SAE TECHNICAL PAPER SERIES

2002-01-3333

Aerodynamic Test and Development of the Corvette C5 for Showroom Stock Racing

Larry Kubes, Jim Spaulding and Dwight Woodbridge
General Motors Corp.

Reprinted From: Proceedings of the 2002 SAE Motorsports Engineering Conference and Exhibition (P-382)

Motorsports Engineering Conference & Exhibition
Indianapolis, Indiana
December 2-5, 2002

SAE International™

400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760 Web: www.sae.org

For permission and licensing requests contact:

SAE Permissions
400 Commonwealth Drive
Warrendale, PA 15096-0001-USA
Email: permissions@sae.org
Fax: 724-772-4028
Tel: 724-772-4891

SAE®
Global Mobility Database®
All SAE papers, standards, and selected books are abstracted and indexed in the Global Mobility Database.

For multiple print copies contact:

SAE Customer Service
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-1615
Email: CustomerService@sae.org

ISSN 0148-7191

Printed in USA

2002-01-3333

Aerodynamic Test and Development of the Corvette C5 for Showroom Stock Racing

Larry Kubes, Jim Spaulding and Dwight Woodbridge
General Motors Corp.

ABSTRACT

This pager documents a one shift (10 hour) wind tunnel test program conducted on a Corvette C5 prepared for Sports Car Club *of* America (S.C.C.A.) World Challenge racing. The testing was conducted at the Canadian National Research Center in Ottawa, Canada. Specific areas of test included front fascia and under tray, rear air discharge, rear wing configuration and angle, B-pillar configuration, and ride height. Standard wind tunnei test procedures were followed. In total twenty-six separate configurations were evaiuated. Data for front and rear lift, total drag, and lift/drag (L/D) ratio are provided for each test configuration. The cumulative effects of the aerodynamic changes evaluated in this program, calculated at 192 KPH (120 MPH), increased front down force by 318 N (72 Lb.), and rear down force by 770 N (173 Lb.). Lift/drag ratio was improved from *-0.597* to –1.016. These changes increased total drag by 381 N (86 Lb.). Further testing lowering ride height 2.5cm rear and 5.0cm front reduced drag by 326 N (73 tb.) and resulted in a L/D Ratio of –1.247. Although data are specific to the Corvette C5. the general principles studied may be applied to any production-based racecar. These modifications should be validated on the racetrack prior to competing to ensure the handiing balance can be optimized for the driver and car combination.

INTRODUCTION

When the Corvette C5 started racing in 1999 the goal was to keep the car as close to production as possible. A typical 1999 Corvette C5 racecar is shown in Figure 1.

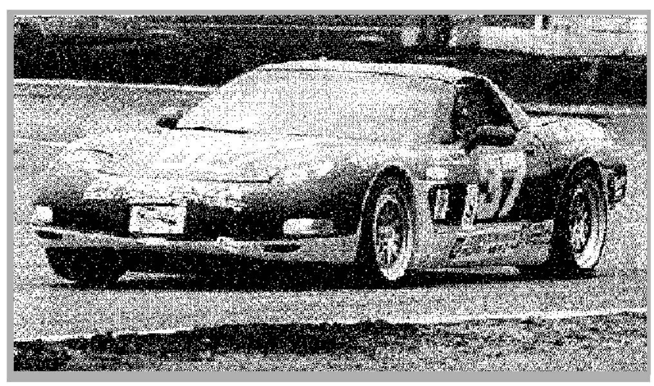

Figure 1 1999 Corvette C5 Showroom Stock Racecar

As time evolved, the S.C.C.A. rules allowed for aerodynamic modifications such as rear wings and front fascias with splitters. In an effort to maintain stock appearance, a package was deveioped that included a front fascia with short splitter, a 10cm rear spoiler on the deck, and rocker panel aerodynamic skirts. This package proved adequate through the 2000 season and is shown in Figure 2

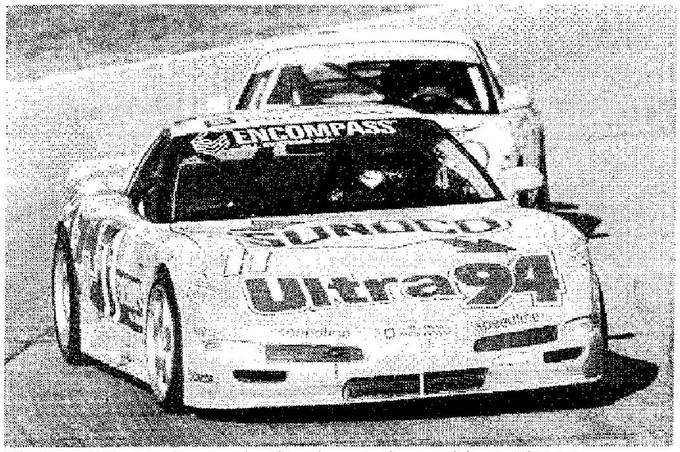

Figure 2 Aerodynamic Package Raced in 2000

The 2001 season included a new spec tire, which was only available in the 295/35-18 size and did not offer the 335/35-18 rear tire the Corvette needed to be competitive. In an effort to compensate for the lack of rear tire size, the sanctioning body approved the use of a rear wing for the 2001 race season. The race teams developed the rear wing shown in Figure 3 based on, on-track performance.

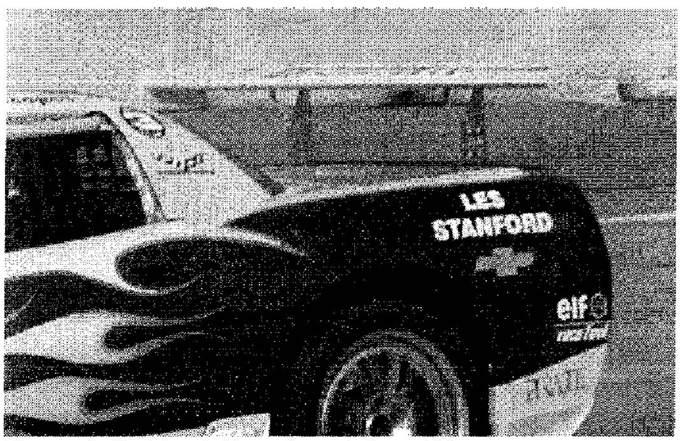

Figure 3 On Track Developed Rear Wing

Even with the addition of a rear wing, the performance disparity due to the smaller sized rear tire was still overwhelming, and merited this aerodynamic development program.

AERODYNAMIC DEVELOPMENT

TEST PROCEDURE

All tests were conducted at the Canadian National Research Center (CNRC). The CNRC complex contains four wind tunnels of various sizes and purpose. These tests were conducted in the NRC 9 m fixed plane, full-scale wind tunnel. These tests were run at 192 KPH wind speed. The square tunnel section is 9.14m in height and width with a 22.5m long test section. To remove the boundary layer, two suction sections are employed, reducing the boundary layer from 25mm to 4mm at the front bumper. Additionally, the tunnel employs 50 pressure taps in the four flush load plates to permit the forces on the exposed pad surfaces to be accurately removed.

Test Notes:

Lift data is presented where positive is up and negative is down. A negative lift number corresponds to a negative vertical force, thus more force at the tire contact patch to the ground commonly referred to as down force.

Data is presented in chronological order as the tests were run. If a modification was made that resulted in a gain or no change, the modification remained on the car for the remainder of the test. Typical of most development programs, changes were made from front to rear of the vehicle.

BASELINE TESTS

The first test in this program was the car as received from the last race as shown in Figure 4.

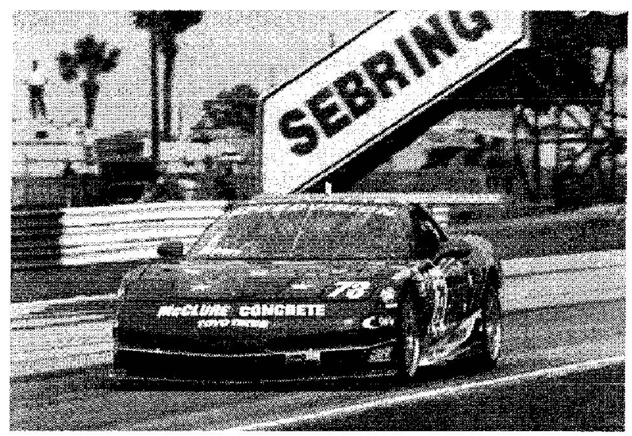

Figure 4 Baseline as Last Raced

2001 Race Season Baseline Results with Wing:

DRAG	FT LIFT	RR LIFT	L/D RATIO
1669 N	59.2 N	-1066 N	-0.597

The addition of the rear wing accomplished the objective of significant rear down force but with total loss of front down force. This was an indication that improvements could be made to the aerodynamic package that would result in improved on track vehicle balance.

BASIC AERODYNAMIC DETAILS

Several basic aerodynamic features were detailed to improve the car as received. Figures 5, 6, & 7 illustrate these changes.

Figure 5 Taped Upper Grill

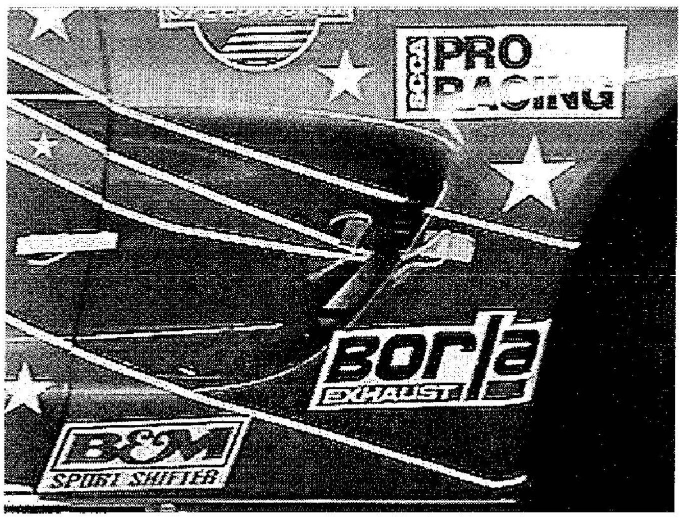

Figure 6 Open Side Duct

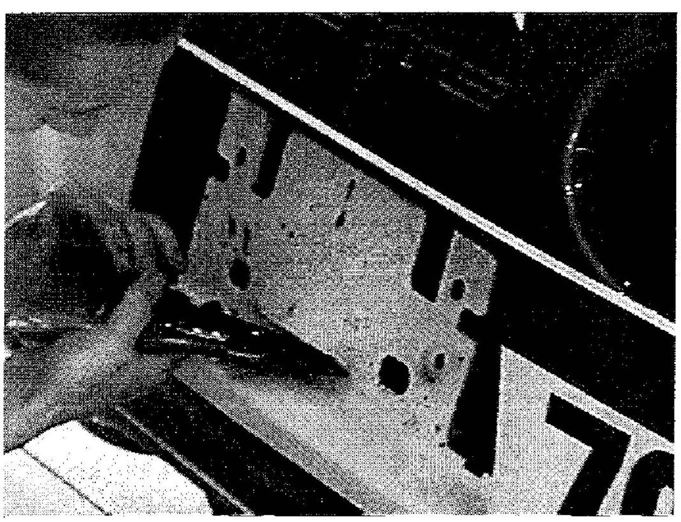

Figure 7 Open Rear License Opening

Aerodynamic Detail Test results:

TEST	DRAG	FT LIFT	RR LIFT	L/R RATIO
BASELINE	1669 N	59 N	-1066 N	-0.597
TAPED GRILL	1629 N	-78 N	-996 N	-0.659
SIDE DUCT	1629 N	-74 N	-998 N	-0.652
OPEN RR LIC.	1629 N	-70 N	-984 N	-0.648

Closing off the upper grill openings improved front down force by 137 N and reduced drag by 41 N. This change is recommended for the race cars with the caution that sufficient air flow must be maintained through the lower ducts to cool the engine. Radiator airflow is measured in the wind tunnel using anonometers and captured in the coefficient result sheet as a VR1 ratio (See Appendix). This is the ratio of free stream airflow to that passing through the radiator. Experience has proven, that dependent on ambient conditions, a VR1 ratio of 0.150 is desired for road racing.

Opening the side ducts showed little difference in the wind tunnel. Experience has shown this modification to be beneficial on the racetrack, as a result of airflow from rotating tires.

As was the case with the side duct openings, removal of the license plate had little effect in the wind tunnel. Racetrack experience has shown that an improvement in down force can be realized by exhausting air through openings in the rear fascia of the car. This has also shown to be an excellent area to exhaust air from coolers that can be mounted in the rear of the vehicle.

FRONT FASICA and SPLITTER

A shaped or non-flat ground effects type of under tray, commonly called the "Laguna" style under tray was fitted for the next series of tests. This under tray closed-out the area from the back of the front fascia to the back of the radiator the full width of the vehicle. The purpose is to generate a low-pressure area under the front of the vehicle. As a result, the vehicle became a "front breather" type vehicle.

Splitters are low horizontal extensions that are mounted just above and parallel to the ground plane and extend forward on the vehicle. Splitter lengths from 2.5 cm to 10 cm, measured from the forward most point of the front fascia, were also tested in this series of tests. The "Laguna" under tray and splitter are shown in Figure 8.

Figure 8 "Laguna" Under Tray and Splitter

"Laguna" Tray and Splitter Test Results:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
BASELINE	1629 N	-70 N	-947 N	-0.648
ADD TRAY (3.75cm SPLITTER)	1714 N	-355 N	-855 N	-0.706
2.5cm SPLIT.	1714 N	-311 N	-985 N	-0.698
5.0 cm SPLIT.	1714 N	-389 N	-862 N	-0.730
7.5 CM SPLIT.	1714 N	-515 N	-807 N	-0.771

The "Laguna" under tray provided a significant increase in front down force (285 N) with minimum drag increase or rear down force loss. Extending the front splitter to the maximum 7.5 cm allowed by S.C.C.A. rules further increased front down force (159 N) and improved L/D ratio to –0.77 with no increase in drag. Figure 9 graphically displays lift data for the splitters tested.

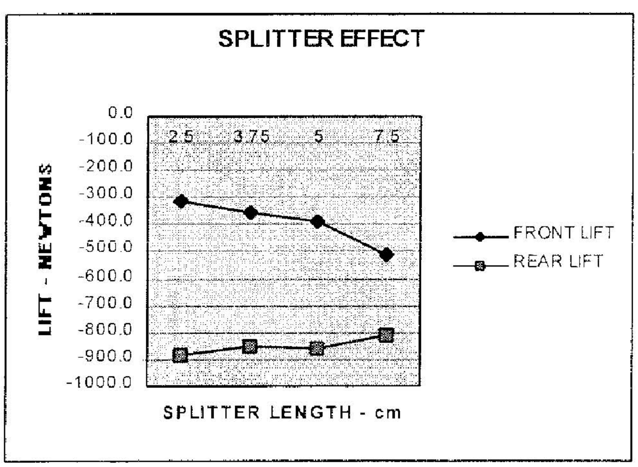

Figure 9 Splitter Effect on Lift

REAR WING EVALUATION

With the front down force increased, attention was turned to develop more rear down force. Two rear wings and two designs of wing end plates were tested.

RACE TEAM WING DESIGN EVALUATION

The wing profile developed on track by the race teams is shown in Figure 3. This wing was tested at wing angles of six (6), nine (9), and twelve (12) degrees. Twelve (12) degrees was found to be the most efficient angle for this wing. Experience from other programs indicated the original 3Rwing profile was not optimized. The following improvements were evaluated, a 2.5 cm wicker, two designs of larger end plates, and a 5 cm extension. Figures 10, 11, & 12 illustrate these configurations.

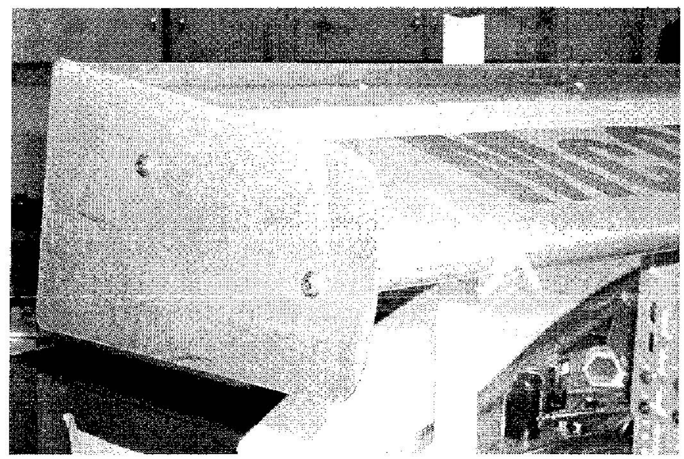

Figure 10 DW1 End Plate, note wicker (vertical piece) located at rear of wing

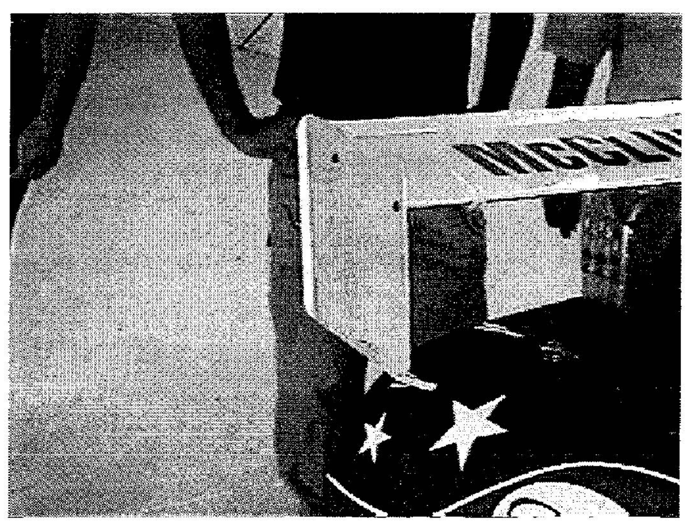

Figure 11Tall End Plate

Figure 12 Wing Extension

3R WING DESIGN TEST RESULTS:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
6 DEGREES	1714 N	-515 N	-807 N	-0.771
9 DEGREES	1758 N	-492 N	-907 N	-0.796
12 DEGREES	1803 N	-474 N	-984 N	-0.809
2.5cm WICKER	1910 N	-404 N	-1229 N	-0.855
DW1 E. PLATE	1914 N	-407 N	-1244 N	-0.863
TALL PLATE	1966 N	-396 N	-1325 N	-0.876
WING EXT.	1902 N	-359 N	-1399 N	-0.924

"IMSA" STYLE WING EVALUATION

A second test matrix was run on the "IMSA" style wing shown in Figure 13.

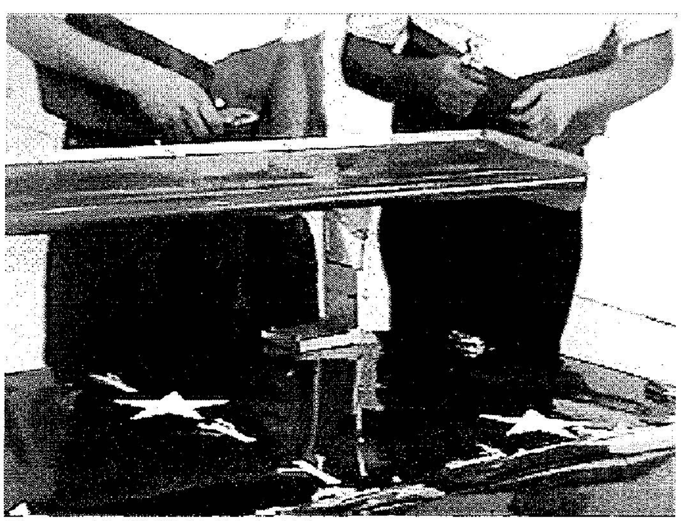

Figure 13 "IMSA" Style Wing

"IMSA" STYLE WING TEST RESULTS:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
6 DEGREE	1818 N	-426 N	-1247 N	-0.920
9 DEGREE	1877 N	-389 N	-1392 N	-0.949
12 DEGREE	1950 N	-348 N	-1514 N	-0.954
15 DEGREE	2021N	-314 N	-1614 N	-0.954
12D DW1	1958 N	-337 N	-1547 N	-0.962
WICKER	2058 N	-255 N	-1781 N	-0.989

Figure 14 graphically presents the Load v. Wing Angle data for the "IMSA" style wing.

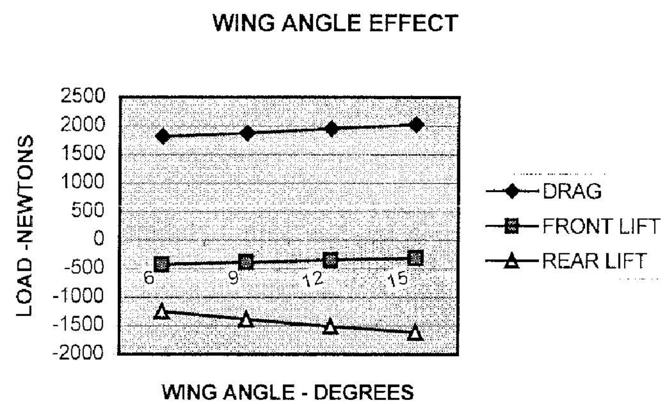

Figure 14 Effect of Wing Angle – "IMSA" Wing

The above data shows that either wing can be effective at developing significant rear down force. The longer chord length rear wing demonstrates a significant improvement in efficiency, the added extension or the IMSA style wing operates to the same level of lift at a 6 degree reduction in attack angle. A wing angle of 12 to 15 degrees provided best efficiency as indicated by the L/D ratio for the IMSA style wing. Increasing the angle of attack over 15 degrees will cause the wing to stall and lose efficiency. At the present time with the small rear tires the "IMSA" style wing is the best choice to maximize rear down force. Wickers and end plate design should be used to tune to specific track and driver preference. The lift balance of the vehicle is very important in the handling of the racecar on the track, this is captured on the coefficient sheet as %frt. (See Appendix). As the team tunes the handling of the racecar, an ideal %frt. aerodynamic balance will be determined for the driver and car combination. This number is the amount of front lift compared to the total lift on the vehicle.

B-PILLAR IMPROVEMENT

The leading edge of the right side B-pillar was rounded to smooth airflow over the car as shown in Figure 15.

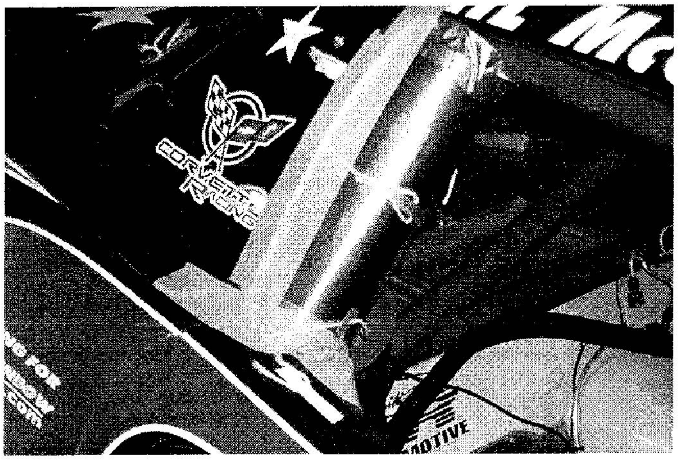

Figure 15 Rounded Right Side B-pillar

ROUNDED B-PILLAR TEST RESULTS:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
BASELINE	2058 N	-255 N	-1781 N	-0.989
MOD PILLAR	2051 N	-259 N	-1825 N	-1.016

This small change improved the efficiency of the wing without increasing drag and should be used on the racecars. This modification is usually only effective for the right side of the vehicle, as a properly mounted window net can achieve the same results as a rounded B-pillar on the left side.

VEHICLE RIDE HEIGHT

Ride height plays a very important role on vehicle drag, lift and front/rear balance. Sanctioning bodies limit static ride height, however aerodynamic forces can change dynamic ride height significantly. A ride height matrix was run to aid in the racers understanding of how ride height can effect vehicle performance.

RIDE HEIGHT TEST RESULTS:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
BASELINE	2051 N	-259 N	-1825 N	-1.016
FT DN 2.5cm	1866 N	-674 N	-1569 N	-1.202
FT DN 5.0cm	1743 N	-792 N	-1558 N	-1.348
RR DN 2.5cm	1725 N	-618 N	-1532 N	-1.247

As the data shows ride height is the most responsive variable tested in this series of tests. Care should be taken to trim the car as low as rules permit and if possible allow the aerodynamic loads to further enhance the dynamic ride height. It is recommended to trim the car with front down rake to reduce drag and increase front down force.

2000 BASELINE SIMULATION

Tests were run without the rear wing and with the 10cm spoiler used for the 2000 season as shown in Figure 1. These tests were run with the "Laguna" under tray in place; therefore, the under tray effect was subtracted out for reference.

2000 SEASON BASELINE TEST RESULTS:

TEST	DRAG	FT LIFT	RR LIFT	L/D RATIO
2000 AERO	1731 N	-422 N	-822 N	-0.718
W/O TRAY	1818 N	-182 N	-722 N	-0.497
W/O SPOILER	1470 N	-522 N	-193 N	-0.486
W/O TRAY	1555 N	-281 N	- 93 N	-0.241

CONCLUSIONS

This series of tests has demonstrated a front down force increase of 318 N, and rear down force increase of 770 N from aerodynamic modifications. Performing a ride height matrix, lowering ride height 2.5 cm rear and 5.0 cm front, reduced drag by 326 N. With this same ride height matrix chassis level, the Corvette gained 359 N of front down force, and lost 292 N rear down force. These improvements changed the Lift/Drag (L/D) Ratio from –0.597 to –1.247 on the 2002 Corvette C5 showroom stock racecar. Although these tests were specific to the C5 Corvette these same principles may be applied to any production based racecar. It is recommended that all changes be validated on the race track to ensure the team understands the effect on the car, and to determine if there are any interactions not measured in the wind tunnel that effect the performance of the car.

The first race for 3R Racing after this development program was Sears Point, Ca. The team reported that the changes made based on the wind tunnel tests allowed the tires to perform better much longer. Before the aerodynamic changes tires would only perform for fifteen to twenty minutes. With the changes the tires were adequate for the entire forty-five minute race. The reduced front lift improved the turn in characteristics of the car. The 3R team finished third and set fastest lap of the race at Sears Point, which was the best performance of the year for the team.

ACKNOWLEDGMENTS

Bob Raub, 3R Racing

3R Racing provided the test vehicle for these tests and crew to support the tests with fabrication and parts changes.

Jim Van Dorn, Pirate Racing / Auto Masters

Pirate Racing supported the test program with parts and provided the photo and video tape documentation used for the presentation.

CONTACT

Larry Kubes, G. M. Racing

APPENDIX

CORVETTE C5 AERO TEST SUMMARY

PRELIMINARY TEST RESULTS:

FORCES

COEFFICIENTS

TEST DATE: 07/13/2001

2001 CORVETTE C5
SHOWROOM STOCK
AERO TEST @ NRC

WIND SPEED = 192 KPA
(120 MPH)

CONFIGURATION	DRAG Newtons	DRAG (lb)	FRONT LIFT Newtons	FRONT LIFT (lb)	REAR LIFT Newtons	REAR LIFT (lb)	L/D RATIO
BASELINE 2001 - 3R TEAM	1669.4	375.3	59.2	13.3	-1055.1	-237.2	-0.597
TAPE UPPER GRILLS	1628.5	366.1	-77.8	-17.5	-995.5	-223.8	-0.659
OPEN SIDE DUCTS	1628.5	366.1	-73.8	-16.6	-988.4	-222.2	-0.652
OPEN RR LIC. OPEN.	1628.5	366.1	-70.3	-15.8	-984.4	-221.3	-0.648
ADD C5R FRT UNDERTRAY							
1.0" SPLITTER	1713.9	385.3	-310.9	-69.9	-884.8	-198.9	-0.698
1.5" SPLITTER	1713.9	385.3	-355.4	-79.9	-854.9	-192.2	-0.706
2.0" SPLITTER	1713.9	385.3	-388.8	-87.4	-862.5	-193.9	-0.730
3.0" SPLITTER	1713.9	385.3	-514.7	-115.7	-806.9	-181.4	-0.771
3R RR WING							
6 DEG. WING ANGLE	1713.9	385.3	-514.7	-115.7	-806.9	-181.4	-0.771
9 DEG. WING ANGLE	1758.4	395.3	-492.4	-110.7	-907.0	-203.9	-0.796
12 DEG. WING ANGLE	1802.9	405.3	-473.7	-106.5	-984.4	-221.3	-0.809
1" RR WICKER	1910.1	429.4	-403.5	-90.7	-1229.0	-276.3	-0.855
LARGER END PLATE DW1	1913.6	430.2	-407.0	-91.5	-1243.7	-279.6	-0.863
LARGE END PLATE TALL	1965.7	441.9	-395.9	-89.0	-1325.1	-297.9	-0.876
2" REAR WING EXTENTION	1902.5	427.7	-359.0	-80.7	-1399.0	-314.5	-0.924
IMSA SINGLE PLANE WING							
6 DEG, WING ANGLE	1817.5	408.6	-425.7	-95.7	-1247.3	-280.4	-0.920
9 DEG, WING ANGLE	1876.7	421.9	-388.8	-87.4	-1391.8	-312.9	-0.949
12 DEG, WING ANGLE	1950.5	438.5	-347.9	-78.2	-1513.7	-340.3	-0.954
15 DEG, WING ANGLE	2020.8	454.3	-314.5	-70.7	-1613.8	-362.8	-0.954
12 DEG, WING ANGLE	1950.5	438.5	-347.9	-78.2	-1513.7	-340.3	-0.954
LARGE END PLATE DW1	1958.1	440.2	-336.7	-75.7	-1547.1	-347.8	-0.962
ADD 1" WICKER	2058.2	462.7	-255.3	-57.4	-1780.6	-400.3	-0.989
B-PILLAR CURVED PANEL	2050.6	461.0	-258.9	-58.2	-1824.7	-410.2	-1.016
CHANGE FROM BASELINE	**381**	86	**-318**	-72	**-770**	-173	-0.419

2001 CORVETTE C5
SHOWROOM STOCK
AERO TEST @ NRC

TEST DATE: 07/13/2001

WIND SPEED = 192 KPA (120 MPH)

RIDE HEIGHT MATRIX	DRAG Newtons	DRAG (lb)	FRONT LIFT Newtons	FRONT LIFT (lb)	REAR LIFT Newtons	REAR LIFT (lb)	L/D RATIO
BASELINE	2050.6	461.0	-258.9	-58.2	-1824.7	-410.2	-1.016
NOISE DOWN 1"	1865.6	419.4	-673.5	-151.4	-1569.3	-352.8	-1.202
NOISE DOWN 2"	1743.3	391.9	-792.2	-178.1	-1558.2	-350.3	-1.348
TAIL DOWN 1"	1725.0	387.8	-618.3	-139.0	-1532.4	-344.5	-1.247
CHANGE FROM BASELINE	**-326**	-73	**-359**	-81	**292**	66	-0.231
2000 AERO KIT	1732.1	389.4	-422.1	-94.9	-821.6	-184.7	-0.718
W/O 4" RR SPOILER	1469.7	330.4	-521.8	-117.3	-192.6	-43.3	-0.486
SUBSTRACT OUT UNDERTRAY:							
2000 AERO KIT	1817.5	408.6	-181.5	-40.8	-721.9	-162.3	-0.497
W/O 4" RR SPOILER	1555.1	349.6	-281.1	-63.2	-93.0	-20.9	-0.241

Test No: NRC 6273
Vehicle: WC Corvette

Engineer: D. M. Woodbridge

NRC - (GM Test)

Aerodynamics Laboratory

PRELIMINARY
TEST RESULTS

Date:
7/13/01

Ref.
Frontal
Area: 2.1m2
Scale: 1.00

(Calculations assume air density, $\rho = 1.225$ kg/m^3)

FORCES @ [illegible] MPH

Run	CONFIGURATION	Yaw	LF	RF	LR	RR	Run	Ref.	Drag (lb)	ΔDrag (lb)	Drag (hp)	ΔDrag (hp)	F. Lift (lb)	ΔF. Lift (lb)	R. Lift (lb)	ΔR. Lift (lb)
1	Baseline: 3r Automotive Speedvision Cup car	-6	4	4	4	4	**1.01**		388.6		124.4		48.3		-224.7	
	slope as meas. 4.5" grd clearance, WC spec	-2	4	4	4	4	**1.03**		378.6		121.2		19.1		-227.2	
	rear wing @ 6 deg, .5" wicker	-1	4	4	4	4	**1.04**		377.0		120.6		15.0		-233.0	
	104" whlbase, 62" track	0	4	4	4	4	**1.05**		375.3		120.1		13.3		-237.2	
		1	4	4	4	4	**1.06**		374.5		119.8		15.0		-238.0	
		2	4	4	4	4	**1.07**		375.3		120.1		17.5		-233.0	
		3	4	4	4	4	**1.08**		377.0		120.6		22.5		-228.0	
2	Tape upper grills	-3	4	4	4	4	**2.01**	*1.02*	372.0	*-16.6*	119.0	*-5.3*	-8.3	*-56.6*	-214.7	*10.0*
		0	4	4	4	4	**2.02**	*1.05*	366.1	*-9.2*	117.2	*-2.9*	-17.5	*-30.8*	-223.8	*13.3*
		3	4	4	4	4	**2.03**	*1.08*	368.6	*-8.3*	118.0	*-2.7*	-11.6	*-34.1*	-217.2	*10.8*
3	Open side panel ducts	-3	4	4	4	4	**3.01**	*2.01*	372.0	*0.0*	119.0	*0.0*	-7.5	*0.8*	-212.2	*2.5*
		0	4	4	4	4	**3.02**	*2.02*	366.1	*0.0*	117.2	*0.0*	-16.6	*0.8*	-222.2	*1.7*
		3	4	4	4	4	**3.03**	*2.03*	367.8	*-0.8*	117.7	*-0.3*	-10.8	*0.8*	-215.5	*1.7*
4	open Rear License Plate hole	-3	4	4	4	4	**4.01**	*3.01*	371.1	*-0.8*	118.8	*-0.3*	-7.5	*0.0*	-208.9	*3.3*
		0	4	4	4	4	**4.02**	*3.02*	366.1	*0.0*	117.2	*0.0*	-15.8	*0.8*	-221.3	*0.8*
		3	4	4	4	4	**4.03**	*3.03*	367.8	*0.0*	117.7	*0.0*	-9.2	*1.7*	-212.2	*3.3*
5	C5R "Laguna" style undertray	-3	4	4	4	4	**5.01**	*4.01*	390.3	*19.1*	124.9	*6.1*	-67.4	*-59.9*	-187.2	*21.6*
	splitter length at 1.5"	0	4	4	4	4	**5.02**	*4.02*	385.3	*19.1*	123.3	*6.1*	-79.9	*-64.1*	-192.2	*29.1*
		3	4	4	4	4	**5.03**	*4.03*	386.9	*19.1*	123.8	*6.1*	-75.7	*-66.6*	-189.7	*22.5*

6	Splitter set to 1"	-3	4	4	4	4	**6.01**	*5.01*	390.3	*0.0*	124.9	*0.0*	-58.2	*9.2*	-193.1	*-5.8*
		0	4	4	4	4	**6.02**	*5.02*	385.3	*0.0*	123.3	*0.0*	-69.9	*10.0*	-198.9	*-6.7*
		3	4	4	4	4	**6.03**	*5.03*	386.1	*-0.8*	123.6	*-0.3*	-65.7	*10.0*	-194.7	*-5.0*
7	Splitter set to 2"	-3	4	4	4	4	**7.01**	*6.01*	390.3	*0.0*	124.9	*0.0*	-74.1	*-15.8*	-184.7	*8.3*
		0	4	4	4	4	**7.02**	*6.02*	385.3	*0.0*	123.3	*0.0*	-87.4	*-17.5*	-193.9	*5.0*
		3	4	4	4	4	**7.03**	*6.03*	386.9	*0.8*	123.8	*0.3*	-79.9	*-14.1*	-185.6	*9.2*
8	Splitter set to 3"	-3	4	4	4	4	**8.01**	*7.01*	390.3	*0.0*	124.9	*0.0*	-99.0	*-25.0*	-174.7	*10.0*
		0	4	4	4	4	**8.02**	*7.02*	385.3	*0.0*	123.3	*0.0*	-115.7	*-28.3*	-181.4	*12.5*
		3	4	4	4	4	**8.03**	*7.03*	386.9	*0.0*	123.8	*0.0*	-109.0	*-29.1*	-176.4	*9.2*
9	Rear Wing angle set to 9 degrees	-3	4	4	4	4	**9.01**	*8.01*	400.3	*10.0*	128.1	*3.2*	-94.9	*4.2*	-198.0	*-23.3*
		0	4	4	4	4	**9.02**	*8.02*	395.3	*10.0*	126.5	*3.2*	-110.7	*5.0*	-203.9	*-22.5*
		3	4	4	4	4	**9.03**	*8.03*	396.9	*10.0*	127.0	*3.2*	-104.0	*5.0*	-200.5	*-24.1*
10	Rear Wing angle set to 12 degrees	-3	4	4	4	4	**10.01**	*9.01*	410.2	*10.0*	131.3	*3.2*	-91.5	*3.3*	-214.7	*-16.6*
		0	4	4	4	4	**10.02**	*9.02*	405.3	*10.0*	129.7	*3.2*	-106.5	*4.2*	-221.3	*-17.5*
		3	4	4	4	4	**10.03**	*9.03*	406.9	*10.0*	130.2	*3.2*	-99.0	*5.0*	-217.2	*-16.6*
11	1" Rear Wicker	-3	4	4	4	4	**11.01**	*10.01*	435.2	*25.0*	139.3	*8.0*	-74.9	*16.6*	-269.6	*-54.9*
		0	4	4	4	4	**11.02**	*10.02*	429.4	*24.1*	137.4	*7.7*	-90.7	*15.8*	-276.3	*-54.9*
		3	4	4	4	4	**11.03**	*10.03*	432.7	*25.8*	138.5	*8.3*	-82.4	*16.6*	-273.8	*-56.6*
12	Larger Endplate - dw1	-3	4	4	4	4	**12.01**	*11.01*	434.4	*-0.8*	139.0	*-0.3*	-75.7	*-0.8*	-270.4	*-0.8*
		0	4	4	4	4	**12.02**	*11.02*	430.2	*0.8*	137.7	*0.3*	-91.5	*-0.8*	-279.6	*-3.3*
		3	4	4	4	4	**12.03**	*11.03*	432.7	*0.0*	138.5	*0.0*	-83.2	*-0.8*	-276.3	*-2.5*
13	Larger Endplate - tall	-3	4	4	4	4	**13.01**	*11.01*	441.9	*6.7*	141.4	*2.1*	-77.4	*-2.5*	-271.3	*-1.7*
		0	4	4	4	4	**13.02**	*11.02*	441.9	*12.5*	141.4	*4.0*	-89.0	*1.7*	-297.9	*-21.6*
		3	4	4	4	4	**13.03**	*11.03*	440.2	*7.5*	140.9	*2.4*	-84.9	*-2.5*	-277.9	*-4.2*
14	2" rear wing extension	-3	4	4	4	4	**14.01**	*10.01*	431.9	*21.6*	138.2	*6.9*	-64.9	*26.6*	-307.9	*-93.2*
		0	4	4	4	4	**14.02**	*10.02*	427.7	*22.5*	136.9	*7.2*	-80.7	*25.8*	-314.5	*-93.2*
		3	4	4	4	4	**14.03**	*10.03*	429.4	*22.5*	137.4	*7.2*	-72.4	*26.6*	-312.1	*-94.9*
15	IMSA single plane profile rear wing	-3	4	4	4	4	**15.01**	*8.01*	411.9	*21.6*	131.8	*6.9*	-79.9	*19.1*	-277.9	*-103.2*
	6 degree angle of attack	0	4	4	4	4	**15.02**	*8.02*	408.6	*23.3*	130.7	*7.5*	-95.7	*20.0*	-280.4	*-99.0*
		3	4	4	4	4	**15.03**	*8.03*	411.1	*24.1*	131.5	*7.7*	-89.0	*20.0*	-279.6	*-103.2*

16	Rear Wing angle set to 9 degrees	-3	4	4	4	4	**16.01**	*15.01*	426.9	*15.0*	136.6	*4.8*	-69.9	*10.0*	-312.1	*-34.1*
		0	4	4	4	4	**16.02**	*15.02*	421.9	*13.3*	135.0	*4.3*	-87.4	*8.3*	-312.9	*-32.5*
		3	4	4	4	4	**16.03**	*15.03*	425.2	*14.1*	136.1	*4.5*	-79.1	*10.0*	-314.5	*-34.9*
17	Rear Wing angle set to 12 degrees	-3	4	4	4	4	**17.01**	*16.01*	442.7	*15.8*	141.7	*5.1*	-60.7	*9.2*	-342.0	*-30.0*
		0	4	4	4	4	**17.02**	*16.02*	438.5	*16.6*	140.3	*5.3*	-78.2	*9.2*	-340.3	*-27.5*
		3	4	4	4	4	**17.03**	*16.03*	441.9	*16.6*	141.4	*5.3*	-69.1	*10.0*	-347.8	*-33.3*
18	Rear Wing angle set to 15 degrees	-3	4	4	4	4	**18.01**	*17.01*	459.3	*16.6*	147.0	*5.3*	-54.1	*6.7*	-364.5	*-22.5*
		0	4	4	4	4	**18.02**	*17.02*	454.3	*15.8*	145.4	*5.1*	-70.7	*7.5*	-362.8	*-22.5*
		3	4	4	4	4	**18.03**	*17.03*	458.5	*16.6*	146.7	*5.3*	-62.4	*6.7*	-370.3	*-22.5*
19	Wing at 12 degrees	-3	4	4	4	4	**19.01**	*17.01*	445.2	*2.5*	142.5	*0.8*	-59.9	*0.8*	-349.5	*-7.5*
	Large rear endplate - dw1	0	4	4	4	4	**19.02**	*17.02*	440.2	*1.7*	140.9	*0.5*	-75.7	*2.5*	-347.8	*-7.5*
		3	4	4	4	4	**19.03**	*17.03*	443.5	*1.7*	141.9	*0.5*	-68.2	*0.8*	-355.3	*-7.5*
20	1" rear wicker	-3	4	4	4	4	**20.01**	*19.01*	467.7	*22.5*	149.7	*7.2*	-40.8	*19.1*	-404.4	*-54.9*
		0	4	4	4	4	**20.02**	*19.02*	462.7	*22.5*	148.1	*7.2*	-57.4	*18.3*	-400.3	*-52.4*
		3	4	4	4	4	**20.03**	*19.03*	465.2	*21.6*	148.9	*6.9*	-49.1	*19.1*	-406.1	*-50.8*
21	B Pillar Curved Panels	-3	4	4	4	4	**21.01**	*20.01*	466.8	*-0.8*	149.4	*-0.3*	-39.1	*1.7*	-421.1	*-16.6*
		0	4	4	4	4	**21.02**	*20.02*	461.0	*-1.7*	147.5	*-0.5*	-58.2	*-0.8*	-410.2	*-10.0*
		3	4	4	4	4	**21.03**	*20.03*	464.3	*-0.8*	148.6	*-0.3*	-48.3	*0.8*	-418.6	*-12.5*
22	Ride Height Matrix - Nose Down 1"	0	3	3	4	4	**22.01**	*19.02*	419.4	*-20.8*	134.2	*-6.7*	-151.4	*-75.7*	-352.8	*-5.0*
23	Nose Down 2"	0	2	2	4	4	**23.01**	*22.01*	391.9	*-27.5*	125.4	*-8.8*	-178.1	*-26.6*	-350.3	*2.5*
24	Tail down 1" - (Heave down 1" & rake 1")	0	2	2	3	3	**24.01**	*22.01*	387.8	*-31.6*	124.1	*-10.1*	-139.0	*12.5*	-344.5	*8.3*
		3	2	2	3	3	**26.02**	*25.02*		*#VALUE!*		*#VALUE!*		*#VALUE!*		*#VALUE!*
25	GRAND AM CONFIGURATION	0	2	2	3	3	**25.01**		330.4		105.7		-117.3		-43.3	
	No Rear wing / duckbill, no splitter	3	2	2	3	3	**25.02**		319.5		102.3		-114.8		-15.0	
26	4" rear spoiler	0	2	2	3	3	**26.01**	*25.01*	389.4	*1.7*	124.6	*0.5*	-94.9	*44.1*	-184.7	*159.8*
		3	2	2	3	3	**26.02**	*25.02*		*#VALUE!*		*#VALUE!*		*#VALUE!*		*#VALUE!*

Test No: NRC 6273
Vehicle: WC Corvette
Engr.: D. M. Woodbridge

NRC - (GM Test)
Aerodynamics Laboratory
PRELIMINARY TEST RESULTS

Date: 7/13/01
Ref. Frontal Area: 2.100 m^2
Scale: 1.00

COEFFICIENTS

Run	CONFIGURATION	Yaw	LF	RF	LR	RR	Run	Ref.	C_D	ΔC_D	C_{LF}	ΔC_{LF}	C_{LR}	ΔC_{LR}	L/D	ΔL/D	%FRT	Δ%FRT	VR1	ΔVR1	VR2	ΔVR2	VR3	ΔVR3
1	Baseline: 3r Automotive SpeedVision Cup	-6	4.25	4.25	4.00	4.00	1.01		.467		.056		-.270		-.454		-27.4%		.184					
	All Grills open, 1.5" flat plane splitter 2 deg	-3	4.25	4.25	4.00	4.00	1.02		.457		.030		-.270		-.525		-12.5%		.184					
	slope as meas. 4.5" grd clearance, WC spec	-2	4.25	4.25	4.00	4.00	1.03		.455		.023		-.273		-.549		-9.2%		.184					
	rear wing @ 6 deg, .5" wicker	-1	4.25	4.25	4.00	4.00	1.04		.453		.018		-.260		-.578		-8.9%		.184					
	104" whlbase, 62" track	0	4.25	4.25	4.00	4.00	1.05		.451		.016		-.265		-.596		-5.9%		.184					
		1	4.25	4.25	4.00	4.00	1.06		.450		.016		-.266		-.596		-6.7%		.184					
		2	4.25	4.25	4.00	4.00	1.07		.451		.021		-.260		-.574		-8.1%		.184					
		3	4.25	4.25	4.00	4.00	1.08		.453		.027		-.274		-.545		-10.9%		.184					
2	Tape upper grills	-3	4.25	4.25	4.00	4.00	2.01	1.02	.447	-.010	-.010	-.040	-.258	+.012	-.600	-.074	3.7%		.151	-.033				
		0	4.25	4.25	4.00	4.00	2.02	1.05	.440	-.011	-.021	-.037	-.269	+.016	-.659	-.063	7.2%		.151	-.033				
		3	4.25	4.25	4.00	4.00	2.03	1.08	.443	-.010	-.014	-.041	-.261	+.013	-.621	-.076	5.1%		.147	-.037				
3	Open side panel ducts	-3	4.25	4.25	4.00	4.00	3.01	2.01	.447	+.000	-.009	+.001	-.256	+.003	-.591	+.009	3.4%		.152	+.001	.042	+.004		
		0	4.25	4.25	4.00	4.00	3.02	2.02	.440	+.000	-.020	+.001	-.267	+.002	-.652	+.007	7.0%		.151	+.000	.048	+.024		
		3	4.25	4.25	4.00	4.00	3.03	2.03	.442	-.001	-.013	+.001	-.259	+.002	-.615	+.006	4.8%		.147	+.000	.047	-.004		
4	open Rear License Plate hole	-3	4.25	4.25	4.00	4.00	4.01	3.01	.446	-.001	-.009	+.000	-.251	+.004	-.583	+.008	3.5%		.151	-.001	.049	+.008		
		0	4.25	4.25	4.00	4.00	4.02	3.02	.440	+.000	-.019	+.001	-.266	+.001	-.648	+.005	6.7%		.151	+.000	.052	+.004		
		3	4.25	4.25	4.00	4.00	4.03	3.03	.442	+.000	-.011	+.002	-.255	+.004	-.602	+.014	4.1%		.148	+.001	.049	+.002		
5	CSR "Laguna" style undertray	-3	4.25	4.25	4.00	4.00	5.01	4.01	.469	+.023	-.081	-.072	-.225	+.026	-.652	-.069	26.5%		.138	-.013	.041	-.008		
	splitter length at 1.9"	0	4.25	4.25	4.00	4.00	5.02	4.02	.463	+.023	-.086	-.077	-.231	+.035	-.706	-.059	29.4%		.138	-.013	.050	-.002		
		3	4.25	4.25	4.00	4.00	5.03	4.03	.465	+.023	-.091	-.080	-.228	+.027	-.686	-.084	28.5%		.135	-.013	.047	-.001		
6	Splitter set to 1"	-3	4.25	4.25	4.00	4.00	6.01	5.01	.469	+.000	-.070	+.011	-.232	-.007	-.644	+.009	23.2%		.139	+.001	.042	+.001		
		0	4.25	4.25	4.00	4.00	6.02	5.02	.463	+.000	-.084	+.012	-.239	-.008	-.698	+.009	26.0%		.139	+.001	.044	-.006		
		3	4.25	4.25	4.00	4.00	6.03	5.03	.464	-.001	-.079	+.012	-.234	-.006	-.675	+.011	25.2%		.136	+.001	.047	-.000		
7	Splitter set to 2"	-3	4.25	4.25	4.00	4.00	7.01	6.01	.469	+.000	-.089	-.019	-.222	+.010	-.663	-.019	28.6%		.139	+.000	.421	+.379		-.139
		0	4.25	4.25	4.00	4.00	7.02	6.02	.463	+.000	-.105	-.021	-.233	+.006	-.730	-.032	31.1%		.139	+.000	.044	+.000		-.139
		3	4.25	4.25	4.00	4.00	7.03	6.03	.465	+.001	-.096	-.017	-.223	+.011	-.686	-.011	30.1%		.136	+.000	.043	-.005		-.136
8	Splitter set to 3"	-3	4.25	4.25	4.00	4.00	8.01	7.01	.469	+.000	-.119	-.030	-.210	+.012	-.701	-.038	36.2%		.140	+.001	.042	-.379		-.139
		0	4.25	4.25	4.00	4.00	8.02	7.02	.463	+.000	-.139	-.034	-.218	+.015	-.771	-.041	38.8%		.139	+.000	.045	+.001		-.139
		3	4.25	4.25	4.00	4.00	8.03	7.03	.465	+.000	-.131	-.035	-.212	+.011	-.738	-.052	38.2%		.136	+.000	.043	+.000		-.136
9	Rear Wing angle set to 9 degrees	-3	4.25	4.25	4.00	4.00	9.01	8.01	.481	+.012	-.114	+.005	-.238	-.028	-.732	-.030	32.4%		.140	+.000	.042	-.000		-.140
		0	4.25	4.25	4.00	4.00	9.02	8.02	.475	+.012	-.133	+.006	-.245	-.027	-.796	-.025	35.2%		.140	+.001	.044	-.001		-.139
		3	4.25	4.25	4.00	4.00	9.03	8.03	.477	+.012	-.125	+.006	-.241	-.029	-.767	-.030	34.2%		.136	+.000	.043	-.000		-.136
10	Rear Wing angle set to 12 degrees	-3	4.25	4.25	4.00	4.00	10.01	9.01	.493	+.012	-.110	+.004	-.258	-.020	-.746	-.015	29.9%		.140	+.000	.042	-.000		-.140
		0	4.25	4.25	4.00	4.00	10.02	9.02	.487	+.012	-.128	+.005	-.266	-.021	-.809	-.013	32.5%		.140	+.000	.044	+.000		-.140
		3	4.25	4.25	4.00	4.00	10.03	9.03	.489	+.012	-.119	+.006	-.261	-.020	-.777	-.010	31.3%		.137	+.000	.043	+.000		-.136
11	1" Rear Wicker	-3	4.25	4.25	4.00	4.00	11.01	10.01	.523	+.030	-.090	+.020	-.324	-.066	-.782	-.045	21.7%		.140	+.000	.041	-.000		-.140
		0	4.25	4.25	4.00	4.00	11.02	10.02	.516	+.029	-.109	+.019	-.332	-.066	-.855	-.046	24.7%		.140	+.000	.044	-.001		-.140
		3	4.25	4.25	4.00	4.00	11.03	10.03	.520	+.031	-.099	+.020	-.329	-.068	-.823	-.046	23.1%		.137	+.000	.041	-.001		-.137
12	Larger Endplate - dw1	-3	4.25	4.25	4.00	4.00	12.01	11.01	.522	-.001	-.091	-.001	-.325	-.001	-.787	-.005	21.9%		.141	+.001	.042	+.000		-.140

COEFFICIENTS

Run	CONFIGURATION	Yaw	LF	RF	LR	RR	Run	Ref.	C_D	ΔC_D	C_{LF}	ΔC_{LF}	C_{LR}	ΔC_{LR}	L/D	ΔL/D	%FRT	Δ%FRT	VR1	ΔVR1	VR2	ΔVR2	VR3	ΔVR3
		0	4.25	4.25	4.00	4.00	12.02	11.02	.517	+.001	-.110	-.001	-.336	-.004	-.863	-.008	24.7%		.140	+.000	.043	-.000		-.140
		3	4.25	4.25	4.00	4.00	12.03	11.03	.520	+.000	-.100	-.001	-.332	-.003	-.831	-.008	23.1%		.137	+.000	.041	+.000		-.137
13	Larger Endplate - tall	-3	4.25	4.25	4.00	4.00	13.01	11.01	.531	+.008	-.093	-.003	-.326	-.002	-.789	+.003	22.2%		.141	+.001	.041	-.000		-.140
		0	4.25	4.25	4.00	4.00	13.02	11.02	.531	+.015	-.107	+.002	-.358	-.026	-.876	-.021	23.0%		.140	+.000	.042	-.001		-.140
		3	4.25	4.25	4.00	4.00	13.03	11.03	.529	+.009	-.102	-.003	-.334	-.005	-.824	-.001	23.4%		.137	+.001	.041	-.001		-.137
14	2" rear wing extension	-3	4.25	4.25	4.00	4.00	14.01	10.01	.519	+.026	-.078	+.032	-.370	-.112	-.863	-.117	17.4%		.141	+.001	.042	-.000		-.140
		0	4.25	4.25	4.00	4.00	14.02	10.02	.514	+.027	-.087	+.031	-.378	-.112	-.924	-.115	20.4%		.140	+.000	.043	-.001		-.140
		3	4.25	4.25	4.00	4.00	14.03	10.03	.516	+.027	-.087	+.032	-.375	-.114	-.895	-.118	18.8%		.136	-.000	.041	-.002		-.137
15	IMSA single plane profile rear wing	-3	4.25	4.25	4.00	4.00	15.01	5.01	.495	+.026	-.096	+.023	-.334	-.124	-.869	-.167	22.3%		.139	-.001	.041	-.001		-.140
	5 degree angle of attack	0	4.25	4.25	4.00	4.00	15.02	5.02	.491	+.026	-.115	+.024	-.337	-.119	-.921	-.150	25.4%		.138	-.001	.042	-.002		-.139
		3	4.25	4.25	4.00	4.00	15.03	5.03	.494	+.029	-.107	+.024	-.336	-.124	-.897	-.159	24.2%		.135	-.001	.040	-.003		-.136
16	Rear Wing angle set to 9 degrees	-3	4.25	4.25	4.00	4.00	16.01	15.01	.513	+.018	-.084	+.012	-.375	-.041	-.895	-.026	18.3%		.139	-.001	.040	-.001		-.139
		0	4.25	4.25	4.00	4.00	16.02	15.02	.507	+.016	-.105	+.010	-.376	-.039	-.949	-.028	21.8%		.138	-.001	.041	-.001		-.138
		3	4.25	4.25	4.00	4.00	16.03	15.03	.511	+.017	-.095	+.012	-.376	-.042	-.926	-.029	20.1%		.135	-.000	.039	-.001		-.135
17	Rear Wing angle set to 12 degrees	-3	4.25	4.25	4.00	4.00	17.01	16.01	.532	+.019	-.073	+.011	-.411	-.036	-.910	-.015	15.1%		.138	-.001	.039	-.001		-.139
		0	4.25	4.25	4.00	4.00	17.02	16.02	.527	+.020	-.094	+.011	-.409	-.033	-.954	-.006	18.7%		.137	-.001	.041	-.000		-.138
		3	4.25	4.25	4.00	4.00	17.03	16.03	.531	+.020	-.083	+.012	-.418	-.040	-.944	-.018	16.8%		.134	-.001	.039	+.000		-.135
18	Rear Wing angle set to 15 degrees	-3	4.25	4.25	4.00	4.00	18.01	17.01	.552	+.020	-.085	+.008	-.438	-.027	-.911	-.001	12.9%		.138	+.000	.039	+.000		-.139
		0	4.25	4.25	4.00	4.00	18.02	17.02	.546	+.019	-.085	+.009	-.436	-.027	-.954	+.000	16.3%		.137	+.000	.042	+.001		-.137
		3	4.25	4.25	4.00	4.00	18.03	17.03	.551	+.020	-.076	+.008	-.445	-.027	-.944	-.000	14.4%		.134	+.000	.039	+.000		-.134
19	Wing at 12 degrees	-3	4.25	4.25	4.00	4.00	19.01	17.01	.535	+.003	-.072	+.001	-.420	-.009	-.920	-.010	14.8%		.138	+.000	.041	+.002		-.138
	Large rear endplate - dv1	0	4.25	4.25	4.00	4.00	19.02	17.02	.529	+.002	-.091	+.003	-.418	-.009	-.962	-.008	17.9%		.137	+.000	.043	+.002		-.137
		3	4.25	4.25	4.00	4.00	19.03	17.03	.533	+.002	-.082	+.001	-.427	-.009	-.955	-.011	16.1%		.134	+.000	.041	+.002		-.134
20	1" rear wicker	-3	4.25	4.25	4.00	4.00	20.01	19.01	.562	+.027	-.049	+.023	-.486	-.066	-.952	-.032	9.2%		.138	+.000	.040	-.001		-.138
		0	4.25	4.25	4.00	4.00	20.02	19.02	.558	+.027	-.069	+.022	-.481	-.063	-.989	-.027	12.5%		.137	+.000	.043	+.000		-.137
		3	4.25	4.25	4.00	4.00	20.03	19.03	.559	+.026	-.059	+.023	-.488	-.061	-.979	-.024	10.8%		.134	+.000	.040	-.001		-.134
21	B Pillar Curved Panels	-3	4.25	4.25	4.00	4.00	21.01	20.01	.561	-.001	-.047	+.002	-.508	-.020	-.988	-.034	8.5%		.138	+.000	.042	+.002		-.138
		0	4.25	4.25	4.00	4.00	21.02	20.02	.554	-.002	-.070	-.001	-.493	-.012	-1.016	-.027	12.4%		.137	+.000	.045	+.002		-.137
		3	4.25	4.25	4.00	4.00	21.03	20.03	.558	-.001	-.058	+.001	-.503	-.015	-1.005	-.027	10.3%		.134	+.000	.043	+.003		-.134
22	Ride Height Matrix - Nose Down 1"	0	3.25	3.25	4.00	4.00	22.01	19.02	.504	-.025	-.182	-.091	-.424	-.006	-1.202	-.240	30.0%		.140	+.003	.046	+.003		-.137
23	Nose Down 2"	0	2.25	2.25	4.00	4.00	23.01	22.01	.471	-.033	-.214	-.032	-.421	+.003	-1.348	-.146	33.7%		.145	+.005	.049	+.002		-.140
24	Tail down 1" - (Heave down 1" & rake 1")	0	2.25	2.25	3.00	3.00	24.01	22.01	.466	-.036	-.167	+.015	-.414	+.010	-1.247	-.044	28.7%		.139	-.001	.048	+.001		-.140
25	GRAND AM CONFIGURATION	0	2.25	2.25	3.00	3.00	25.01		.397		-.141		-.052		-.466		73.1%		.137		.035			
	No Rear wing / duckbill, no splitter	3	2.25	2.25	3.00	3.00	25.02		.384		-.138		-.018		-.408		88.5%		.134		.031			
26	4" rear spoiler	0	2.25	2.25	3.00	3.00	26.01	25.01	.468	+.071	-.114	+.027	-.222	-.170	-.718	-.232	33.9%			+.456		-.731		
		3	2.25	2.25	3.00	3.00	26.02	25.02		-.384		+.138		+.018						+.406		-.885		-.134