EZSlam
Performance Repeatability and Reproducibility

1. INTRODUCTION

1.1. Objectives
This document will briefly introduce EZSlam and its operation then go into depth understanding EZSlam's metrics derived from a diverse array of applications. This report does not elaborate on the specific nature of each metric. For information regarding the specific metric, its detailed description, algorithm, and convention can be reviewed in the EZSlam documentation.

Figure 1: EZSlam installed on automobile door.

1.1 Testing Layout

Setup:
- Installation by each operator at the beginning of each session
- Session performed within guidelines defined by EZSlam Manual
- 3 trained operators perform measurements.
- 1 door
- 1 automobile

Procedure Notes
- The nature of a door system, especially after frequent consecutive slamming, might evolve.
- This variation is included in the numbers as it cannot be decoupled from the study.

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1.2 Results and Criteria

Absolute Variation

- Each metric is evaluated based on the variation on the value, expressed as a 95% uncertainty interval, or as 3 sigma of the population.

Range

- Each metric is associated with a sensor range or practical range. The purpose of these values is to put the variation in perspective with respect to the measurement range.

Ratio

- The absolute variation is expressed as a percentage of the range of the sensor or metric.

User Note:

- Tools are available in the software to limit variation by entering known information into the algorithm. These optimizations are explained in the manual. This will always improve the variation and reduce the uncertainty.

Important !

All values cannot be compared to a nominal target value due to the innovative character of EZSlam and the advanced modeling. For these cases, variation is the final criteria. It is at the user's discretion to observe the absolute variation or relative variation.

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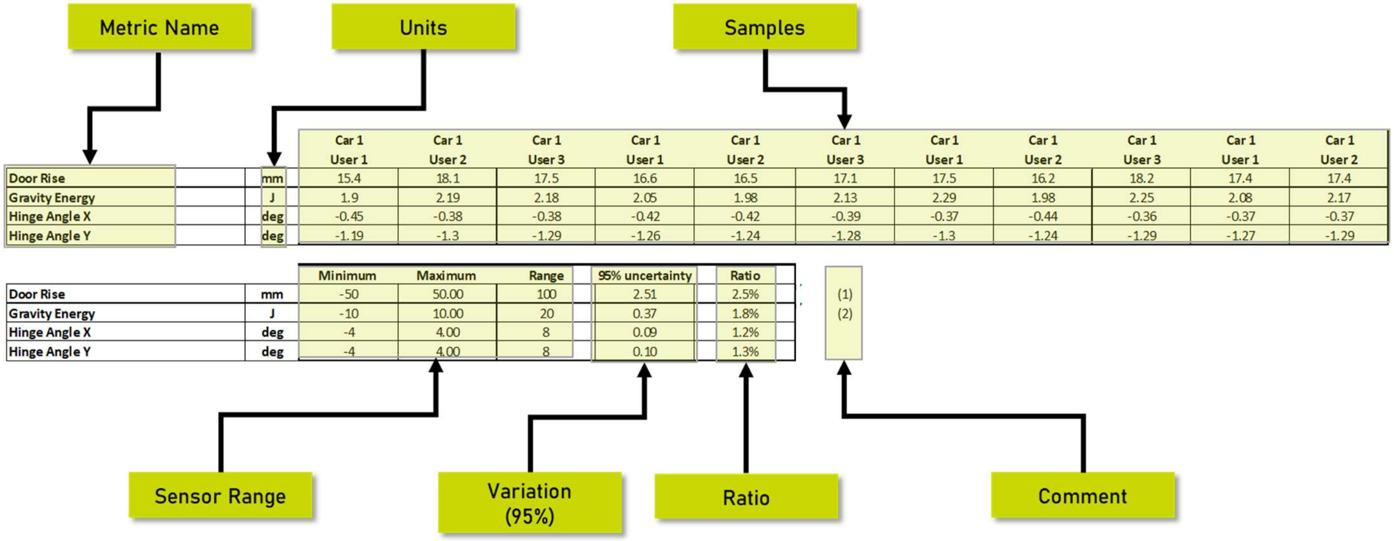
1.3 Reporting Layout



		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Door Rise	mm	15.4	18.1	17.5	16.6	16.5	17.1	17.5	16.2	18.2	17.4	17.4
Gravity Energy	J	1.9	2.19	2.18	2.05	1.98	2.13	2.29	1.98	2.25	2.08	2.17
Hinge Angle X	deg	-0.45	-0.38	-0.38	-0.42	-0.42	-0.39	-0.37	-0.44	-0.36	-0.37	-0.37
Hinge Angle Y	deg	-1.19	-1.3	-1.29	-1.26	-1.24	-1.28	-1.3	-1.24	-1.29	-1.27	-1.29

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Door Rise	mm	-50	50.00	100	2.51	2.5%	(1)
Gravity Energy	J	-10	10.00	20	0.37	1.8%	(2)
Hinge Angle X	deg	-4	4.00	8	0.09	1.2%	
Hinge Angle Y	deg	-4	4.00	8	0.10	1.3%	

Figure 2: Metrics, data samples, and summary statistics

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2. Metrics Data

2.1 Closing Dynamics

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Closing Type		Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant	Latch Dominant
Quality Index	%	71	67	71	70	70	70	66	72	72	64	68
Minimum Power	Watt	12	13	14	14	13	14	16	11	15	17	12

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Closing Type		na	na	na	na	na	(1)
Quality Index	%	0	100	100	7.80	7.8%	(2)
Minimum Power	Watt	5	140	135	5.38	4.0%	(3)

Figure 3: Closing Type, Quality Index, and Minimum Power examples.

Closing Type is a discreet evaluation of 3 types: latch dominant, check dominant, or self-closing. Statistics do not apply to discrete metrics.
Quality Index is a combined metric of all measurements combined. Expressed as a fraction or percentage of the default or nominal value.
Minimum Power is a combined metric of energy and speed. Lower values (<50) are considered easy to close; higher values (>100) would be considered hard to close.

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Minimum Closing Speed	mm/sec	737	753	745	753	746	745	753	722	749	755	722
Minimum Impact Speed	mm/sec	737	753	745	753	746	745	753	722	749	755	722
Minimum Impact Energy	J	3.59	3.66	3.71	3.75	3.57	3.72	3.98	3.41	3.71	3.66	3.49
Minimum Pulse - Full Open	J	2.39	2.68	2.54	2.95	2.84	2.52	2.68	2.45	3.06	1.59	1.83
Minimum Pulse - Outer Detent	J	2	2.38	1.93	2.24	2.06	-	2.26	1.81	2.48	1.71	1.63
Minimum Pulse - Inner Detent	J	2.42	2.52	2.57	2.6	2.44	2.57	2.83	2.27	2.62	-	2.36

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Minimum Closing Speed	mm/sec	0	1800.00	1800	35.63	2.0%	(1)
Minimum Impact Speed	mm/sec	0	1800.00	1800	35.63	2.0%	(2)
Minimum Impact Energy	J	0	25.00	25	0.45	1.8%	
Minimum Pulse - Full Open	J	0	25.00	25	1.34	5.4%	(3)
Minimum Pulse - Outer Detent	J	0	25.00	25	0.86	3.4%	
Minimum Pulse - Inner Detent	J	0	25.00	25	0.47	1.9%	

Figure 4: Closing Speed, Impact Speed, and Minimum Pulse examples.

Closing Speed can have a wide operating range. The speed definition can be set in the convention, and the choice can influence repeatability in both positive and negative ways.
Impact Speed has a fixed convention and will maintain its own definition, method, and characteristic -- independent from the active convention.
Minimum Pulse from a detent position will depend on the number of detents designed into the door. Values will not be determined if no second detent is found.

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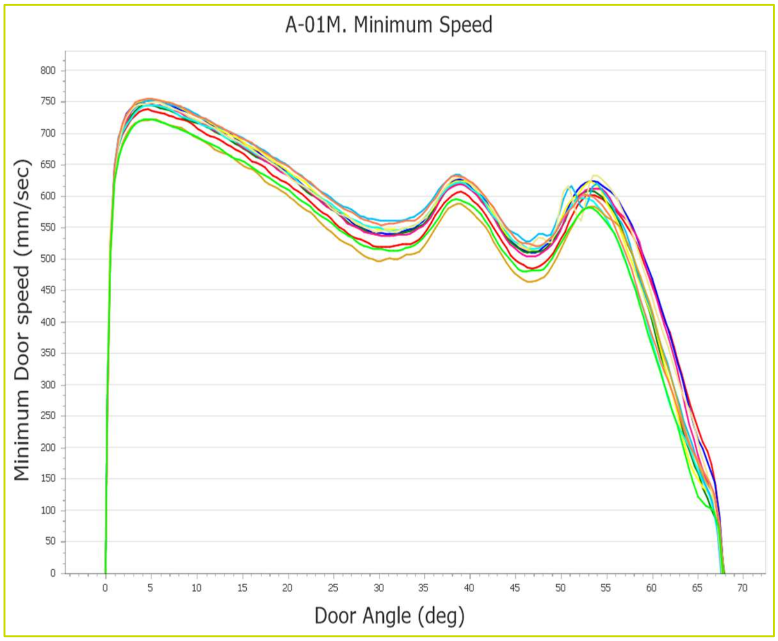

Figure 5: *Minimum door speed as a function of door angle*

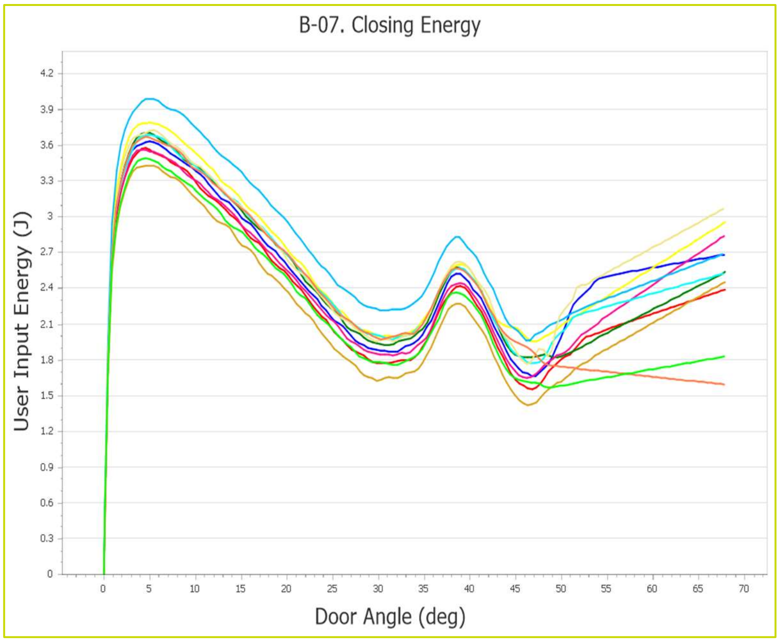

Figure 6: *User input energy as a function of door angle*

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2.2 Latch and Seal System

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Typical Overslam	mm	1.88	1.83	1.91	1.8	1.96	1.86	1.93	1.84	1.81	1.89	1.89
Striker Alignment	mm	0.6	0.49	0.57	0.58	0.74	0.68	0.7	0.41	0.62	0.7	0.82
Latch Point - Static	mm	0.98	1.04	1.36	1.1	1.44	1.47	1.55	1.14	0.88	1.11	1.02
Latch Point - Dynamic	mm	0.54	0.41	0.49	0.57	0.49	0.52	0.64	0.33	0.44	0.51	0.58
Latching Force	N	316	279.1	314.4	310	296	311.4	320.6	298.3	276.3	322.1	281.1
Latching Energy	J	0.89	0.84	0.85	0.81	0.87	0.87	0.95	0.87	0.71	0.88	0.85
Residual Force	N	186.9	173.4	161.1	168.8	158.8	165	156.7	164.6	155.5	185.2	182.7
Residual Energy	J	0.63	0.6	0.57	0.57	0.56	0.55	0.61	0.61	0.57	0.62	0.63

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Typical Overslam	mm	0	6.00	6	0.15	2.5%	
Striker Alignment	mm	-10	10.00	20	0.35	1.7%	
Latch Point - Static	mm	0	10.00	10	0.68	6.8%	
Latch Point - Dynamic	mm	0	10.00	10	0.26	2.6%	
Latching Force	N	0	700.00	700	51.29	7.3%	(1)
Latching Energy	J	0	6.00	6	0.18	3.0%	
Residual Force	N	0	700.00	700	34.54	4.9%	
Residual Energy	J	0	6.00	6	0.09	1.5%	

Figure 7: *Metrics and values associated with latch and seal system.*

Beyond reasonable human force (~400N), variation might increase due to an uncomfortable excessive force.

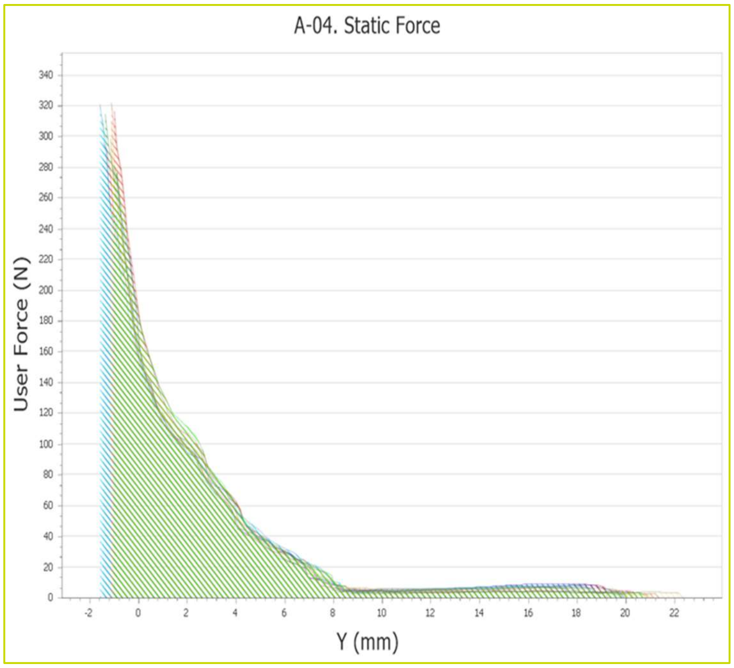

Figure 8: *Static force: User force along the y-axis*

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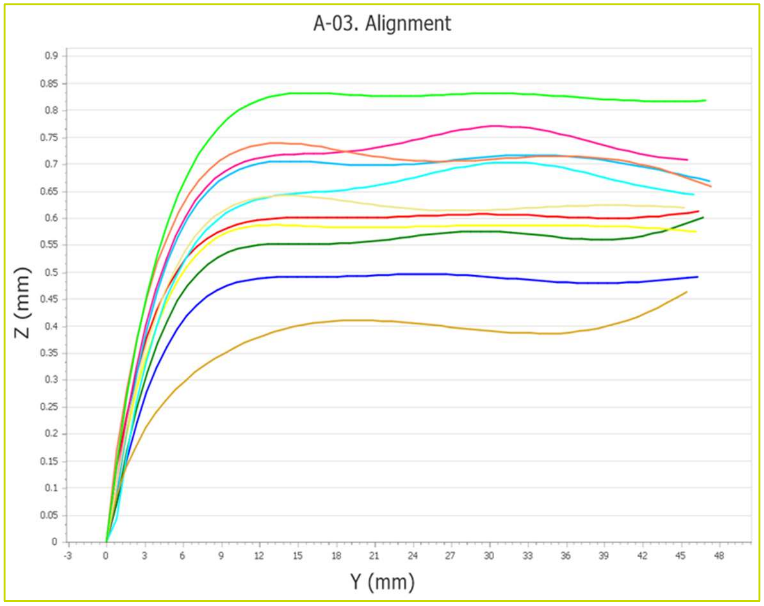

Figure 9: Alignment behavior along the z- and y- axes.

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2.3 Hinge System

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Door Rise	mm	15.4	18.1	17.5	16.6	16.5	17.1	17.5	16.2	18.2	17.4	17.4
Gravity Energy	J	1.9	2.19	2.18	2.05	1.98	2.13	2.29	1.98	2.25	2.08	2.17
Hinge Angle X	deg	-0.45	-0.38	-0.38	-0.42	-0.42	-0.39	-0.37	-0.44	-0.36	-0.37	-0.37
Hinge Angle Y	deg	-1.19	-1.3	-1.29	-1.26	-1.24	-1.28	-1.3	-1.24	-1.29	-1.27	-1.29

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Door Rise	mm	-50	50.00	100	2.51	2.5%	(1)
Gravity Energy	J	-10	10.00	20	0.37	1.8%	(2)
Hinge Angle X	deg	-4	4.00	8	0.09	1.2%	
Hinge Angle Y	deg	-4	4.00	8	0.10	1.3%	

Figure 10: Door Rise and Gravity Energy sample values

Door Rise and the associated range are a combination of the hinge inclination and the body positioning.
Gravity Energy is a combination of the abovementioned door rise and door weight.

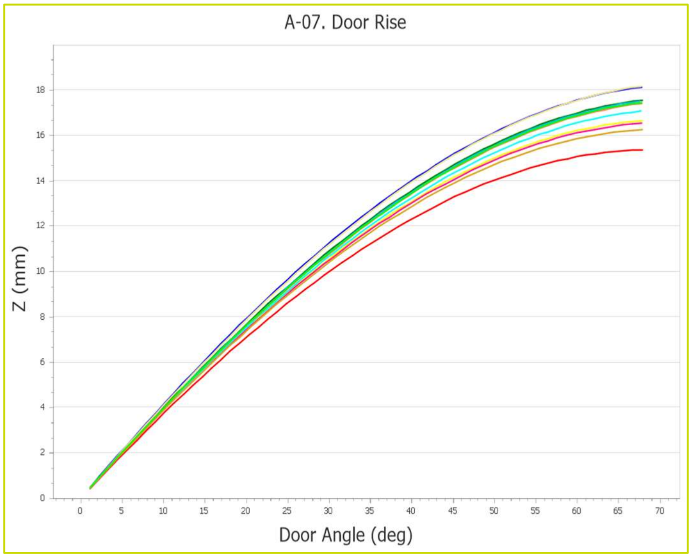

Figure 11: Door Rise along the z-axis for varying door angles

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2.4 Check System

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Number of Detents		2	2	2	2	2	1	2	2	2	2	2
Angle of Open Door	**deg**	67.9	67.8	67.9	67.9	67.8	67.7	67.6	67.9	67.7	67.8	67.8
Angle of Outer Detent	**deg**	53.2	52.8	52.9	53	53.2	-	53.2	53.3	53.7	54	53.5
Angle of Inner Detent	**deg**	38.6	38.5	38.8	38.7	38.7	38.5	38.6	38.8	39.5	39	39
Maximum Pulling Force to First Detent	**N**	13.8	13.1	13.8	13.9	13.6	14.6	13.8	14.9	13.6	14.5	14.3
Door Check Linearity	**mm/sec**	59	60	57	61	57	55	64	69	52	63	56
Door Check Slope	**mm/sec**	43	53	39	51	48	42	46	60	13	62	42
Max Sweep Energy - Opening	**J**	11.45	11.16	11.43	10.5	10.63	11.53	10.73	11.5	9.92	11.18	10.81
Max Sweep Energy - Closing	**J**	0.84	0.68	0.76	1.03	0.77	0.75	0.78	0.8	1.01	1.36	1.17
Static Friction	**J**	4.67	5.58	4.43	4.46	4.16	4.66	5.37	4.54	4.24	5.34	5.13
Closing Boost	**J**	2.96	0.67	3.32	2.59	3.06	2.96	0.77	3.22	2.4	1.86	1.7
Closing Boost Angle	**deg**	61.5	62.4	62	60.6	61	61.8	61.7	61.5	31.4	31.4	29.1

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Number of Detents		na	na	na	na	na	(1)
Angle of Open Door	**deg**	0	90.00	90	0.30	0.3%	
Angle of Outer Detent	**deg**	0	90.00	90	1.10	1.2%	
Angle of Inner Detent	**deg**	0	90.00	90	0.87	1.0%	
Maximum Pulling Force to First Detent	**N**	0	300.00	300	1.58	0.5%	
Door Check Linearity	**mm/sec**	-150	150.00	300	14.28	4.8%	
Door Check Slope	**mm/sec**	-300	300.00	600	39.17	6.5%	
Max Sweep Energy - Opening	**J**	0	25.00	25	1.54	6.2%	
Max Sweep Energy - Closing	**J**	0	25.00	25	0.64	2.5%	
Static Friction	**J**	0	25.00	25	1.47	5.9%	
Closing Boost	**J**	0	25.00	25	3.26	13.0%	(2)
Closing Boost Angle	**deg**	0	90.00	90	1.69	1.9%	(3)

Figure 12: Number of Detents, Closing Boost, and Closing Boost Angle sample data.

Number of Detents is a discrete value 0, 1 or 2. Statistical analysis cannot be performed.

Closing Boost can be sensitive to design choices. There can be multiple tipping points and the determination could potentially flip one detent to another detent, indicating that both energy levels are very similar.

Closing Boost Angle has the same behavior where the tipping point can flip from one detent to another detent. In the data collection during the 3 last recordings, the tipping point or maximum shifted from the full open to the first detent position. This might be due to the frequent slamming of the same door during the measurement session.

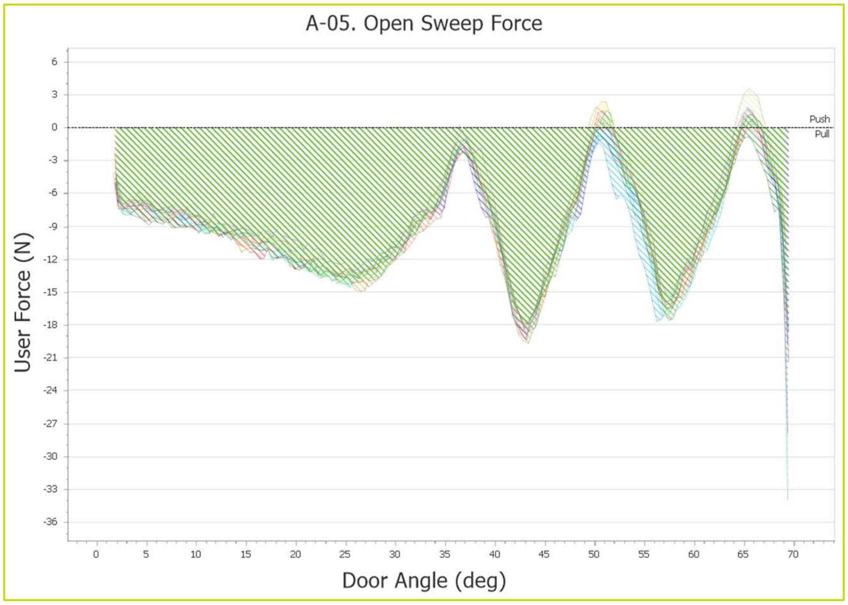

Figure 13: *Open Sweep Force: User force for varying door angles*

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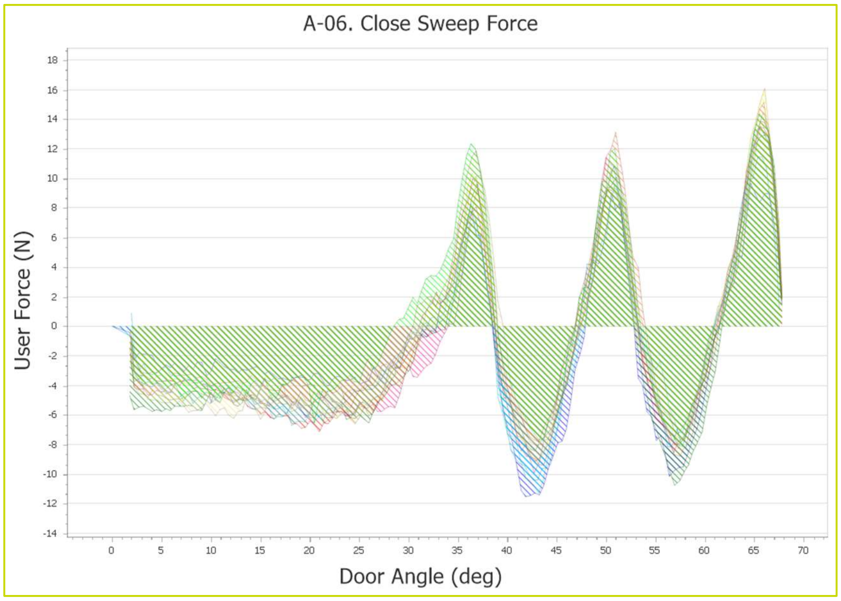

Figure 14: *Close Sweep Force: User force for varying door angles*

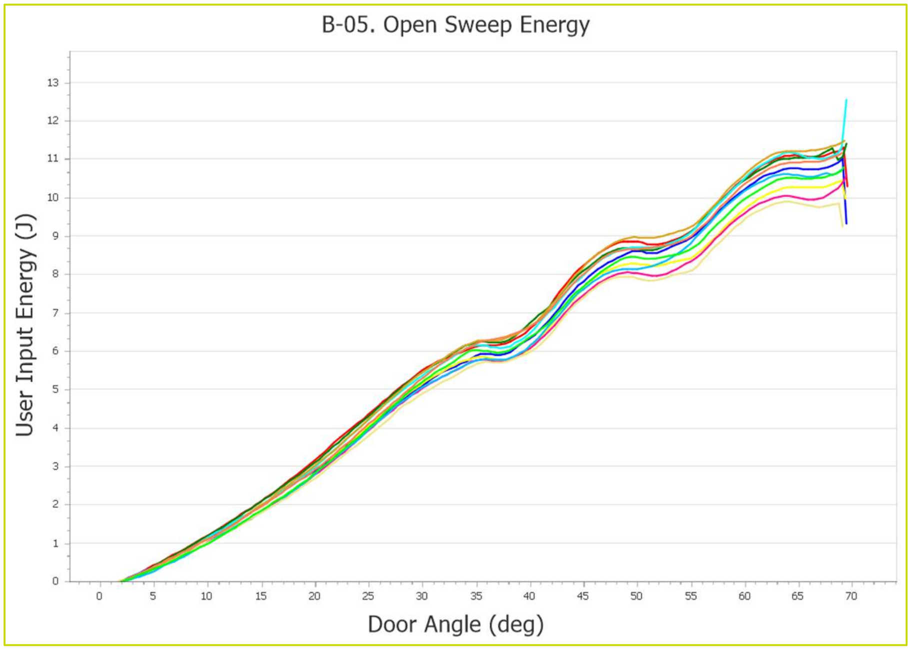

Figure 15: *Open Sweep Energy: User input energy for varying door angles*

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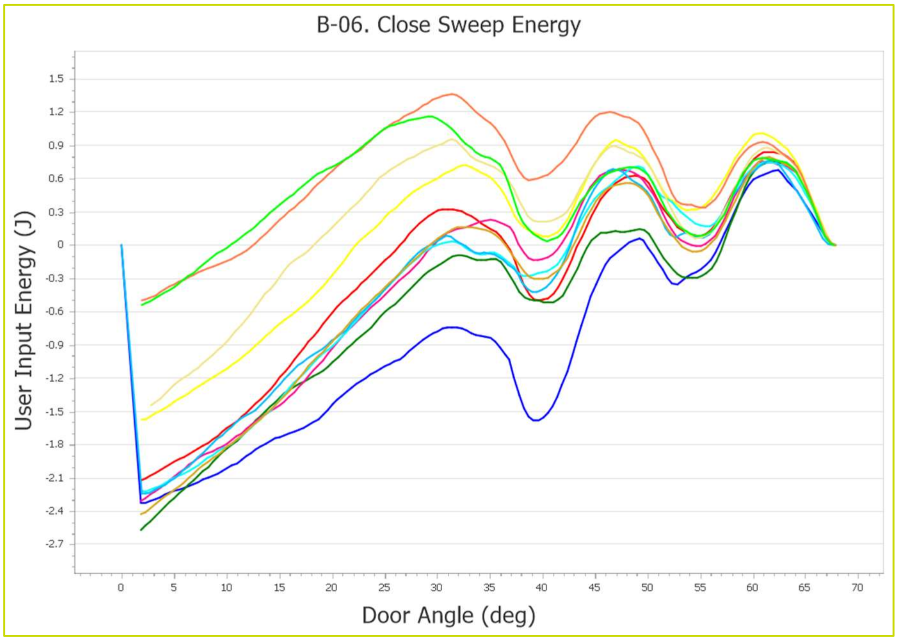

Figure 16: *Close Sweep Force: User input energy for varying door angles*

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2.5 Geometry

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Weight	**kg**	[21.7]	[21.2]	[21.9]	[21.7]	[21.0]	[22.0]	[23.1]	[21.5]	[21.8]	[21.0]	[21.9]
Inertia	**kgm2**	13.9	14	13.7	13.8	13.5	13.5	14	13.7	14.2	13.2	13.4
Door Top Radius	**mm**	[638]	[646]	[630]	[634]	[638]	[622]	[619]	[635]	[643]	[631]	[621]
Door Middle Radius	**mm**	1063	1077	1050	1057	1064	1037	1031	1058	1072	1051	1036
Door Bottom Radius	**mm**	[1063]	[1077]	[1050]	[1057]	[1064]	[1037]	[1031]	[1058]	[1072]	[1051]	[1036]
Height	**mm**	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]	[1200]
Area	**m2**	[1.148]	[1.164]	[1.134]	[1.142]	[1.149]	[1.120]	[1.114]	[1.143]	[1.158]	[1.135]	[1.119]
CG Radius	**mm**	[575]	[583]	[568]	[572]	[575]	[561]	[558]	[572]	[580]	[568]	[560]

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Weight	**kg**	na	na	na	na	na	(1)
Inertia	**kgm2**	4	20.00	16	0.90	5.6%	
Door Top Radius	**mm**	na	na	na	na	na	
Door Middle Radius	**mm**	500	1300.00	800	44.76	5.6%	
Door Bottom Radius	**mm**	na	na	na	na	na	
Height	**mm**	na	na	na	na	na	
Area	**m2**	na	na	na	na	na	
CG Radius	**mm**	na	na	na	na	na	

Figure 17: *Geometry related sample values*

Geometry is entered via the selected profile or individually per session in the geometry tab. Weight, area, and center of gravity are derived from these entered values, the measured inertia, or the radius.

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2.6 Cabin Pressure

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Typical Cabin Pressure	mbar	2.41	2.38	2.45	2.43	2.42	2.51	2.52	2.42	2.39	2.43	2.49
Typical Cabin Vacuum	mbar	-0.26	-0.25	-0.26	-0.25	-0.26	-0.26	-0.26	-0.26	-0.28	-0.26	-0.26
Pressure Wave Size	mbar	59.55	59.91	60	58.81	59.7	60.18	59.69	58.89	66.31	58.27	57.84

		Minimum	Maximum	Range	95% uncertainty	Ratio
Typical Cabin Pressure	mbar	0	5.00	5	0.14	2.8%
Typical Cabin Vacuum	mbar	-5	0.00	5	0.02	0.5%
Pressure Wave Size	mbar	-40	40.00	80	6.74	8.4%

Figure 18: *Cabin pressure sample values*

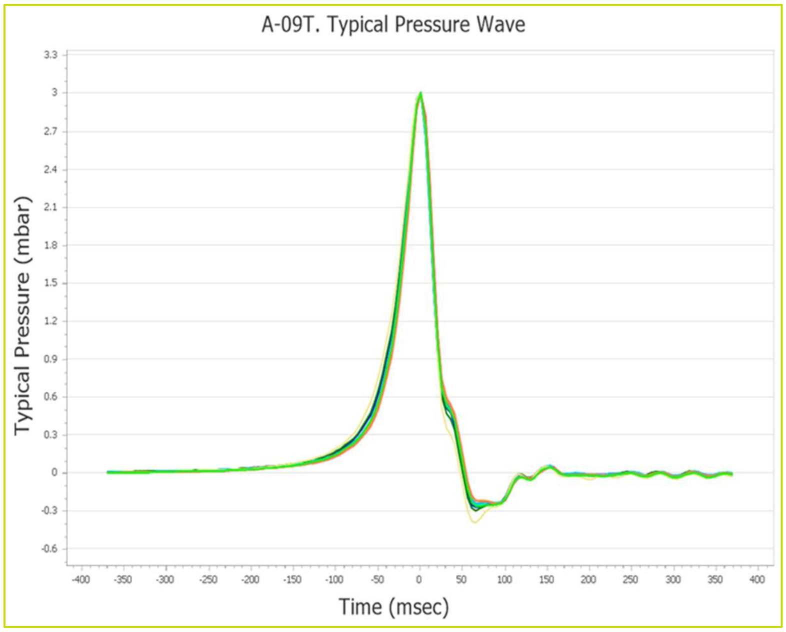

Figure 19: *Cabin pressure transient behavior*

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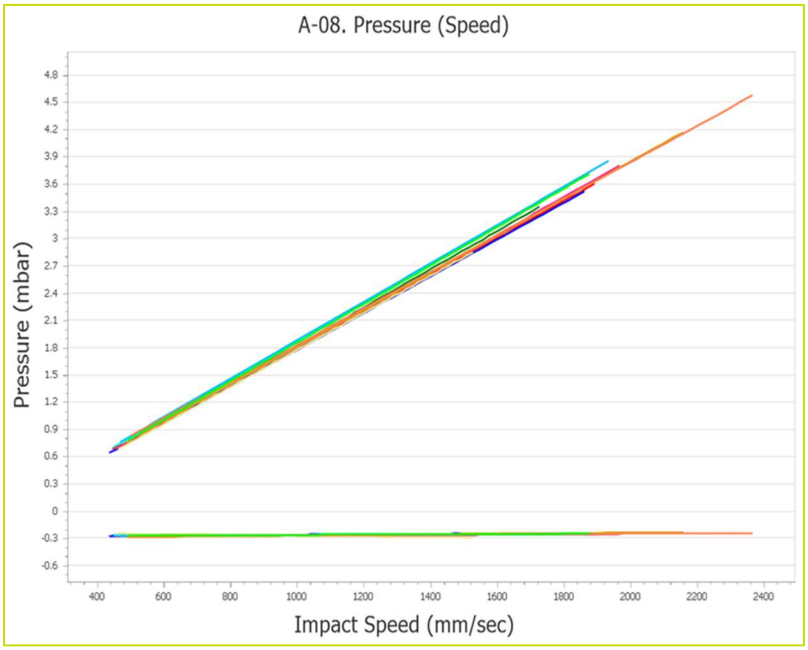

Figure 20: *Gauge Pressure changes as a function of Impact Speed.*

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2.7 Plop

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Plop Speed	mm/sec	128	130	123	118	126	122	120	124	122	116	117
Plop Position	mm	9.8	9.6	10	10	10.1	8.3	9.9	10	10	9.5	9.9

		Minimum	Maximum	Range	95% uncertainty	Ratio
Plop Speed	mm/sec	0	200.00	200	13.43	6.7%
Plop Position	mm	0	60.00	60	1.53	2.6%

Figure 21: *Plop Speed and Plop Position sample data.*

There is an aspect of operating choice which will affect variation and repeatability. Plop tests performed from the outside tend to display higher variation due to the added effects of the handle. Performing the test from the inside leads to improved repeatability.

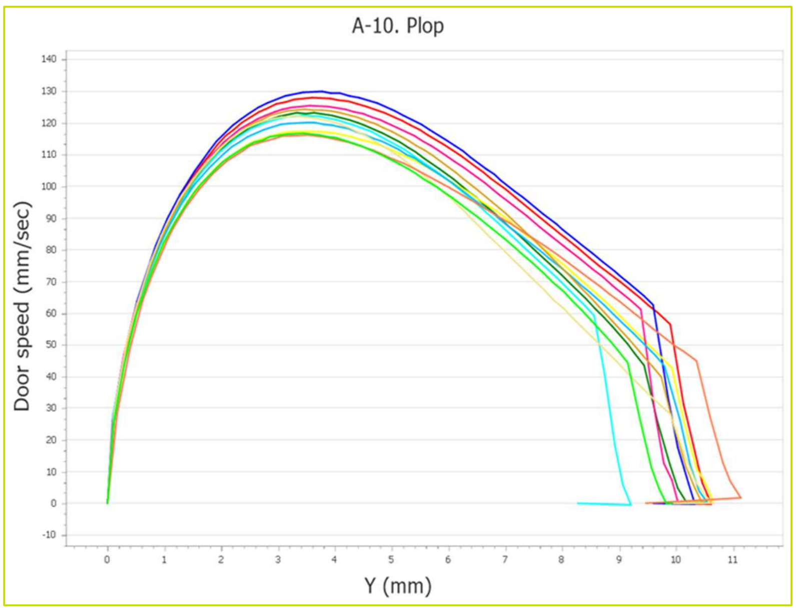

Figure 22: *Plop: Door speed along the y-axis*

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2.8 Opening Energy

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Total Opening Energy	J	11.46	11.16	11.44	10.5	10.63	11.53	10.74	11.5	9.93	11.19	10.81
O.E. Provided by User	J	11.45	11.16	11.43	10.5	10.63	11.53	10.73	11.5	9.92	11.18	10.81
O.E. Provided by Gravity	J	0	0	0	0	0	0	0	0	0	0	0
O.E. Provided by Spring	J	0	0	0	0	0	0	0	0	0	0	0
O.E. Loss to Gravity	J	1.9	2.19	2.18	2.05	1.98	2.13	2.29	1.98	2.25	2.08	2.17
O.E. Loss to Friction	J	4.67	5.58	4.43	4.46	4.16	4.66	5.37	4.54	4.24	5.34	5.13
O.E. Loss to Spring	J	4.89	3.39	4.82	3.99	4.48	4.74	3.08	4.98	3.44	3.76	3.51

		Minimum	Maximum	Range	95% uncertainty	Ratio
Total Opening Energy	J	0	25.00	25	1.54	6.2%
O.E. Provided by User	J	0	25.00	25	1.54	6.2%
O.E. Provided by Gravity	J	0	25.00	25	0.00	0.0%
O.E. Provided by Spring	J	0	25.00	25	0.00	0.0%
O.E. Loss to Gravity	J	0	25.00	25	0.37	1.5%
O.E. Loss to Friction	J	0	25.00	25	1.47	5.9%
O.E. Loss to Spring	J	0	25.00	25	2.11	8.4%

Figure 23: *Opening Energy sample data*

Energy distributions (I,J,K) are determined based on the combination of many previous physical metrics, converted to energy units. Door systems can have design choices resulting in the absence of gravity input, for example. This would be shown in the chart as “0”, with associated “0” variation.

2.9 Minimum Closing Energy

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Total Mininum Closing Energy	J	9.18	8.26	9.54	8.99	9.31	9.4	8.05	9.42	8.75	7.44	7.5
M.C.E. Provided by User	J	2.39	2.68	2.54	2.95	2.84	2.52	2.68	2.45	3.06	1.59	1.83
M.C.E. Provided by Gravity	J	1.9	2.19	2.18	2.05	1.98	2.13	2.29	1.98	2.25	2.08	2.17
M.C.E. Provided by Spring	J	4.89	3.39	4.82	3.99	4.48	4.74	3.08	4.98	3.44	3.76	3.51
M.C.E. Loss to Drag	J	0.33	0.33	0.27	0.32	0.32	0.28	0.3	0.28	0.33	0.26	0.23
M.C.E. Loss to Seal Dynamics	J	1.18	1.16	1.07	1.51	1.29	1.19	1.43	1.19	1.35	1.04	1.02
M.C.E. Loss to Cabin Dynamics	J	2.05	2.12	1.93	2.02	2	1.95	1.98	1.82	2.17	1.58	1.73
M.C.E. Loss to Static Load	J	0.89	0.84	0.85	0.81	0.87	0.87	0.95	0.87	0.71	0.88	0.85
M.C.E. Loss to Gravity	J	0	0	0	0	0	0	0	0	0	0	0
M.C.E. Loss to Friction	J	4.73	3.81	5.42	4.32	4.82	5.11	3.39	5.25	4.18	3.68	3.66
M.C.E. Loss to Spring	J	0	0	0	0	0	0	0	0	0	0	0

		Minimum	Maximum	Range	95% uncertainty	Ratio
Total Mininum Closing Energy	J	0	25.00	25	2.33	9.3%
M.C.E. Provided by User	J	0	25.00	25	1.34	5.4%
M.C.E. Provided by Gravity	J	0	25.00	25	0.37	1.5%
M.C.E. Provided by Spring	J	0	25.00	25	2.11	8.4%
M.C.E. Loss to Drag	J	0	25.00	25	0.10	0.4%
M.C.E. Loss to Seal Dynamics	J	0	25.00	25	0.48	1.9%
M.C.E. Loss to Cabin Dynamics	J	0	25.00	25	0.52	2.1%
M.C.E. Loss to Static Load	J	0	25.00	25	0.18	0.7%
M.C.E. Loss to Gravity	J	0	25.00	25	0.00	0.0%
M.C.E. Loss to Friction	J	0	25.00	25	2.13	8.5%
M.C.E. Loss to Spring	J	0	25.00	25	0.00	0.0%

Figure 24: *Minimum Closing Energy sample data*

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2.10 Typical Closing Energy

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Total Typical Closing Energy	J	18.5	16.61	18.62	17.27	17.06	17.44	17.17	18.11	17.02	17.34	17.68
T.C.E. Provided by User	J	11.71	11.03	11.62	11.24	10.59	10.57	11.8	11.14	11.33	11.5	12
T.C.E. Provided by Gravity	J	1.9	2.19	2.18	2.05	1.98	2.13	2.29	1.98	2.25	2.08	2.17
T.C.E. Provided by Spring	J	4.89	3.39	4.82	3.99	4.48	4.74	3.08	4.98	3.44	3.76	3.51
T.C.E. Loss to Drag	J	1.31	1.34	1.29	1.27	1.29	1.26	1.24	1.29	1.4	1.32	1.26
T.C.E. Loss to Seal Dynamics	J	2.63	2.93	3.08	3.09	2.87	2.75	3.22	2.19	4.04	2.33	3.02
T.C.E. Loss to Cabin Dynamics	J	6.07	6.19	6.26	5.7	5.74	6.05	5.95	5.77	6.49	5.69	6.06
T.C.E. Loss to Static Load	J	2.61	2.41	2.76	2.3	2.47	2.68	2.9	2.77	2.12	3.12	2.95
T.C.E. Loss to Gravity	J	0	0	0	0	0	0	0	0	0	0	0
T.C.E. Loss to Friction	J	4.99	3.21	4.84	3.74	3.85	3.73	2.8	4.54	2.96	3.44	3.81
T.C.E. Loss to Spring	J	0	0	0	0	0	0	0	0	0	0	0

		Minimum	Maximum	Range	95% uncertainty	Ratio
Total Typical Closing Energy	J	0	25.00	25	1.91	7.6%
T.C.E. Provided by User	J	0	25.00	25	1.40	5.6%
T.C.E. Provided by Gravity	J	0	25.00	25	0.37	1.5%
T.C.E. Provided by Spring	J	0	25.00	25	2.11	8.4%
T.C.E. Loss to Drag	J	0	25.00	25	0.13	0.5%
T.C.E. Loss to Seal Dynamics	J	0	25.00	25	1.47	5.9%
T.C.E. Loss to Cabin Dynamics	J	0	25.00	25	0.77	3.1%
T.C.E. Loss to Static Load	J	0	25.00	25	0.90	3.6%
T.C.E. Loss to Gravity	J	0	25.00	25	0.00	0.0%
T.C.E. Loss to Friction	J	0	25.00	25	2.17	8.7%
T.C.E. Loss to Spring	J	0	25.00	25	0.00	0.0%

Figure 25: *Typical Closing Energy sample data*

2.10 Flush Sensitivity

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Total	J	3.73	4.16	5.75	4.37	4.96	5.64	6.6	3.39	2.7	4.37	5.83
Seal Dynamics	J	0.74	1.1	1.61	1.15	1.39	1.59	1.84	0.59	0.96	0.84	1.48
Cabin Dynamics	J	2.06	2.53	3.48	2.68	3.29	4.16	4.1	2.35	1.54	2.68	3.21

		Minimum	Maximum	Range	95% uncertainty	Ratio	
Total	J	0	25.00	25	3.56	14.3%	(1)
Seal Dynamics	J	0	25.00	25	1.21	4.8%	
Cabin Dynamics	J	0	25.00	25	2.46	9.8%	

Figure 26: *Flush Sensitivity sample data*

Flush sensitivity is a mathematical model that predicts the behavior of the door outside its current setup. The linearity of the door system around the current configuration will influence the accuracy of the prediction. The amount of linearity or curvature will be an indication of this aspect.

2.10 Improvement Model

		Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2	Car 1 User 3	Car 1 User 1	Car 1 User 2
Based on 1J of Friction	J	1.12	1.14	1.13	1.13	1.14	1.14	1.11	1.13	1.15	1.12	1.11
Based on 1J of Cabin Dynamics	J	1.76	1.95	1.91	1.8	1.93	2.04	1.77	1.83	2.09	1.71	1.74
Based on 1J of Seal Dynamics	J	1.18	1.27	1.28	1.24	1.26	1.24	1.24	1.13	1.48	1.15	1.24
Based on 1J on Static	J	1.23	1.23	1.27	1.22	1.26	1.29	1.27	1.28	1.21	1.3	1.26

		Minimum	Maximum	Range	95% uncertainty	Ratio
Based on 1J of Friction	J	0	25.00	25	0.04	0.2%
Based on 1J of Cabin Dynamics	J	0	25.00	25	0.38	1.5%
Based on 1J of Seal Dynamics	J	0	25.00	25	0.27	1.1%
Based on 1J on Static	J	0	25.00	25	0.09	0.4%

Figure 27: *Improvement Model sample data*

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