

2010 Toyota Yaris

FE Model

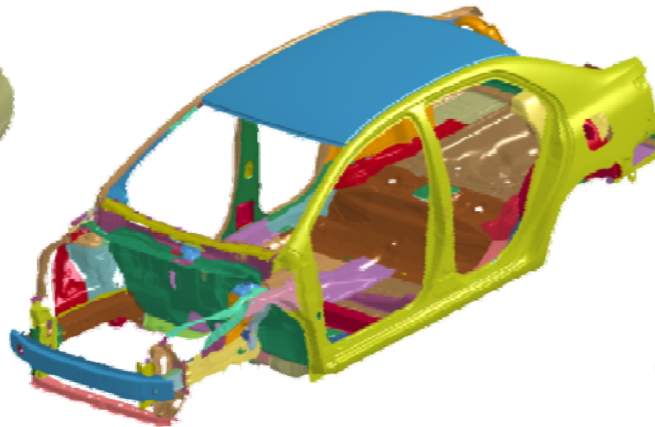
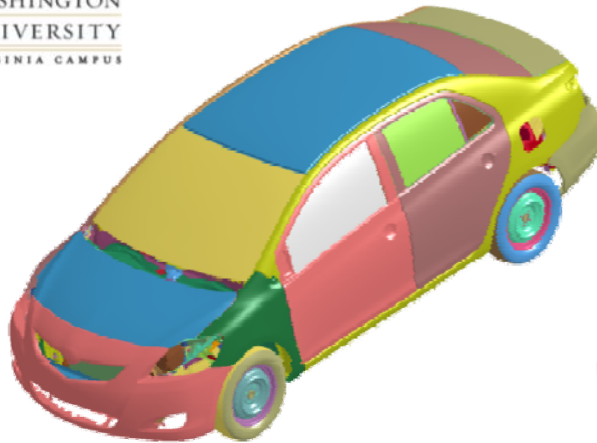


The National Crash Analysis Center
The George Washington University



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Model Information



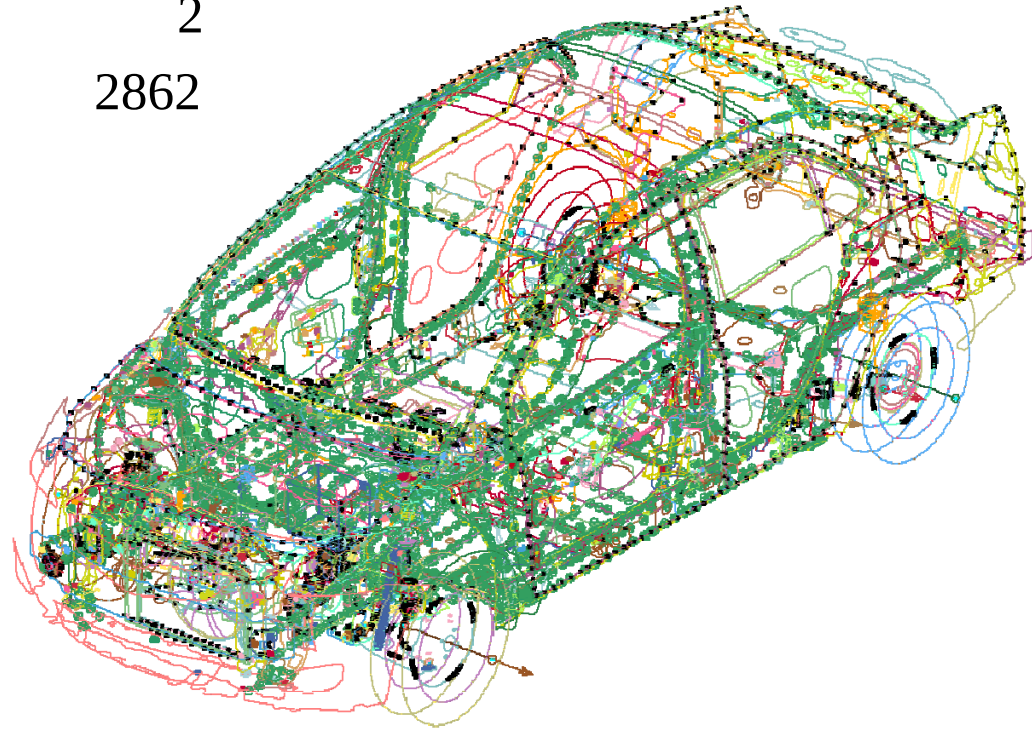
Number of Parts	771
Number of Nodes	998,218
Number of Shells	950,560
Number of Beams	4,497
Number of Solids	19,314
Total Number of Elements	974,383



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Connections

⇒ BEAM CONNECTIONS	4324
⇒ NODAL_RIGID_BODY	423
⇒ EXTRA_NODES_SET	16
⇒ JOINTS	14
⇒ RIGID_BODIES	2
⇒ SPOTWELD	2862

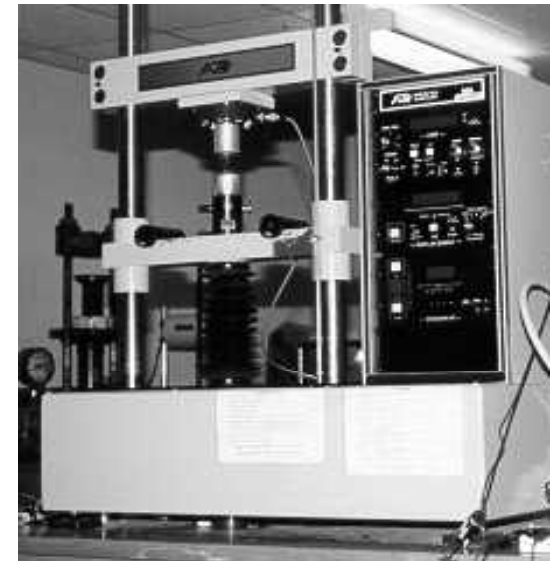
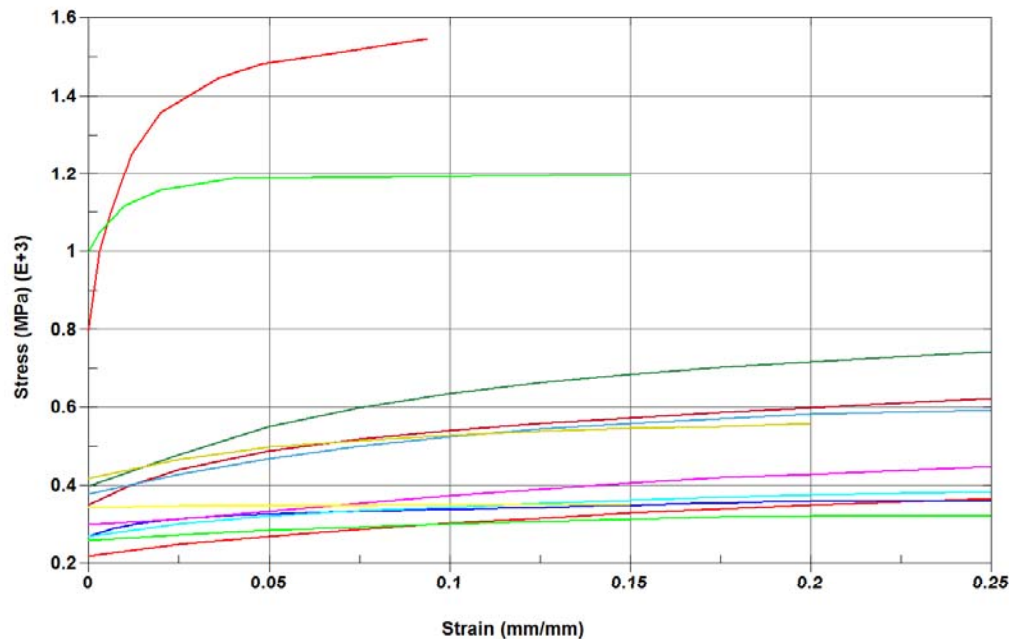




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Material Testing

- Specimens were cut from actual components
- 160 tensile tests
- Data converted
- 12 different materials generated based on test data

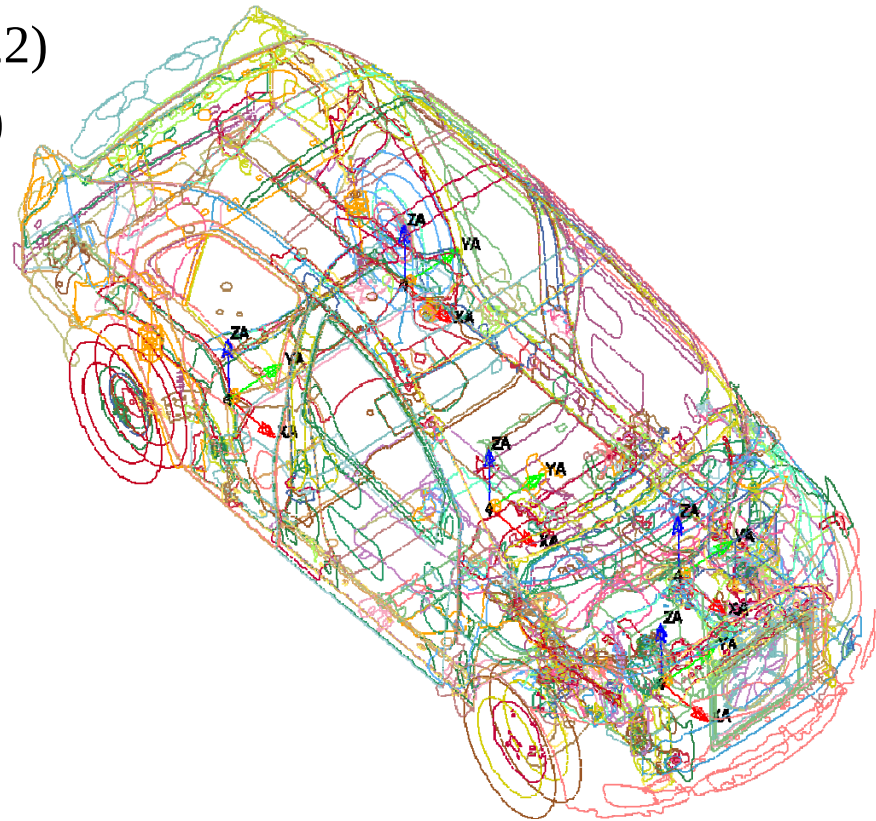




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Accelerometers

- ⇒ Left Rear Seat (Node 4000390)
- ⇒ Right Rear Seat (Node 4000398)
- ⇒ Engine Top (Node 4000414)
- ⇒ Engine Bottom (Node 4000422)
- ⇒ Vehicle C.G. (Node 4000406)

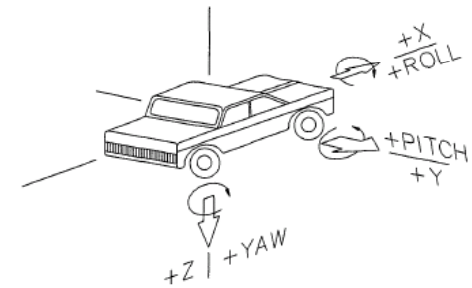




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Inertia Comparisons

	<i>Actual Vehicle</i>	<i>FE Model</i>
Weight, kg	1078	1100
Pitch inertia, kg-m ²	1498	1566
Yaw inertia, kg-m ²	1647	1739
Roll inertia, kg-m ²	388	395
Vehicle CG X, mm	1022	1004
Vehicle CG Y, mm	-8.3	-4.4
Vehicle CG Z, mm	558	569





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Full-Scale Crash Tests

➤ Toyota Yaris (2006-2010)

Test Type	Test Number
Frontal Full Wall	NHTSA 5677 (56.3 km/hr), 6221 (56.2 km/hr), 6059 (39.8 km/hr), 6060 (39.8 km/hr), 6069 (39.8 km/hr)
Frontal Offset	IIHS CEF0610 (64.7 km/hr)
Side Impact NHTSA	NHTSA 5679 (62.1 km/hr), 6220 (62.3 km/hr), 6558 (61.9 km/h), 6585 (61.8 km/hr)
Roof Strength	IIHS SWR0920
Side Impact IIHS	IIHS CES50638 (50.2 km/hr), CES0639 (50.0 km/hr)



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Yaris – Frontal Full Wall – 56 km/hr

➤ Two Full-scale Crash Tests @ 56 km/hr:

⇒ NHTSA 5677 (56.3 km/hr) – 2007 Sedan

⇒ NHTSA 6221 (56.2 km/hr) – 2008 Hatch Back





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Yaris – Frontal Full Wall – 56 km/hr



	FE Model	Test 5677	Test 6221
Weight (kg)	1263	1271	1245
Engine Type	1.5L V4	1.5L V4	1.5L V4
Tire size	P185/60R15	P185/60R15	P185/60R15
Attitude (mm) (As delivered)	F – 668	F – 673	F – 675
	R – 673	R – 680	R – 673
Wheelbase (mm)	2538	2551	2463
CG (mm) Rear of front wheel C/L	1035	999	976
Body Style	4 Door Sedan	4 Door Sedan	3 Door Liftback

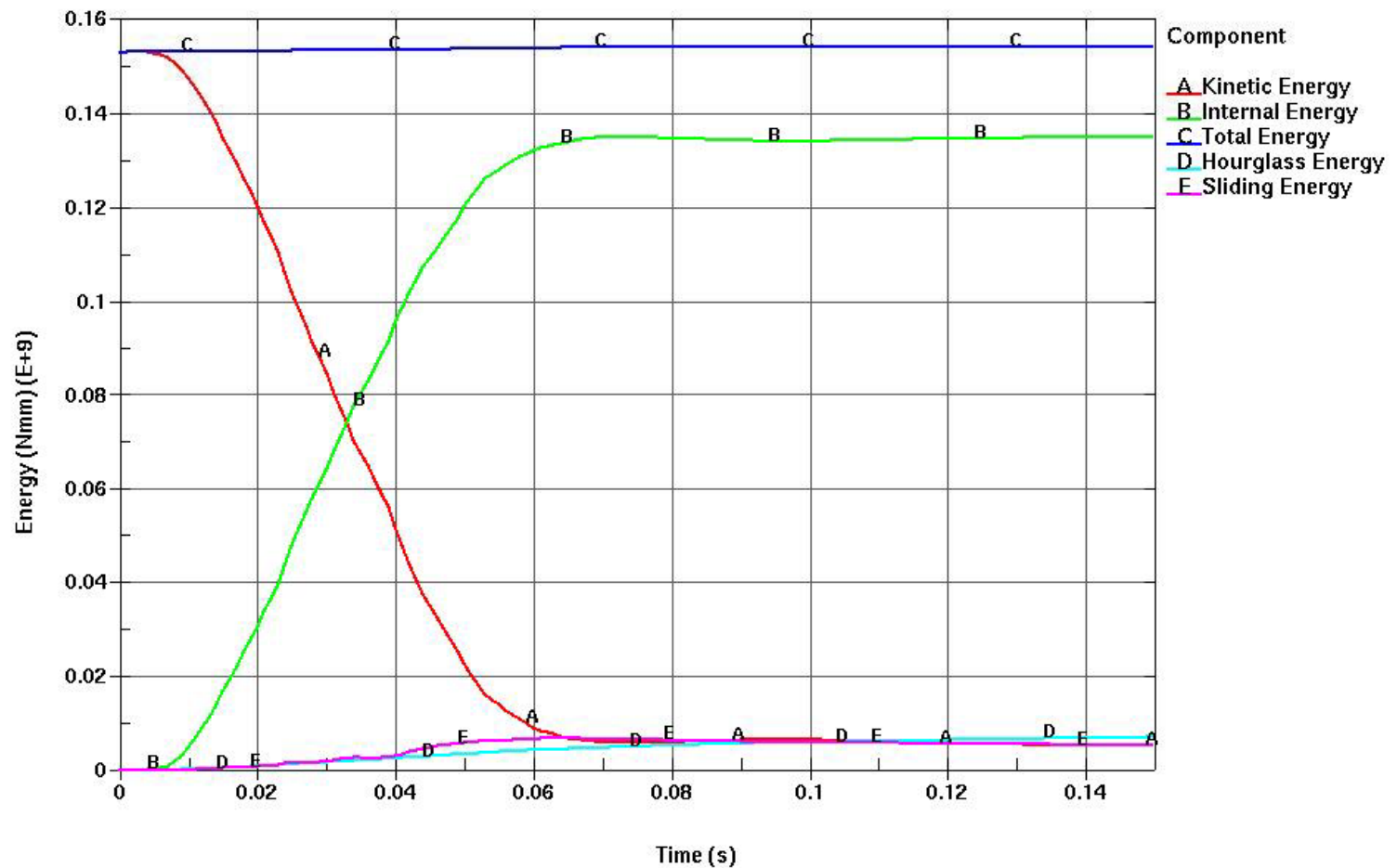
LS-DYNA :

- Version: MPP971sR4.2.1
- Revision: 53450
- Platform: Intel MPI 3.1 Xeon64
- OS Level: Linux Red Hat 4 upd 4
- Precision: Single precision (I4R4)
- Total elapsed time: 2 hr 15 min (150 ms)
- Number of processors: 24



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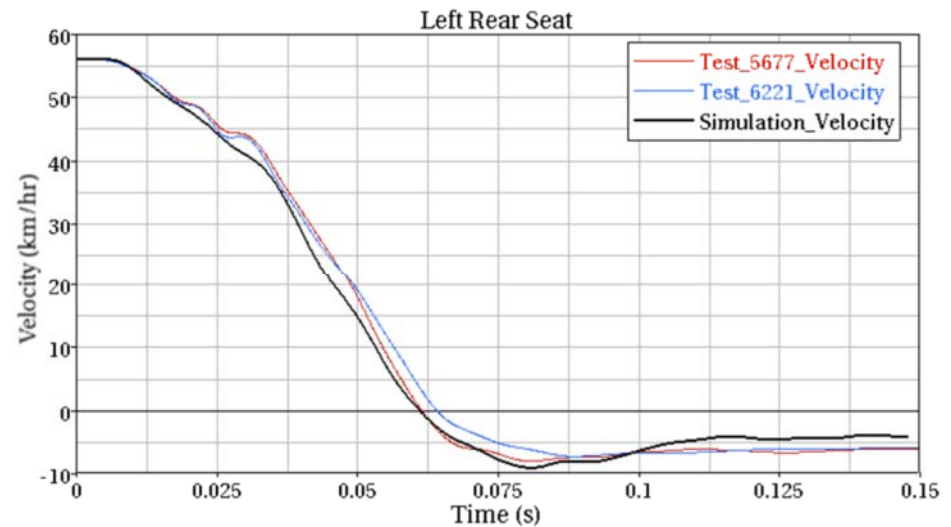
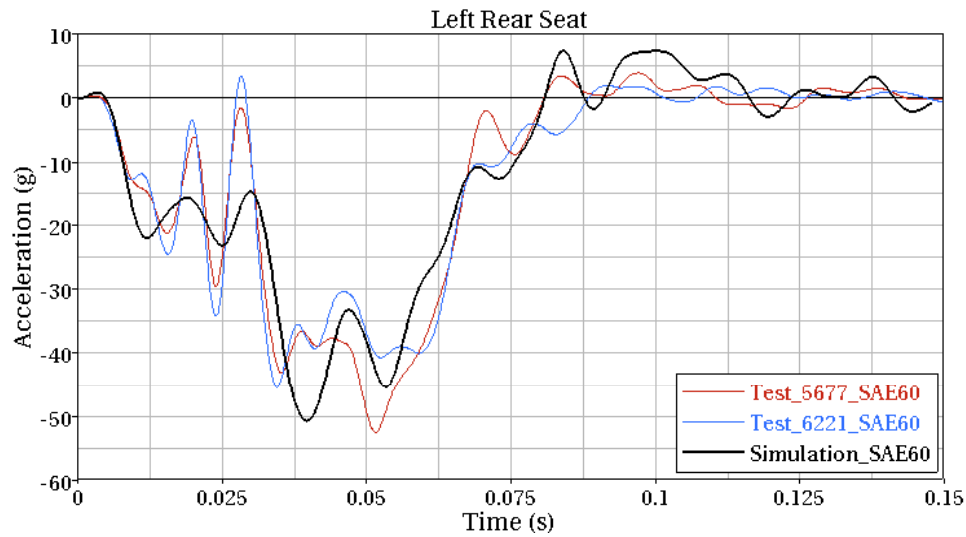
Yaris – Frontal Full Wall – 56 km/hr





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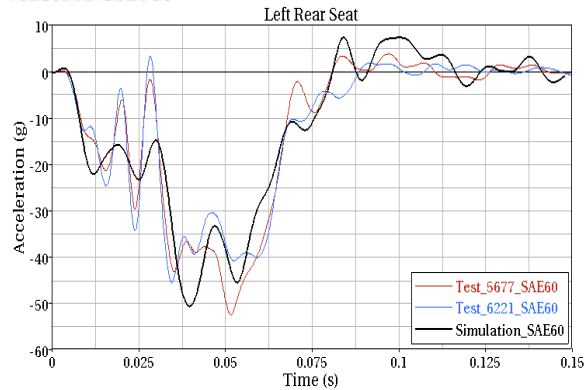
Yaris – Frontal Full Wall – 56 km/hr





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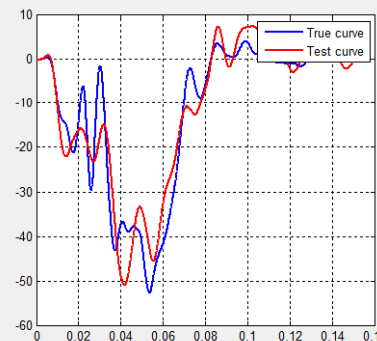
Yaris – Frontal Full Wall – 56 km/hr



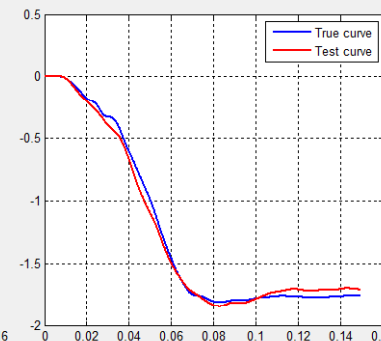
Comparison Metric values

Whole time interval [0,0.1499]

True and Test curves



True and Test curves (integrated)



MPC Metrics

	Value [%]	
Sprague-Geers Magnitude	-2.7	Pass
Sprague-Geers Phase	8.4	Pass
Sprague-Geers	8.8	Pass

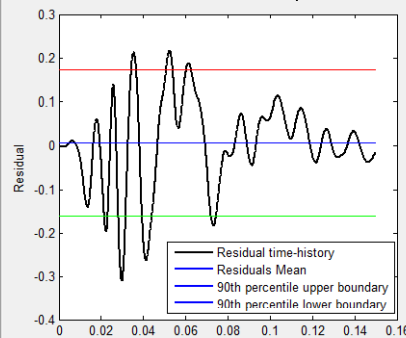
ANOVA Metrics

	Value [%]	
Average	0.6	Pass
Standard deviation	10.1	Pass

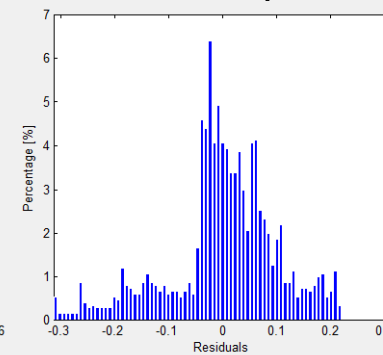
(Values normalized to peak of True curve)

Acceleration Residuals

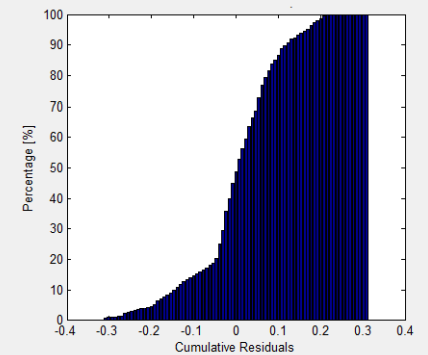
Residuals time history



Residuals histogram



Residuals cumulative distribution

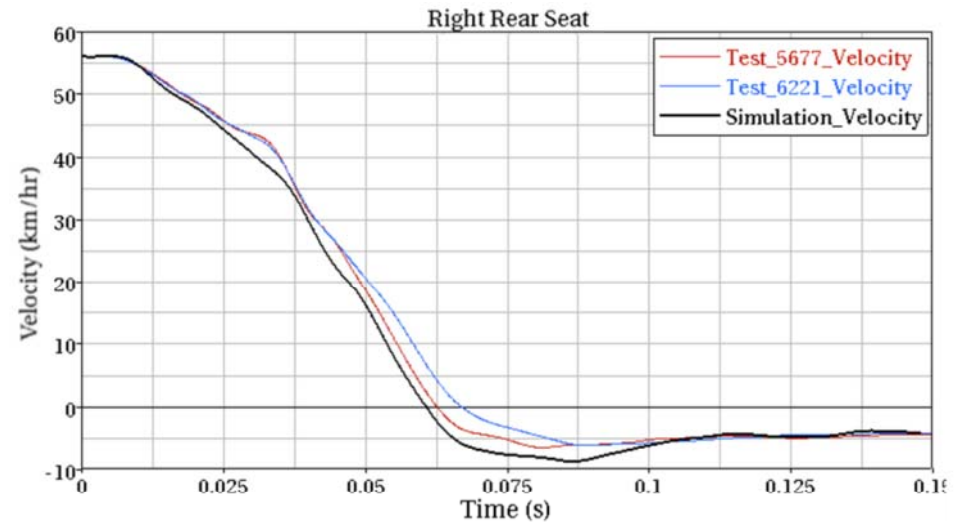
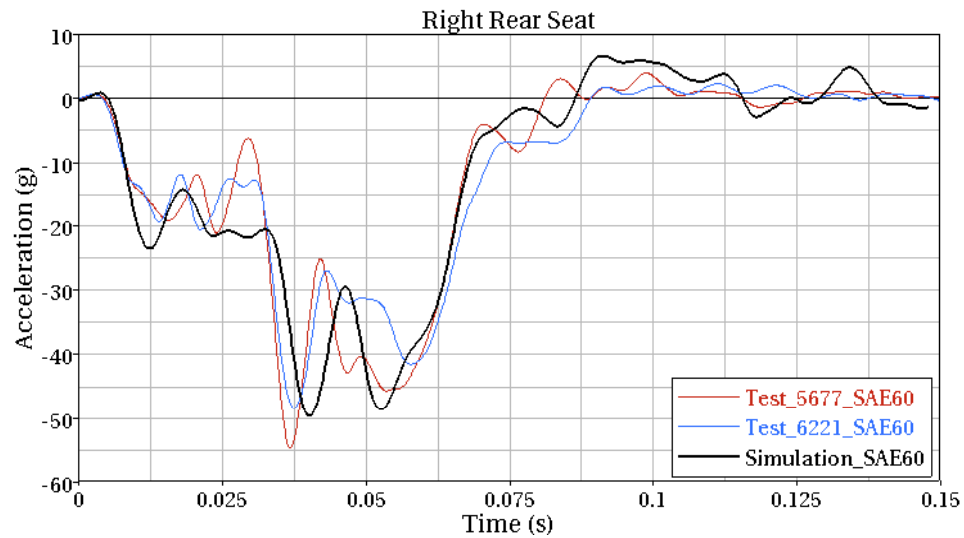


Roadside Safety Verification
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(RSVVP) Comparisons



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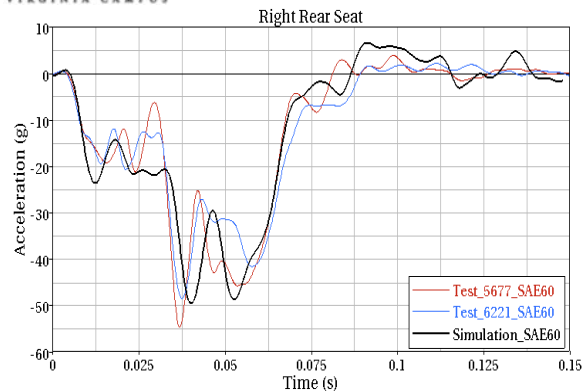
Yaris – Frontal Full Wall – 56 km/hr





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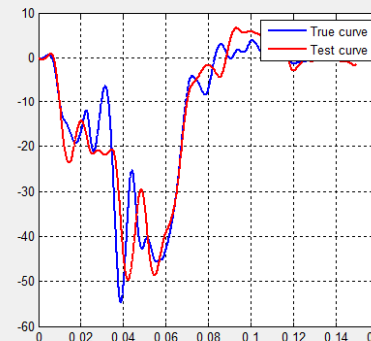
Yaris – Frontal Full Wall – 56 km/hr



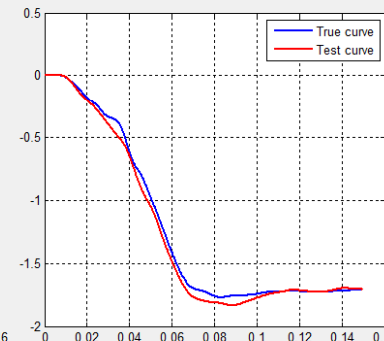
Comparison Metric values

Whole time interval [0,0.1499]

True and Test curves



True and Test curves (integrated)



MPC Metrics

	Value [%]	
Sprague-Geers Magnitude	0.7	Pass
Sprague-Geers Phase	9.3	Pass
Sprague-Geers	9.3	Pass

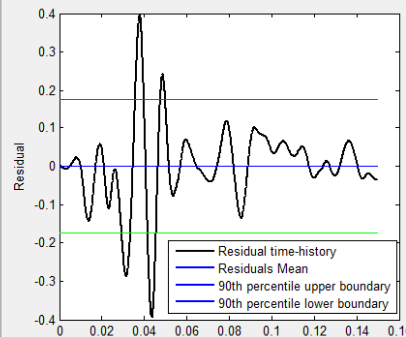
ANOVA Metrics

	Value [%]	
Average	0.1	Pass
Standard deviation	10.6	Pass

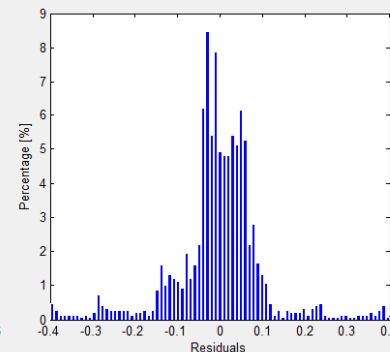
(Values normalized to peak of True curve)

Acceleration Residuals

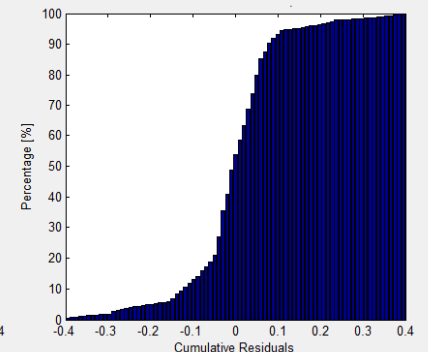
Residuals time history



Residuals histogram



Residuals cumulative distribution

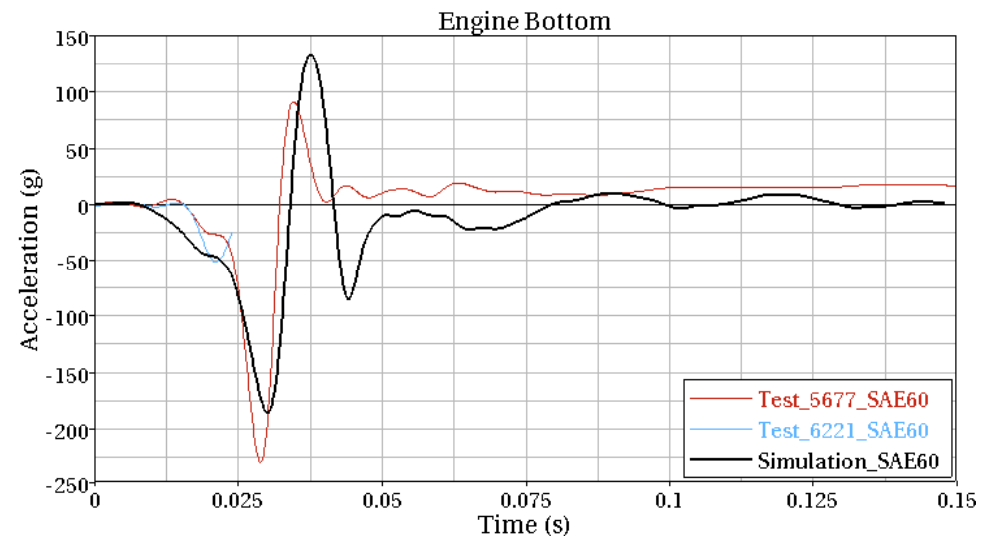
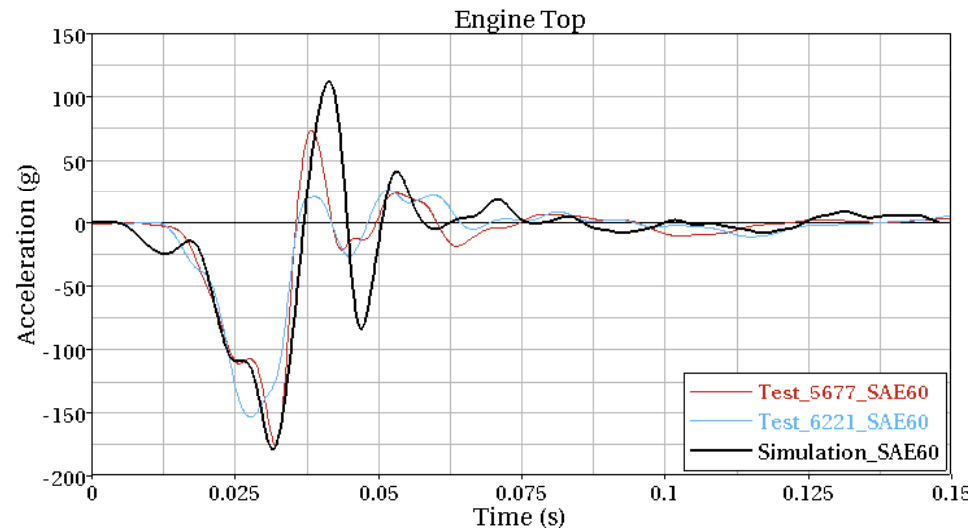


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(RSVVP) Comparisons



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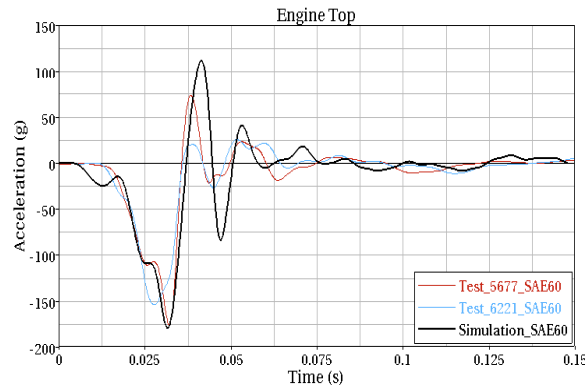
Yaris – Frontal Full Wall – 56 km/hr



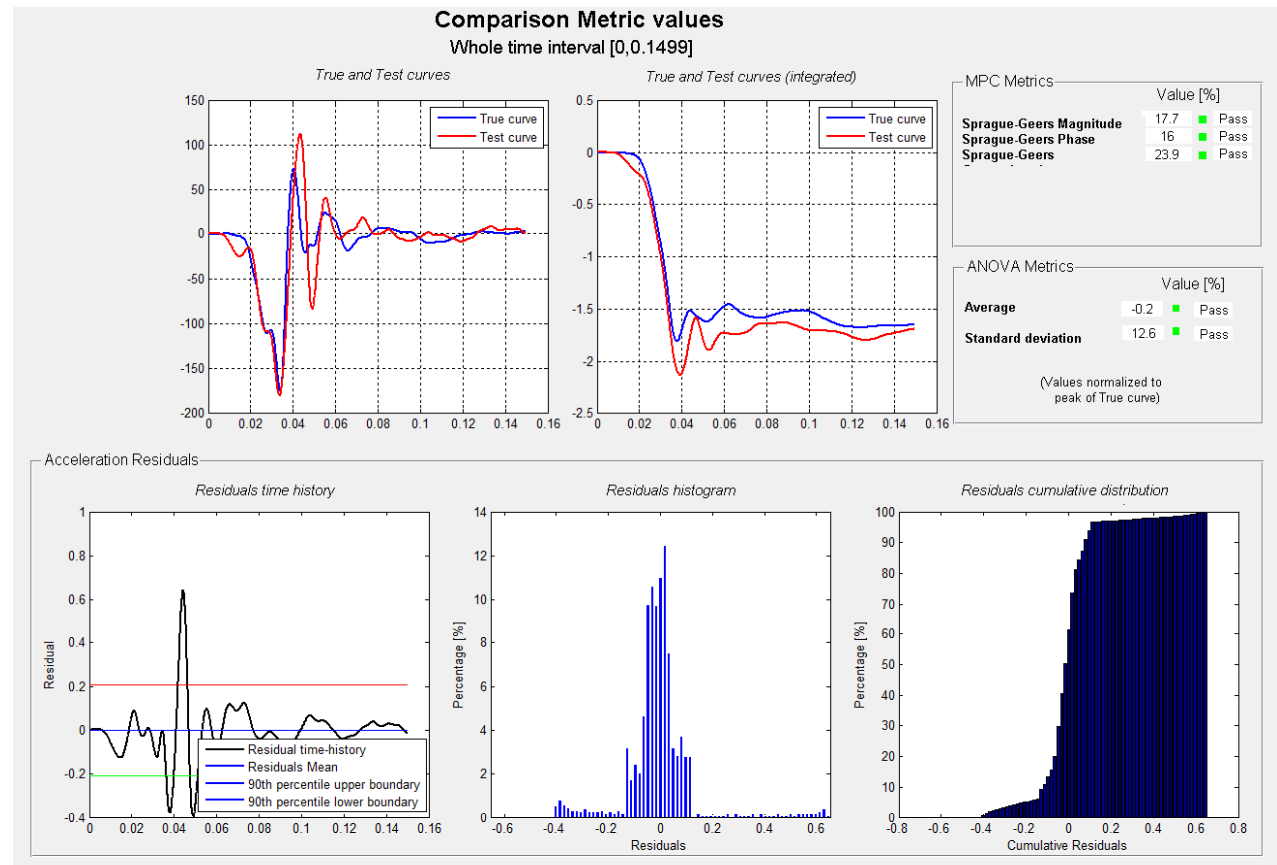


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Yaris – Frontal Full Wall – 56 km/hr



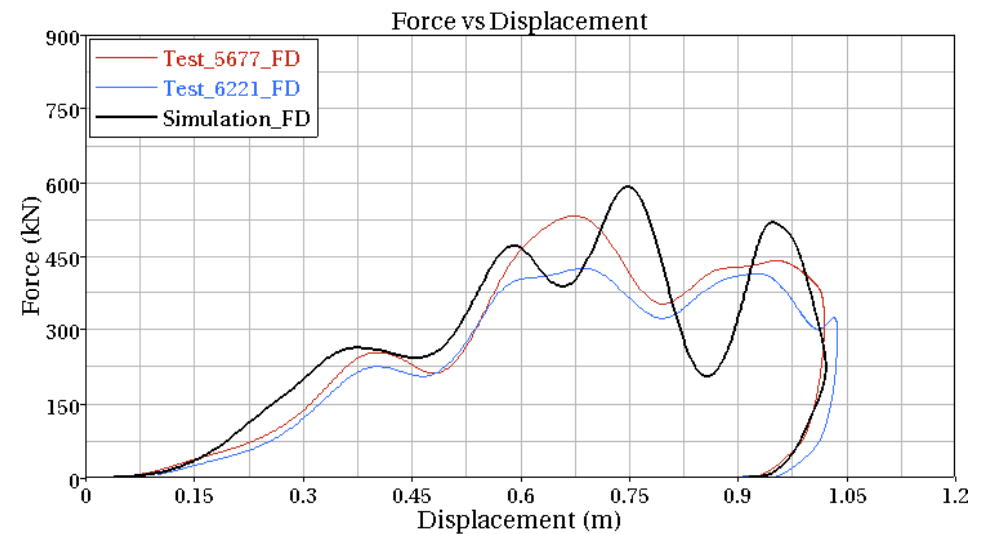
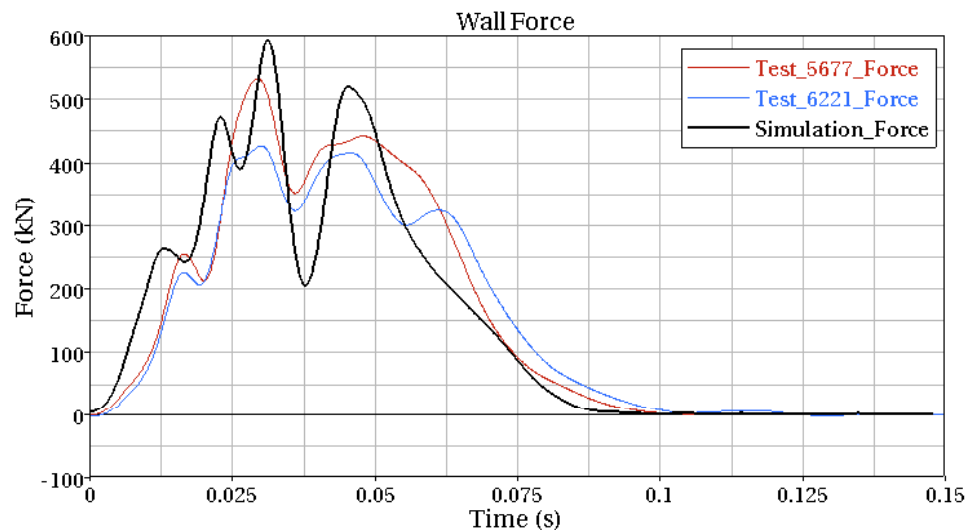
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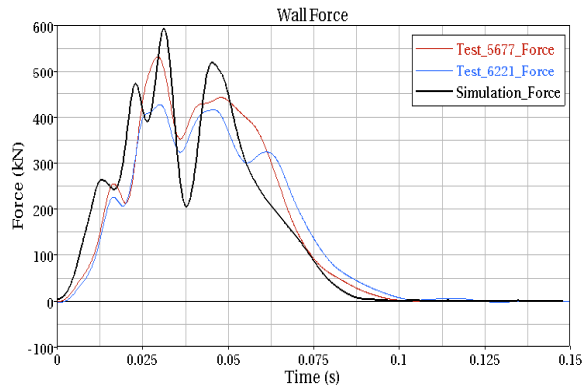
Yaris – Frontal Full Wall – 56 km/hr





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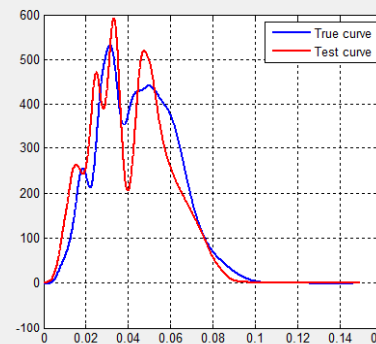
Yaris – Frontal Full Wall – 56 km/hr



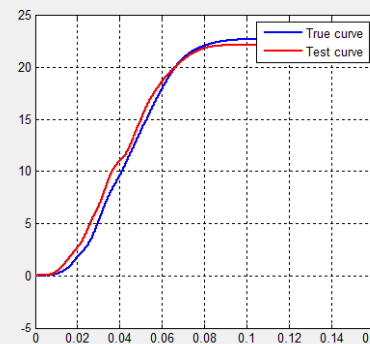
Comparison Metric values

Whole time interval [0,0.1499]

True and Test curves



True and Test curves (integrated)



MPC Metrics

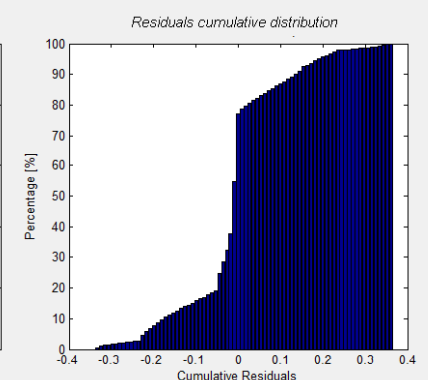
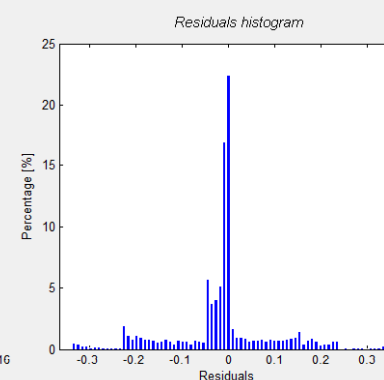
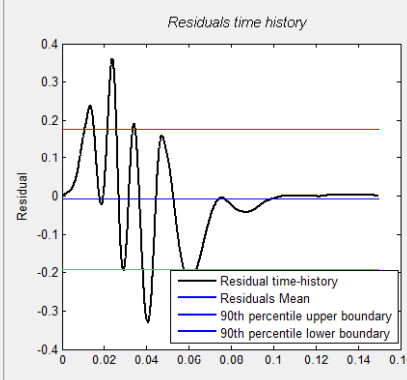
	Value [%]	
Sprague-Geers Magnitude	-1.2	Pass
Sprague-Geers Phase	8.2	Pass
Sprague-Geers	8.3	Pass

ANOVA Metrics

	Value [%]	
Average	-0.7	Pass
Standard deviation	11.2	Pass

(Values normalized to peak of True curve)

Acceleration Residuals

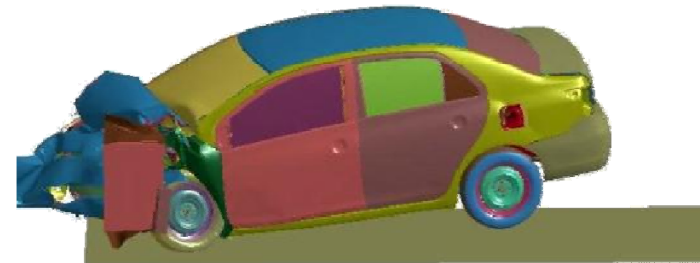
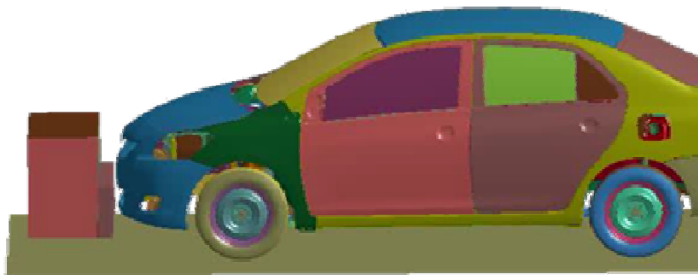


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(RSVVP) Comparisons



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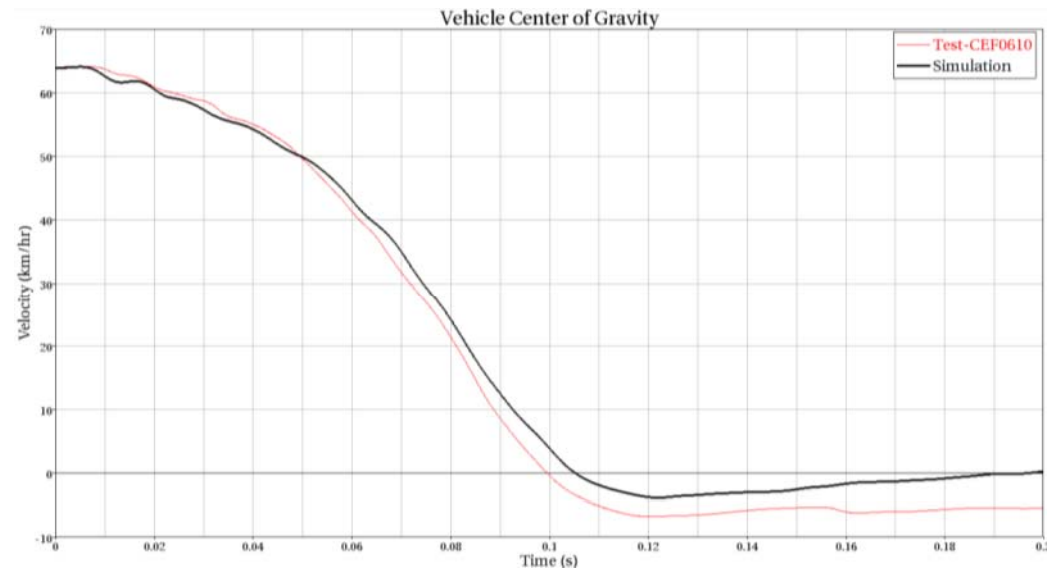
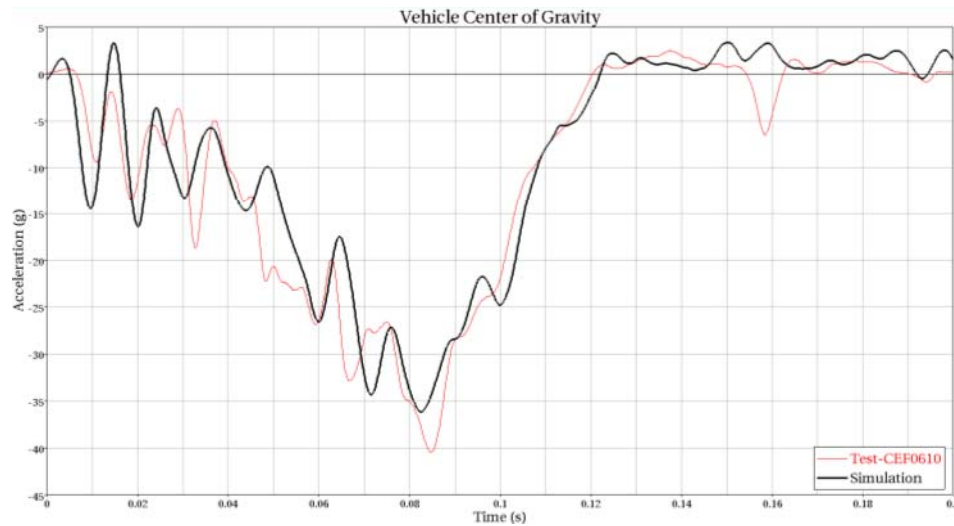
Yaris – Frontal Offset – 64 km/hr





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Yaris – Frontal Offset – 64 km/hr



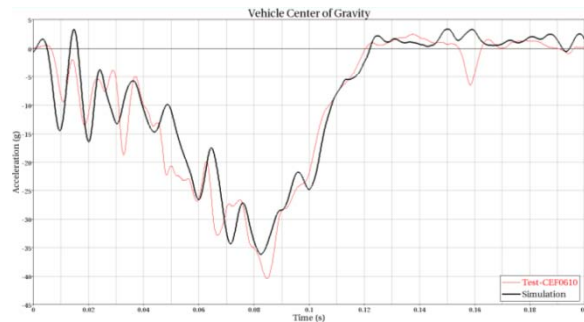
12/20/2011





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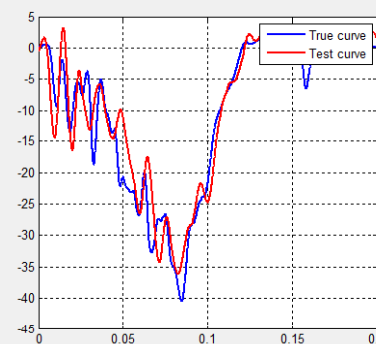
Yaris – Frontal Offset – 64 km/hr



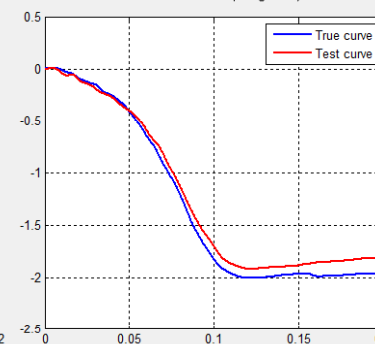
Comparison Metric values

Whole time interval [0,0.1999]

True and Test curves



True and Test curves (integrated)



MPC Metrics

	Value [%]	
Sprague-Geers Magnitude	-5.4	Pass
Sprague-Geers Phase	7.7	Pass
Sprague-Geers	9.4	Pass

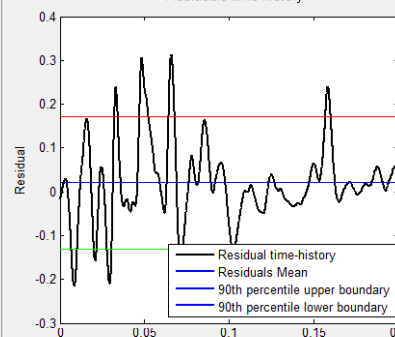
ANOVA Metrics

	Value [%]	
Average	2	Pass
Standard deviation	9.2	Pass

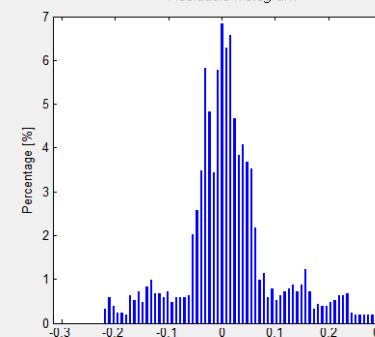
(Values normalized to peak of True curve)

Acceleration Residuals

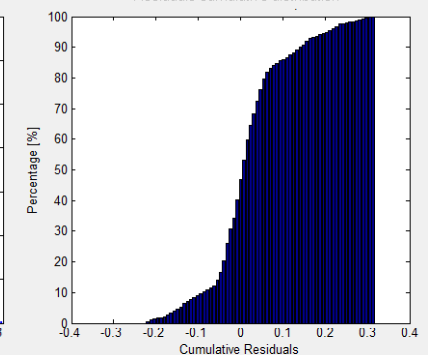
Residuals time history



Residuals histogram



Residuals cumulative distribution



Roadside Safety Verification
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(RSVVP) Comparisons

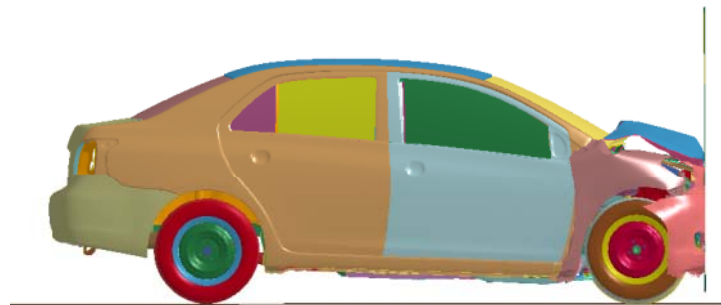


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Yaris – Frontal Full Wall – 40 km/hr



	FE Model	Test 6069
Weight (kg)	1211	1212
Engine Type	1.5L V4	1.5L V4
Tire size	P185/60R15	P185/60R15
Attitude (mm) (As delivered)	F – 668	F – 673
	R – 673	R – 672
Wheelbase (mm)	2538	2550
Body Style	4 Door Sedan	4 Door Sedan



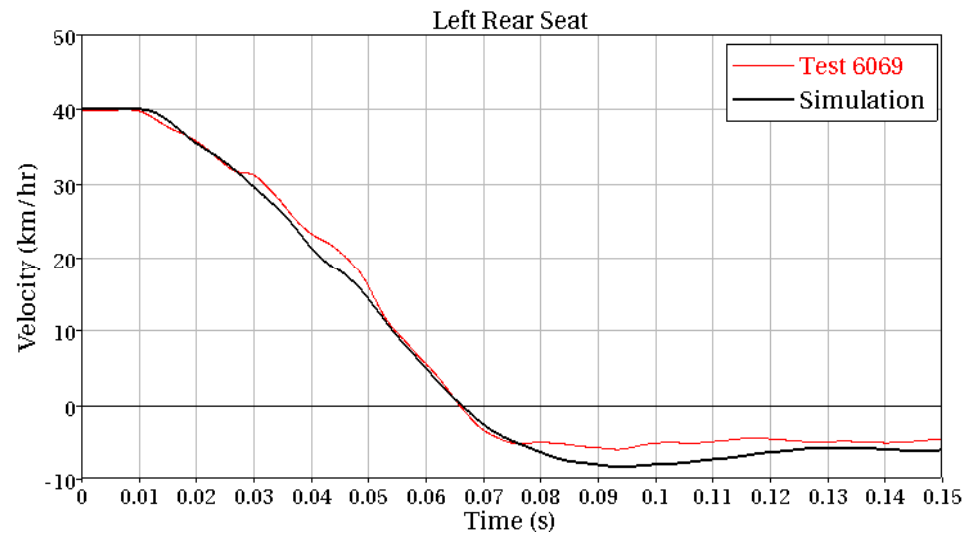
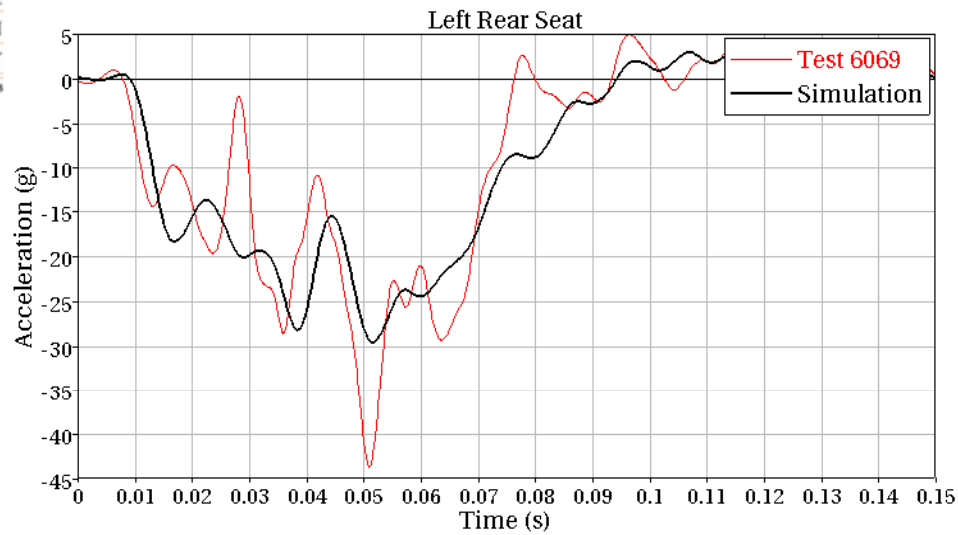
LS-DYNA :

- Version: MPP971sR4.2.1
- Revision: 53450
- Platform: Intel MPI 3.1 Xeon64
- OS Level: Linux Red Hat 4 upd 4
- Precision: Single precision (I4R4)
- Total elapsed time: 2 hr 15 min (150 ms)
- Number of processors: 24



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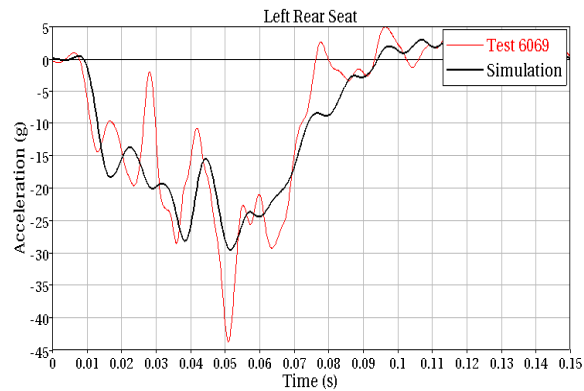
Yaris – Frontal Full Wall – 40 km/hr



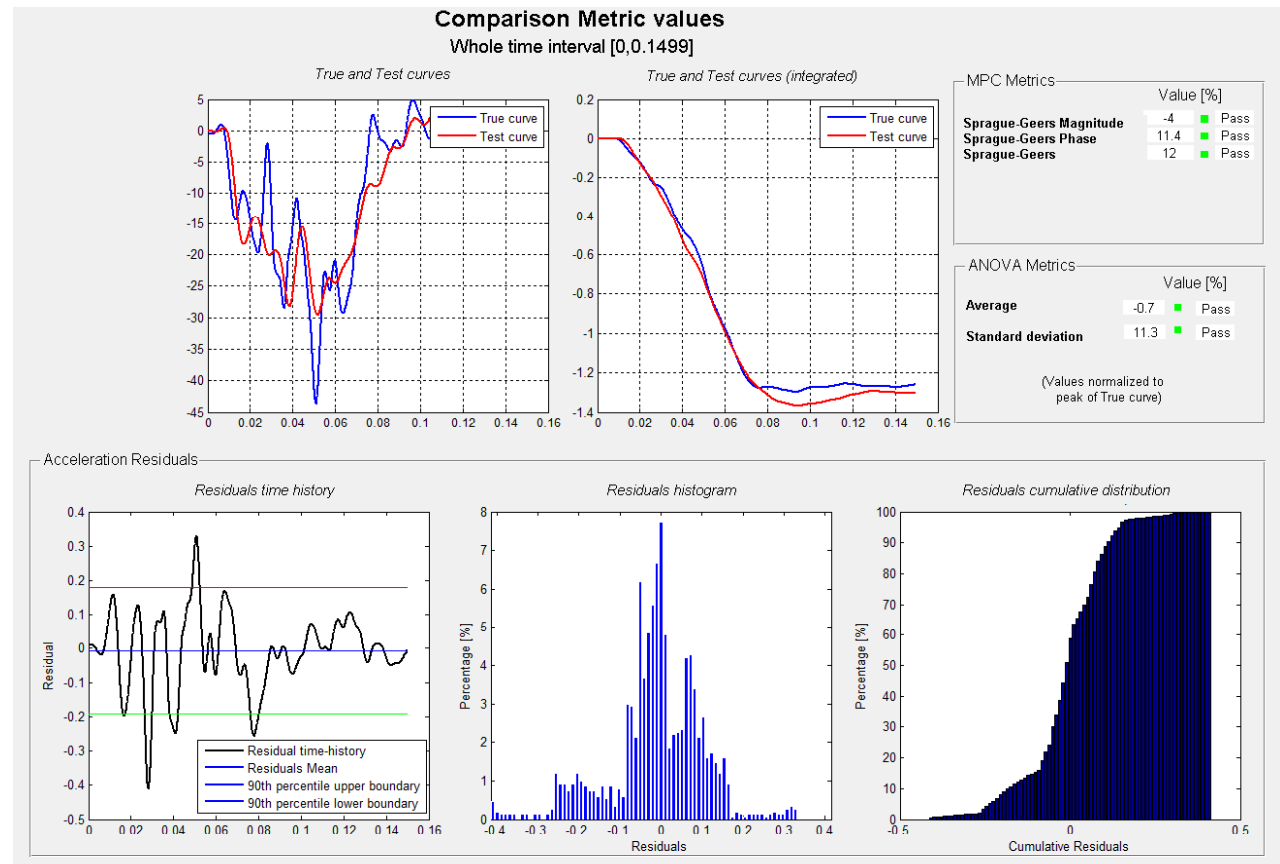


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Yaris – Frontal Full Wall – 40 km/hr



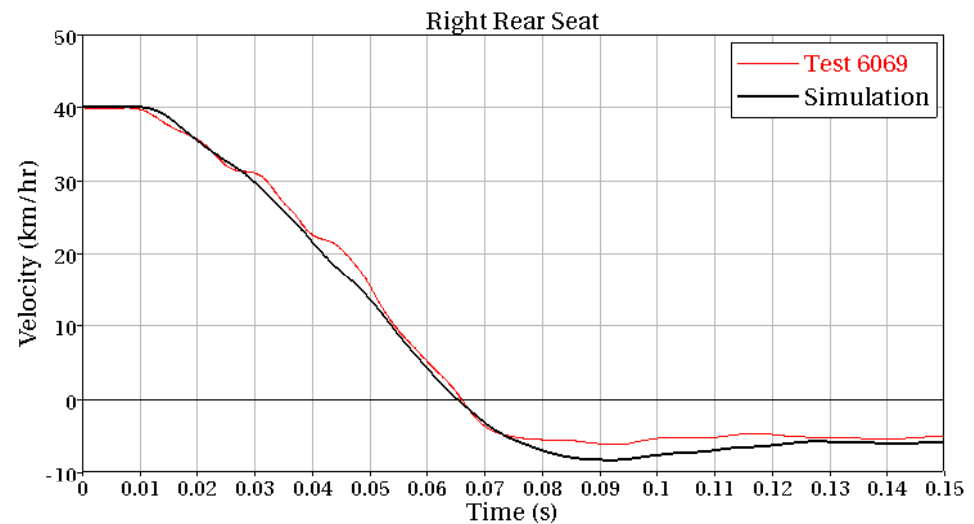
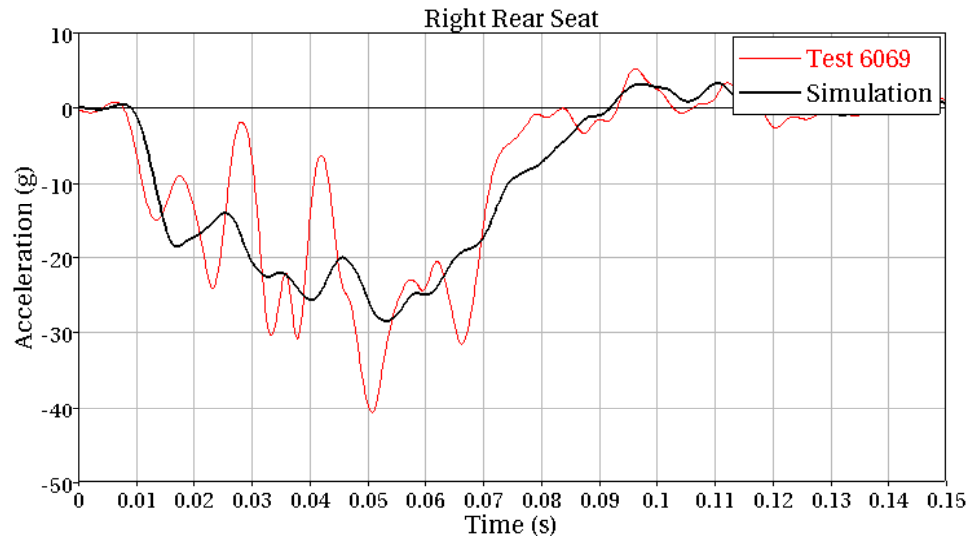
Roadside Safety Verification
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(RSVVP) Comparisons





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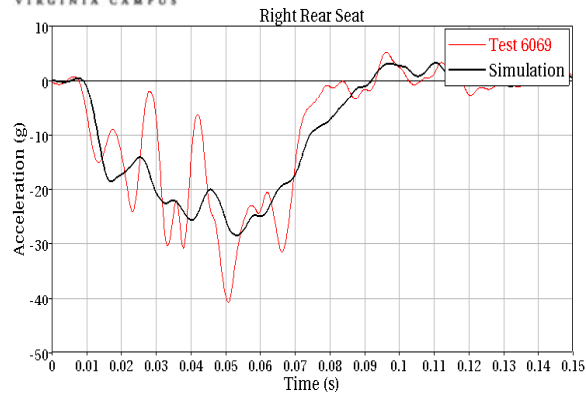
Yaris – Frontal Full Wall – 40 km/hr





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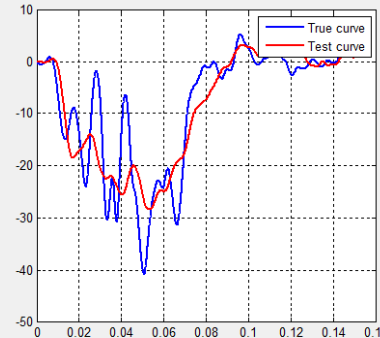
Yaris – Frontal Full Wall – 40 km/hr



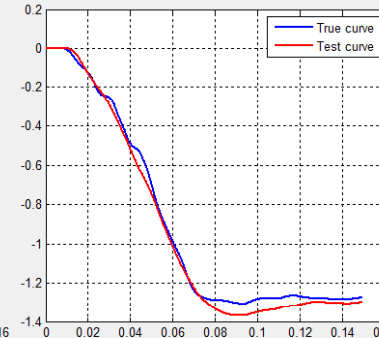
Comparison Metric values

Whole time interval [0,0.1499]

True and Test curves



True and Test curves (integrated)



MPC Metrics

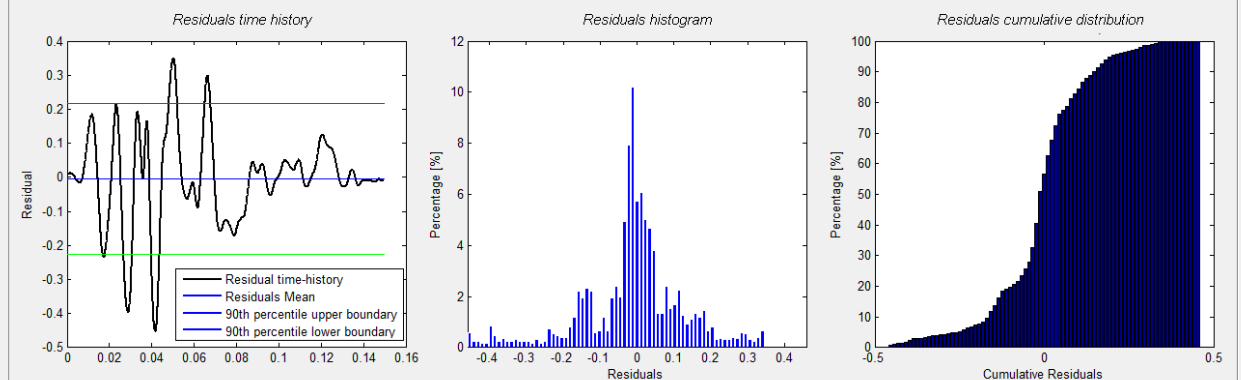
	Value [%]	
Sprague-Geers Magnitude	-4.5	Pass
Sprague-Geers Phase	12.4	Pass
Sprague-Geers	13.2	Pass

ANOVA Metrics

	Value [%]	
Average	-0.4	Pass
Standard deviation	13.5	Pass

(Values normalized to peak of True curve)

Acceleration Residuals

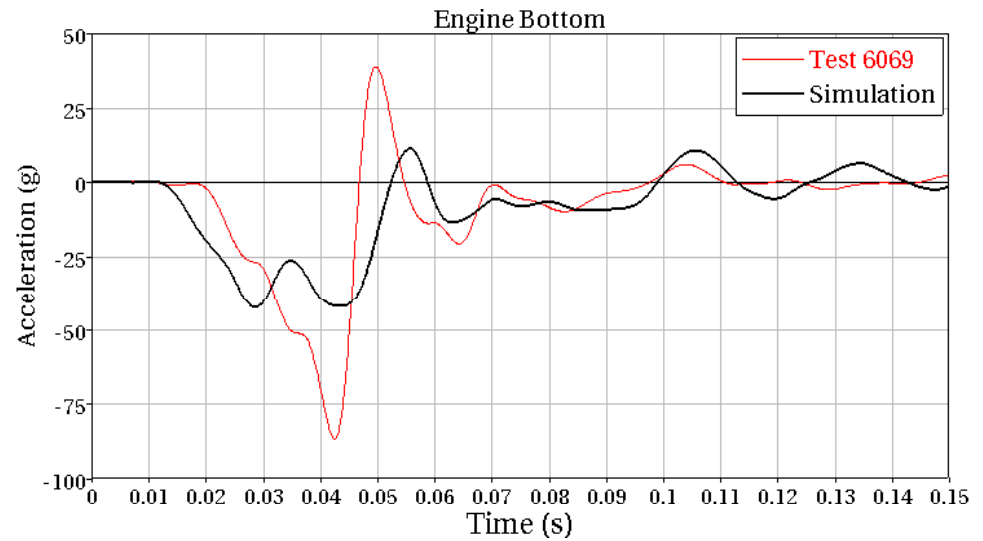
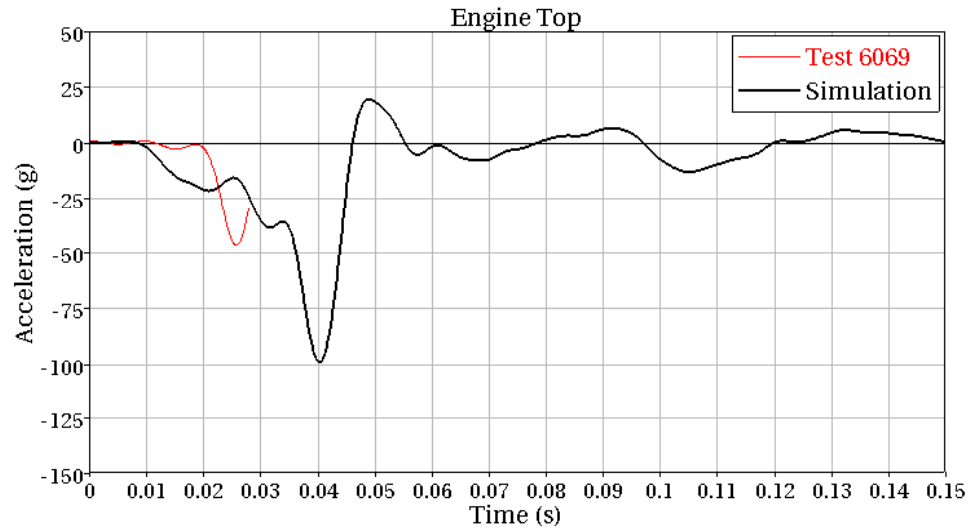


Roadside Safety Verification
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(RSVVP) Comparisons



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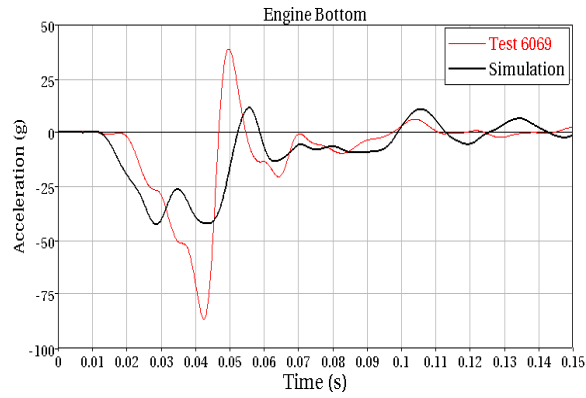
Yaris – Frontal Full Wall – 40 km/hr





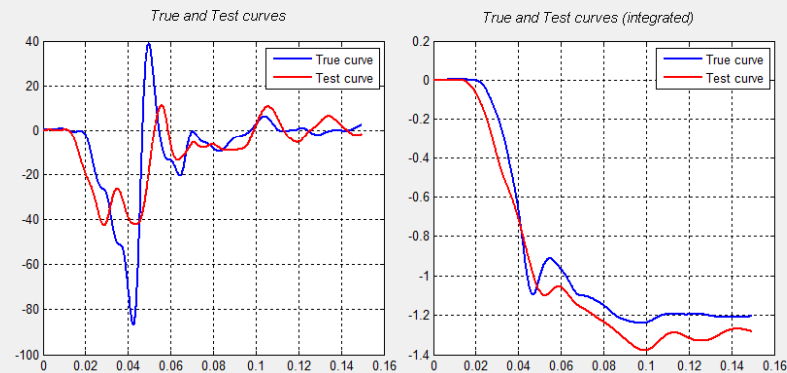
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Yaris – Frontal Full Wall – 40 km/hr



Comparison Metric values

Whole time interval [0,0.1499]



MPC Metrics

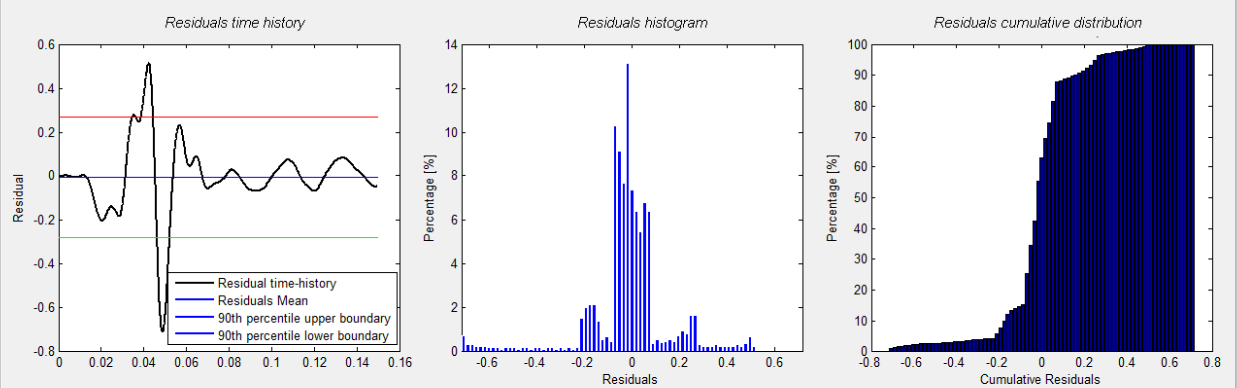
	Value [%]	
Sprague-Geers Magnitude	-23	Pass
Sprague-Geers Phase	23.5	Pass
Sprague-Geers	32.9	Pass

ANOVA Metrics

	Value [%]	
Average	-0.6	Pass
Standard deviation	16.8	Pass

(Values normalized to peak of True curve)

Acceleration Residuals



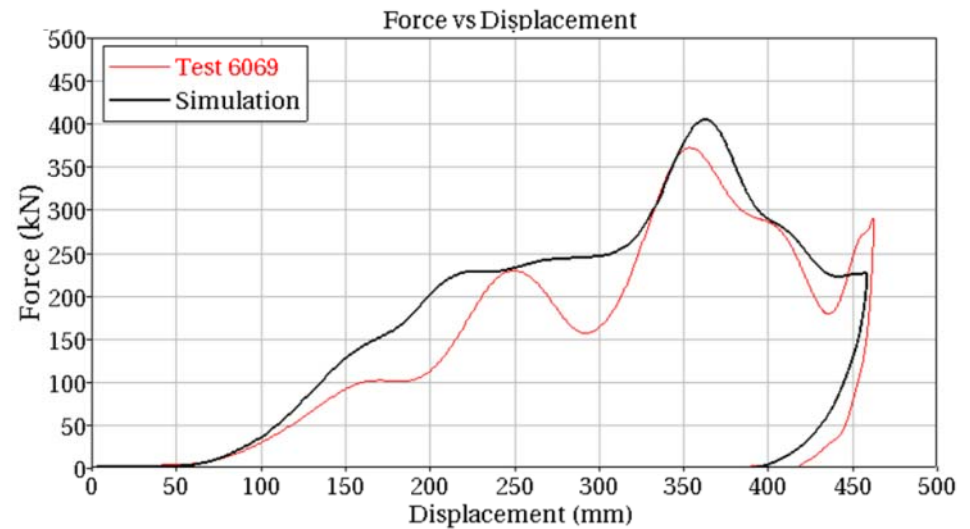
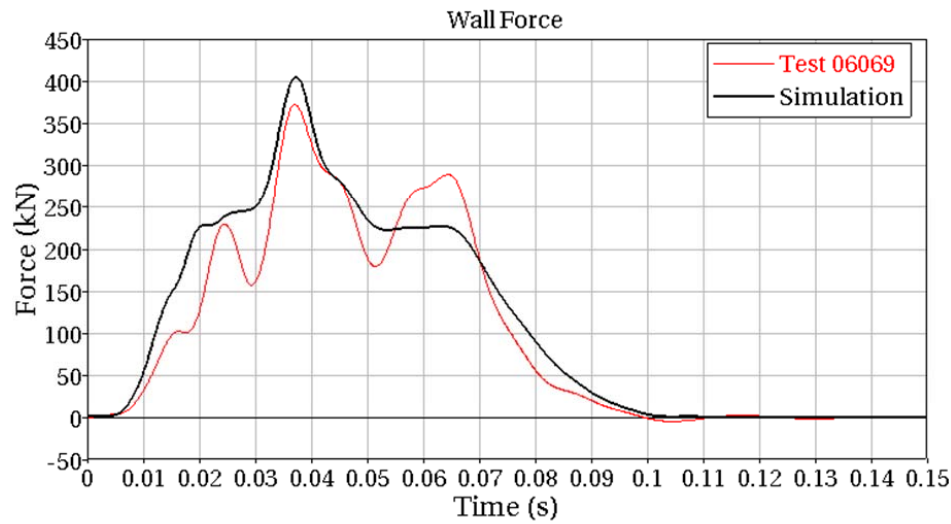
Roadside Safety Verification
and Validation Program
(RSVVP) Comparisons





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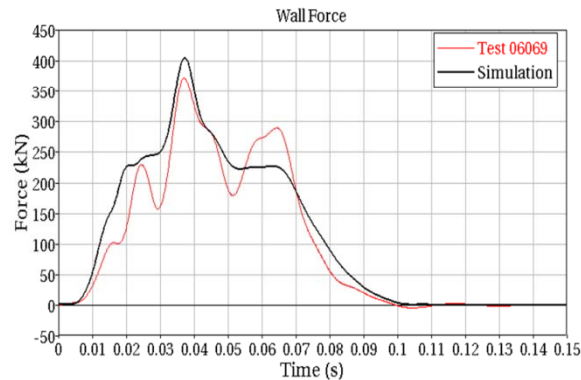
Yaris – Frontal Full Wall – 40 km/hr





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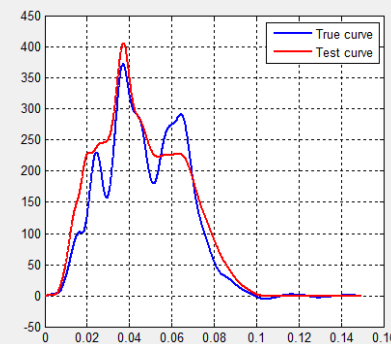
Yaris – Frontal Full Wall – 40 km/hr



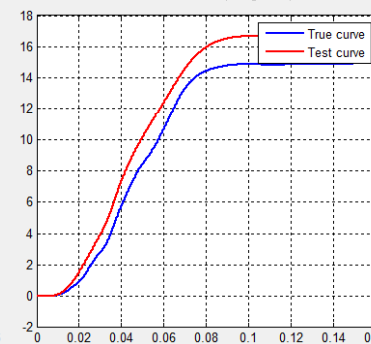
Comparison Metric values

Whole time interval [0,0.1499]

True and Test curves



True and Test curves (integrated)



MPC Metrics

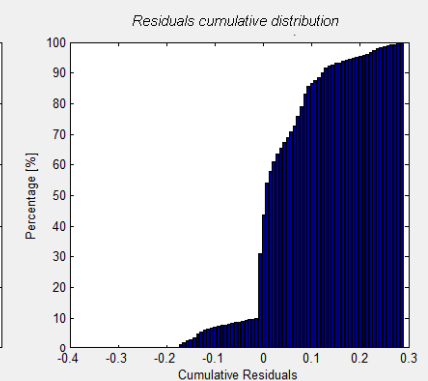
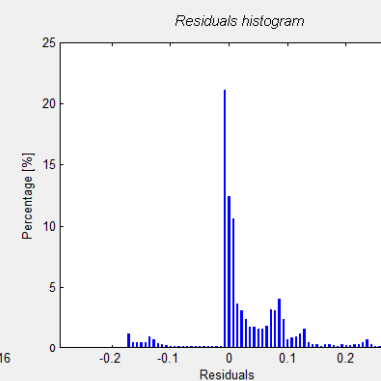
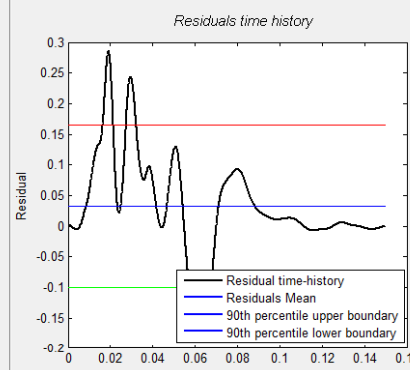
	Value [%]	
Sprague-Geers Magnitude	7.5	Pass
Sprague-Geers Phase	6.1	Pass
Sprague-Geers	9.7	Pass

ANOVA Metrics

	Value [%]	
Average	3.3	Pass
Standard deviation	8.1	Pass

(Values normalized to peak of True curve)

Acceleration Residuals



Roadside Safety Verification
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(RSVVP) Comparisons



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Summary

- **Model verified against 56 km/hr full frontal tests (NHTSA tests 5677 and 6221)**
- **Model verified against 64 km/hr frontal offset test (IIHS test CEF0610)**
- **Model verified against 40 km/hr full frontal test (NHTSA test 6069)**
- **Detailed suspension systems included in the model, verification using full-scale tests is in progress**
- **Future updates will include additional verifications, using NHTSA side, IIHS side, roof strength, and rigid pole tests**