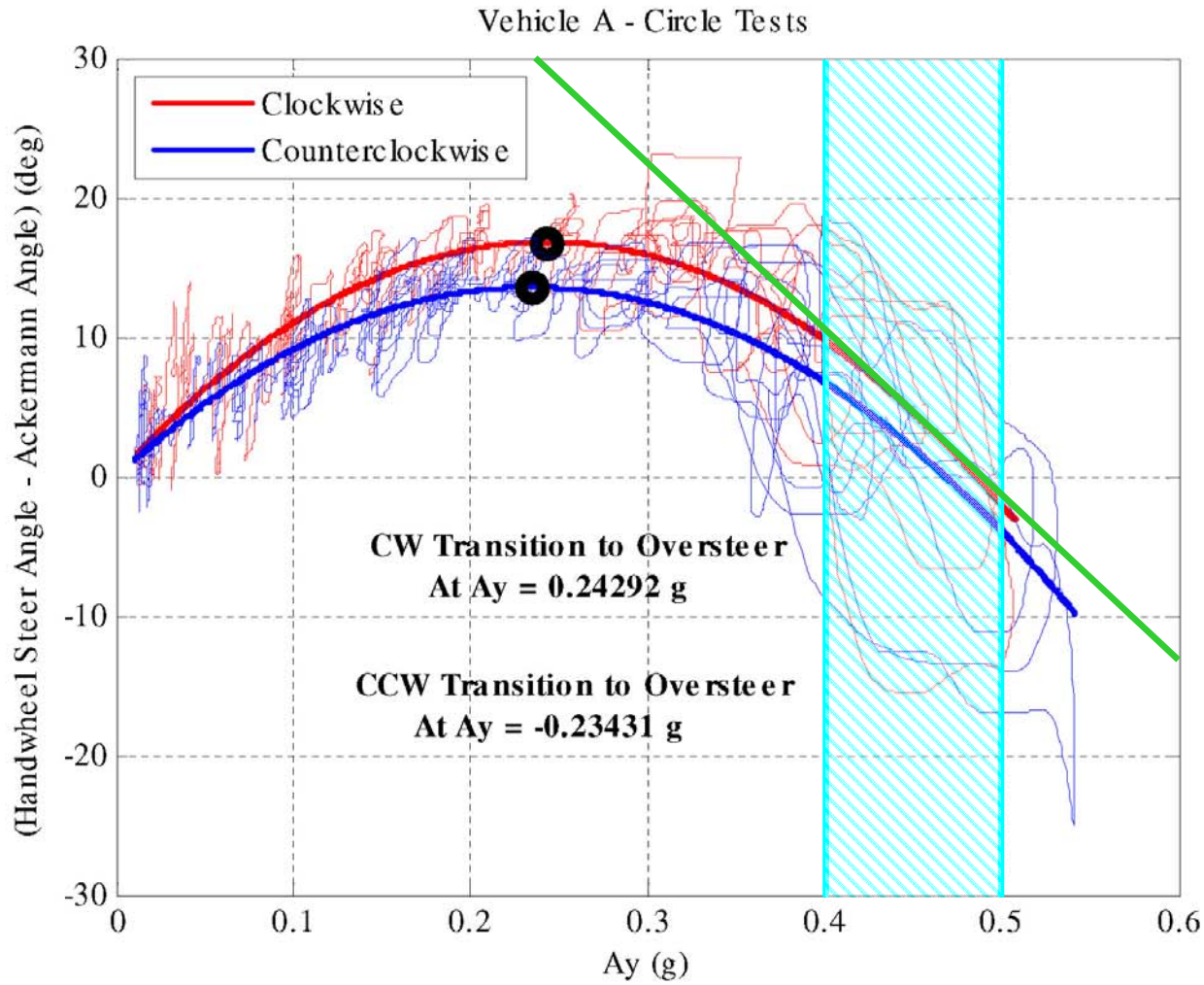
SEA Report Correlation Analysis



SEA Report Correlation Analysis

Pages 44 and 45 (Operator and Passenger) and Pages 57 and 58 (GVWR) contain exhibits comparing the laboratory rollover resistance metrics to the lateral accelerations required for tip-ups in the dropped throttle J-turns. Pages 44 and 57 are bar charts of the values, while Pages 45 and 58 are graphs with plots of the rollover resistance metrics versus lateral acceleration at tip-up. Linear fits of the plots are also provided on the graphs. The graphs on Pages 45 and 58 indicate that TTR has a better correlation to lateral acceleration at tip-up than do SSF or CSV. However, none of the static metrics examined correlated very well with the minimum lateral acceleration thresholds. The data for Vehicle I, the four-passenger vehicle, has the biggest outliers from the linear fits for SSF and CSV in both loading configurations.

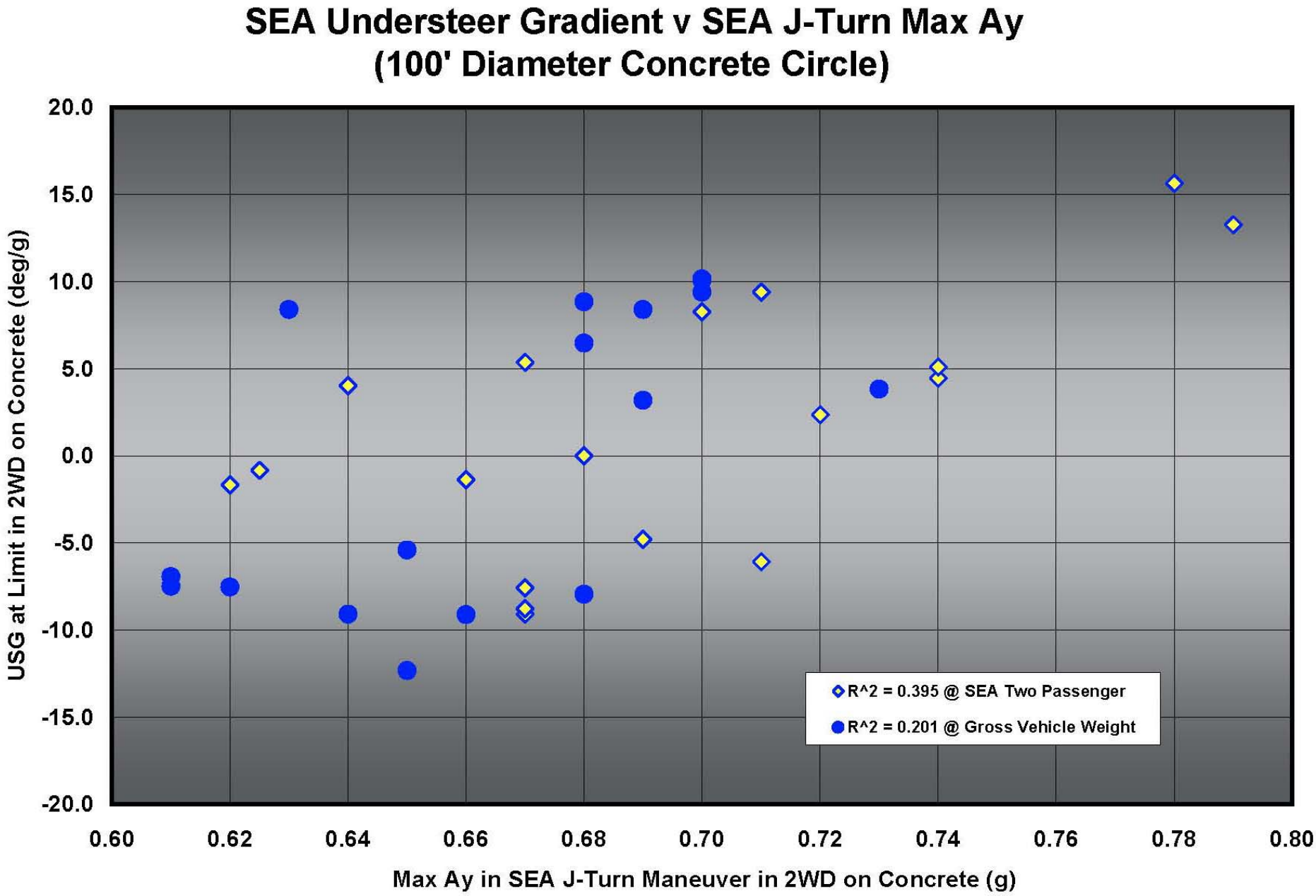
Quantification of USG



– USG

CPSC Circle Test Results – Operator, Instrumentation and Outriggers *Appendix C.1* *Page #3*

USG Correlation on Concrete

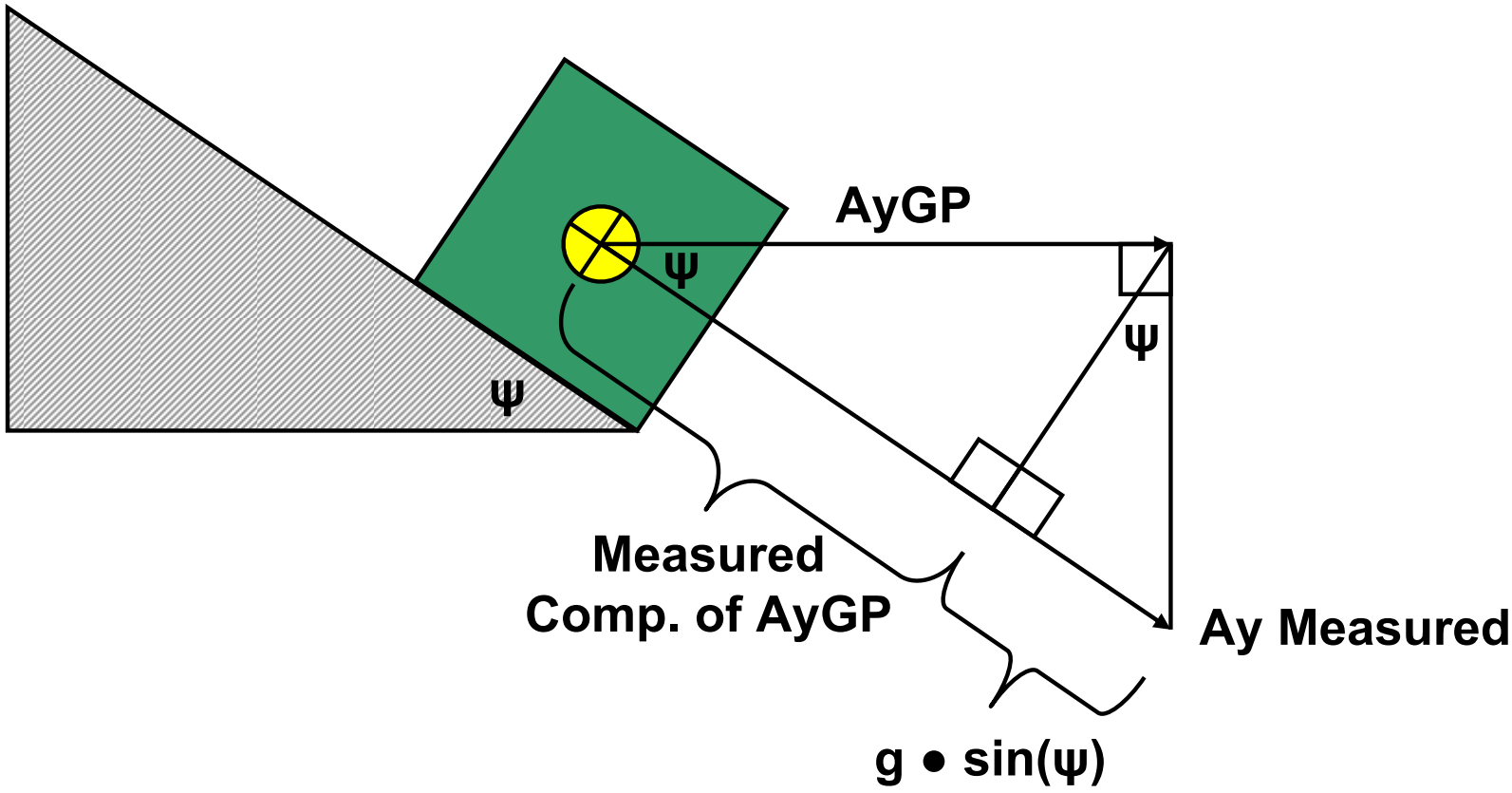


USG Correlation Summary

	SEA Two Passenger	SEA GVW Loading
USG (Concrete) v. SEA Max Ay	0.40	0.20
USG (Concrete) v. SEA TTA	0.27	0.40
USG (Concrete) v. SEA SSF	0.23	0.02
USG (Dirt) v. SEA Max Ay	0.00	0.04
USG (Dirt) v. SEA TTA	0.01	0.07
USG (Dirt) v. SEA SSF	0.07	0.01

Ay Body Roll Correction Factor

Ay Body Roll Correction Factor



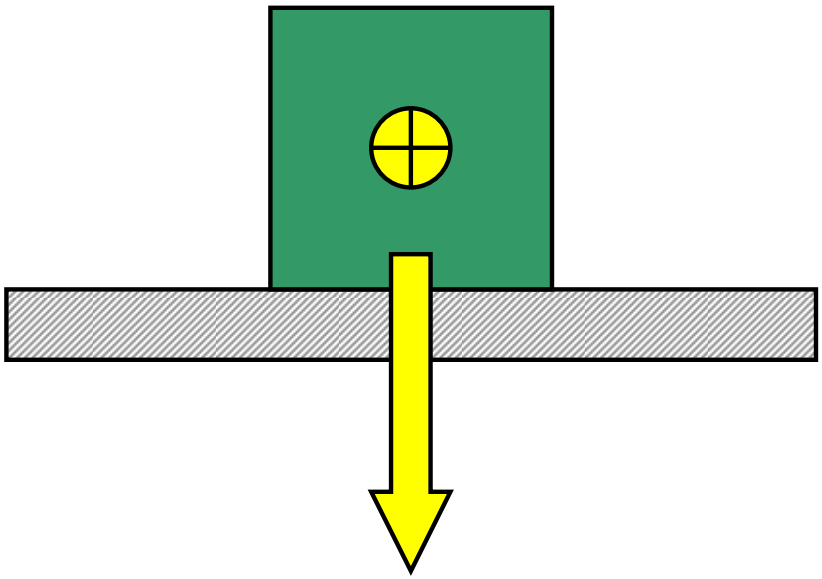
1. Measured Comp. of AyGP = (AyGP • cos(ψ))

2. Ay Measured = (AyGP • cos(ψ)) + (g • sin(ψ))

3. AyGP = (Ay Measured - sin(ψ)) / (cos(ψ)) in units of g

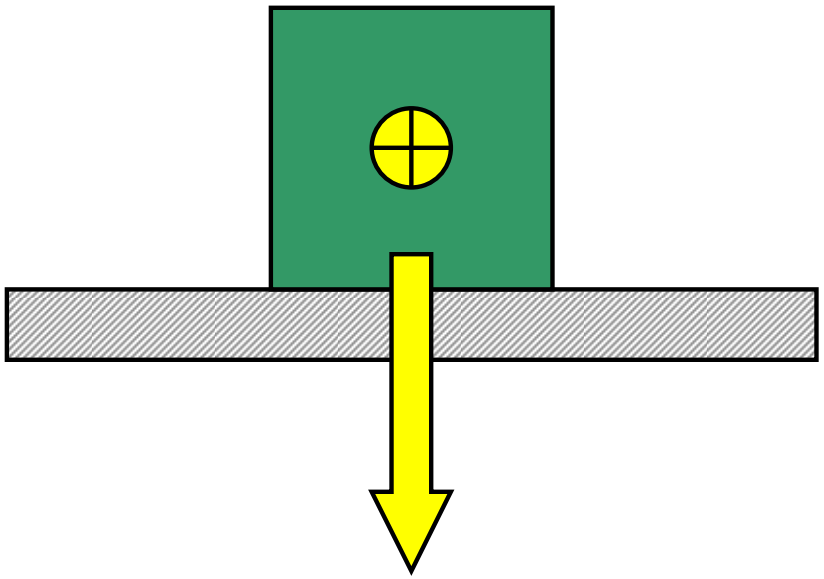
Ay Body Roll Correction Factor

(Ay • cos(ψ)) – (Az • sin(ψ))



1.0 g
convention

(Ay – sin(ψ)) / (cos(ψ))



0.0 g
convention

49 CFR Part 563 – EDR

- **"Delphi recommended that NHTSA provide greater specificity in the definition of 0 G normal acceleration, because the term 0 G is used inconsistently within the industry (e.g., 0 G is sometimes normalized for the 1 G bias due to gravity). We agree with Delphi's comments and have revised the definition."**