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Ground breaking Simulation Solutions

physics on screen

AUTOMATION OF ANSA AND META TO EVALUATE OCCUPANT PERFORMANCE AND SEAT STRUCTURE FOR ROBUSTNESS

Hemant Shettar, Yatin Kumbhar, Santosh Patil
BETA CAE SYSTEMS USA, INC

Presented by : Santosh Patil, PhD
BETA CAE Systems USA

Introduction

- ❑ Automotive seat structure is designed to satisfy various internal and regulatory requirements for comfort, performance and safety.
- ❑ Manufacturing and subsequent testing of the of the seat structure is subjected to various uncertainties.
- ❑ It is critical to design the seats so that the variation in the performance is acceptable over the range of these uncertainties.

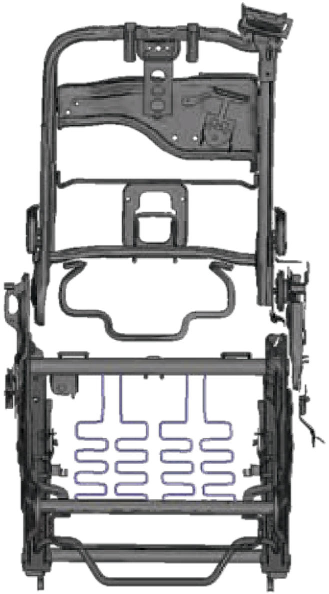
Types of Uncertainties and Challenges

- Uncertainties can be of
  - Material properties
  - Part design and dimensions
  - Welding and Assembly
  - Positioning of test devices and occupants during testing
- Incorporation of Welding and positioning related uncertainties in CAE analysis are more challenging since various automation tools of ANSA and META need to be integrated to achieve complete automation of the process.

Automated Process to incorporate uncertainty into seat design

- In this work two separate load cases of the same seat were evaluated
- Occupant performance by considering the deviation in H point and back angle caused while dummy positioning during testing
- Structural integrity of the seat by considering the manufacturing variations in weld line positions.

Model Discription

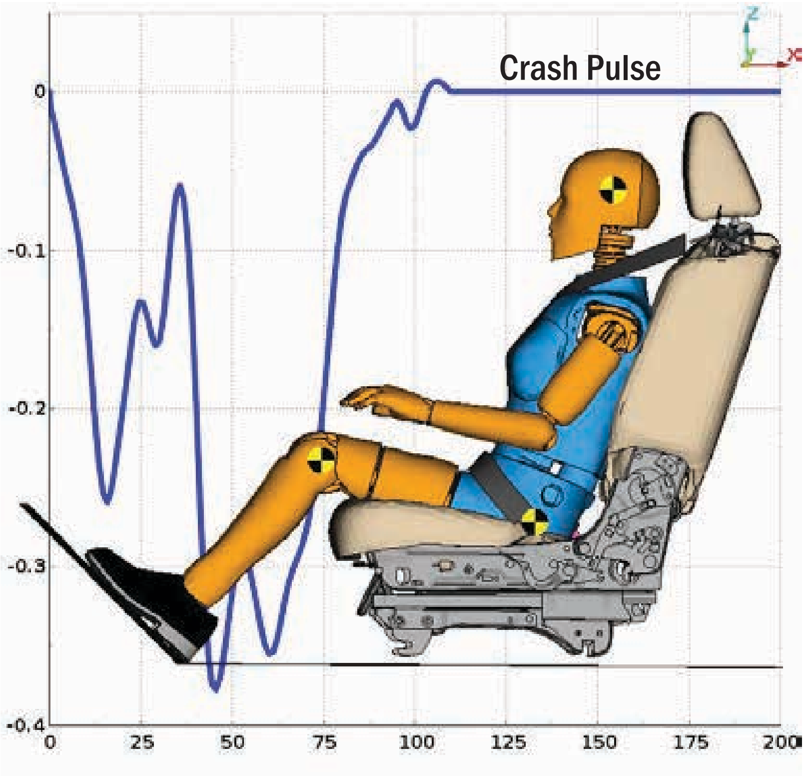


Second-row Seat
Structure

Second-row Seat
with cushions

- An open-source model of a 2019 Honda Odyssey second-row seat from NHTSA Crash Simulation Vehicle database was used for this study
- The available detailed FE model was developed for LS-DYNA simulation code .
- All the weld connections were recreated and realized using ANSA connection manager

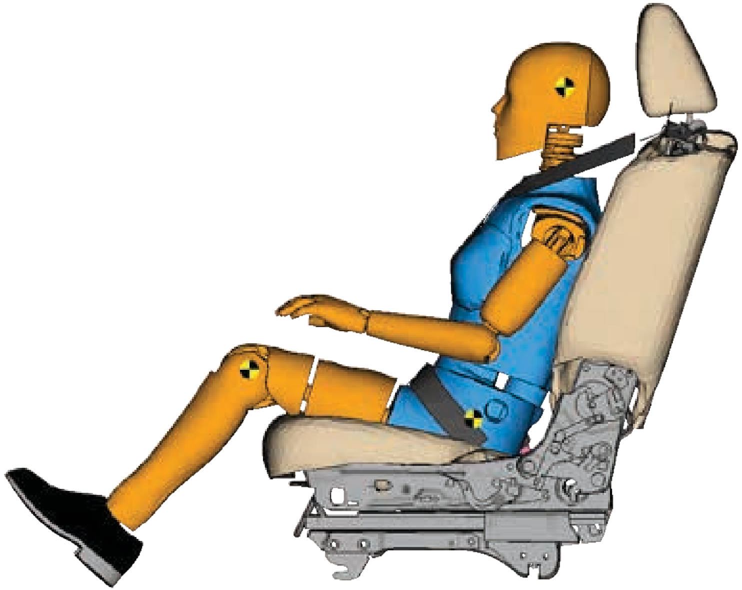
Loadcase 1 – SLED TEST

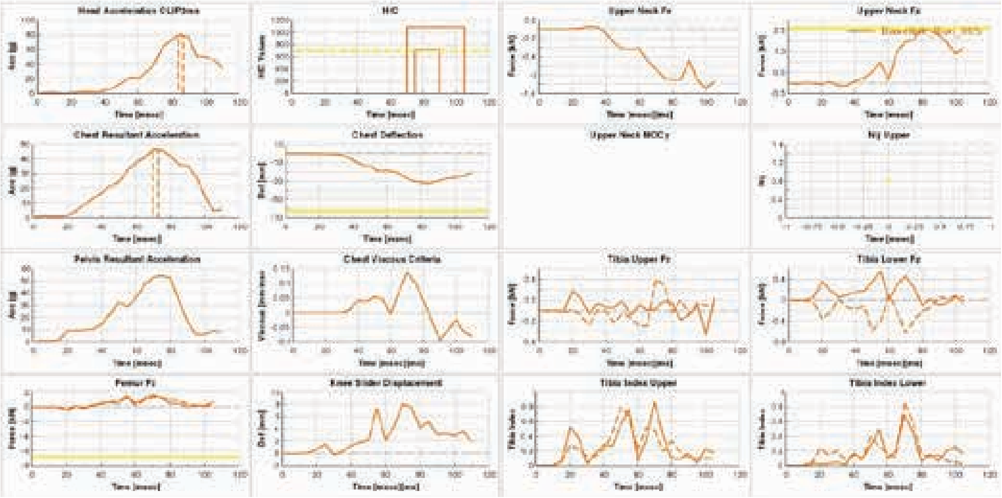


Model Setup

- Sled model is built using the second-row seat and a Hybrid III 5th Dummy.
- A generalized frontal pulse is applied to the Sled.
- Dummy Positioning, Seat Depenetration and Seat Belt routing were accomplished using ANSA safety tools.

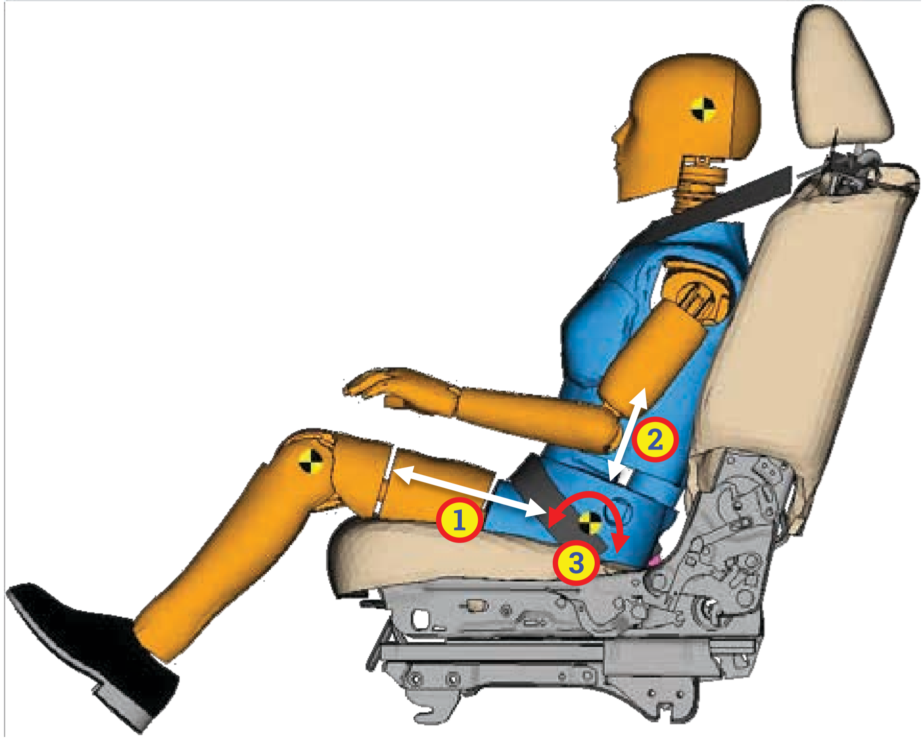
SLED TEST - Baseline Results





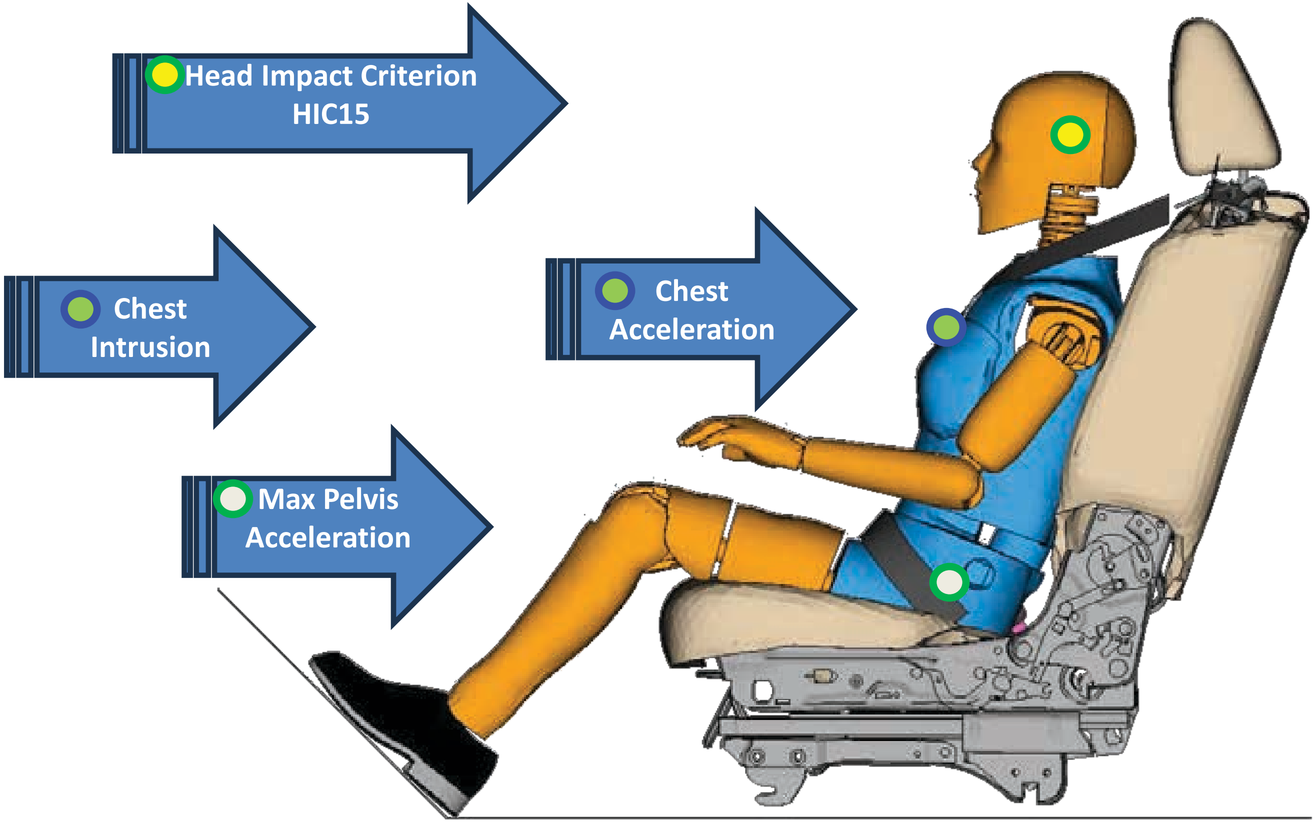
- The extraction of the Occupant injury numbers was done using META OIC tool bar
- The required occupant injury numbers were selected as responses using the OIC tool bar

SLED TEST - Variations

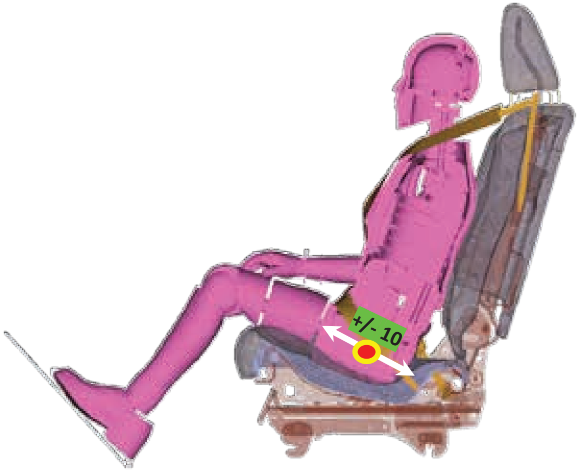


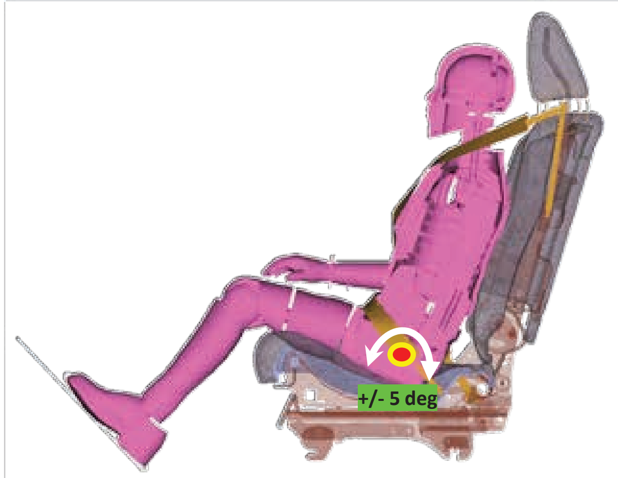
1. Longitudinal H point variation
2. Vertical H point variation
3. Dummy back angle variation

SLED TEST – Injury Number Responses



SLED TEST - ANSA DV Setup Process

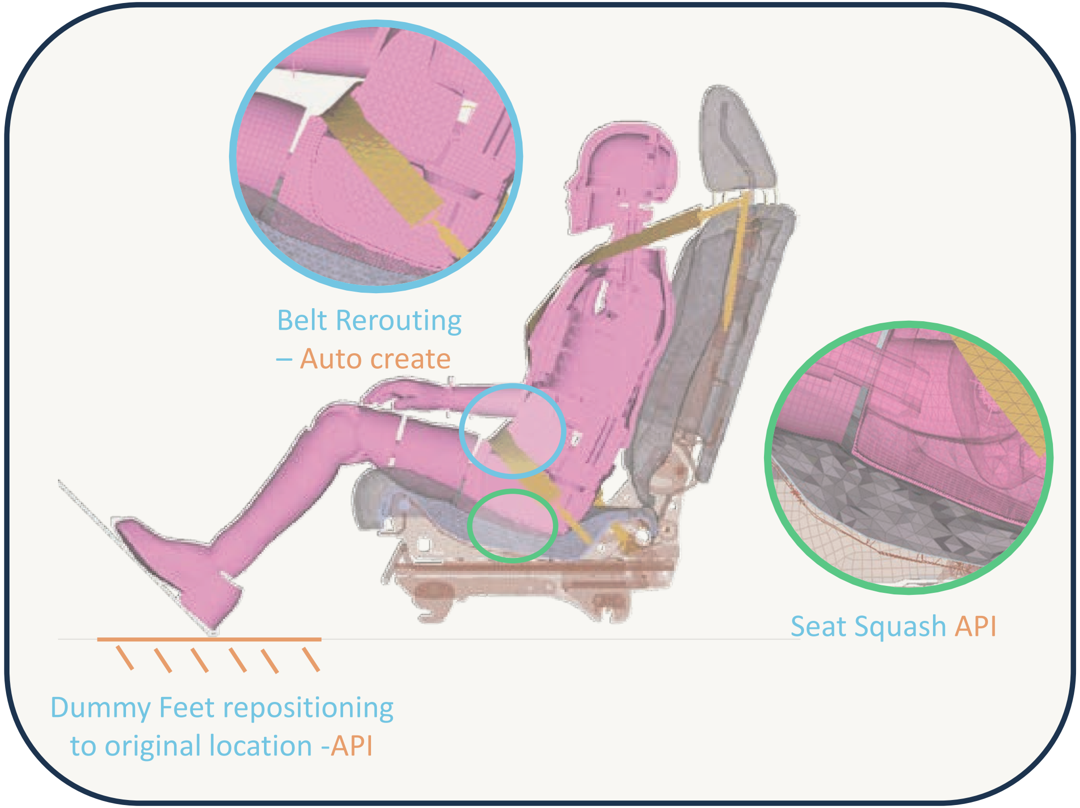




- The Variation of the dummy H Point longitudinally as well as vertically and the dummy back angle variation was achieved by using ANSA Python API.

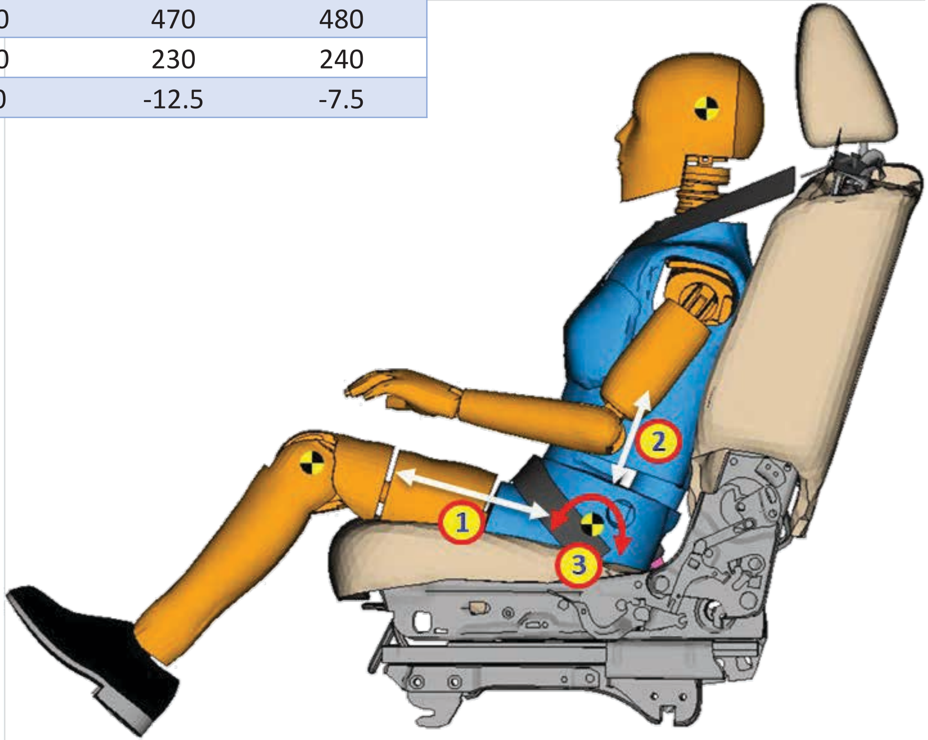
SLED TEST - ANSA DV Setup Process

- The belt rerouting was accomplished by selecting Auto create function in ANSA seat belt tool
- The foam compression was accomplished by invoking the ANSA Seat Depentration tool using API functions.
- The dummy feet repositioning to original location was accomplished using API functions to articulate Kinematic configuration.
- Complete process including the job submission to result extraction was automated using ANSA Optimization tool



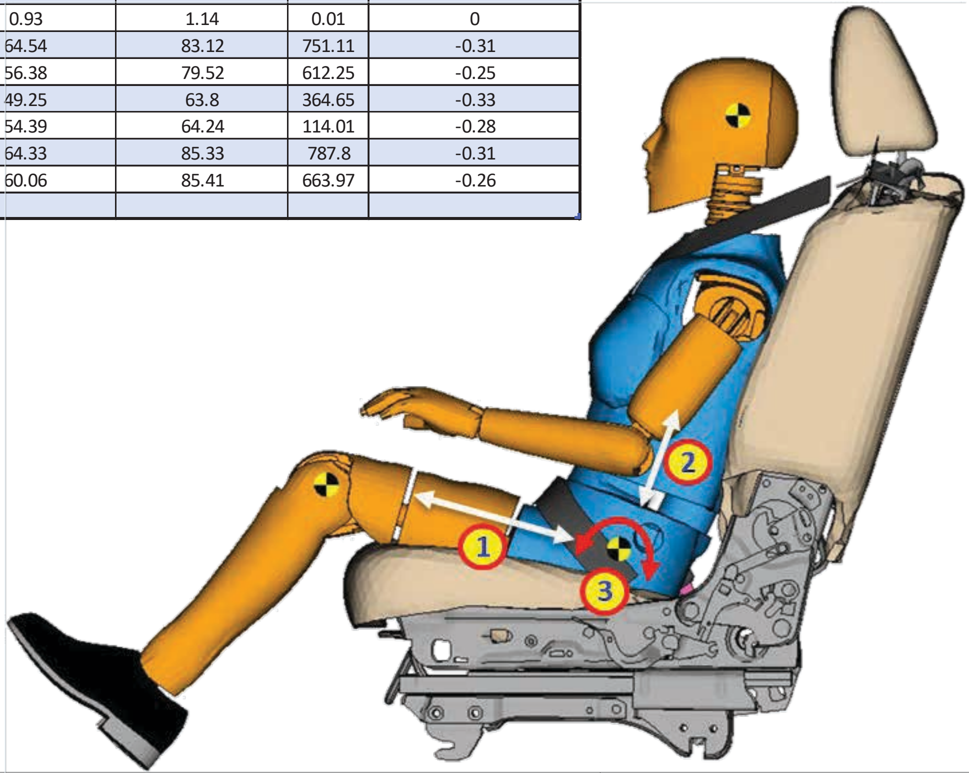
SLED TEST – Design Variables Bounds

No.	Name	Type	Range	Current Value	Min Value	Max Value
1	X	REAL	BOUNDS	480	470	480
2	Z	REAL	BOUNDS	230	230	240
3	INCR_ANGLE	REAL	BOUNDS	-10	-12.5	-7.5



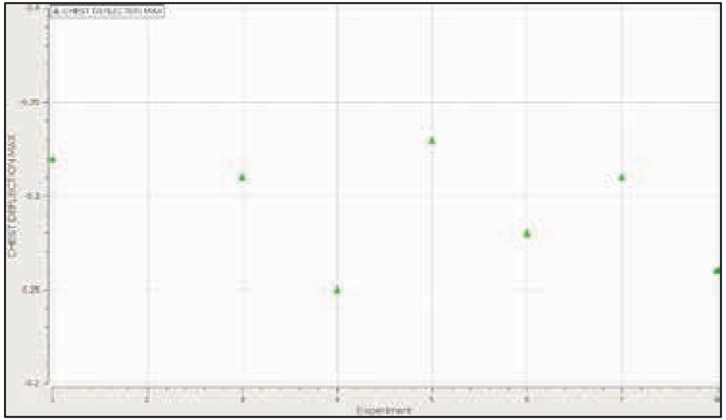
SLED TEST - Design Variables and Response Table

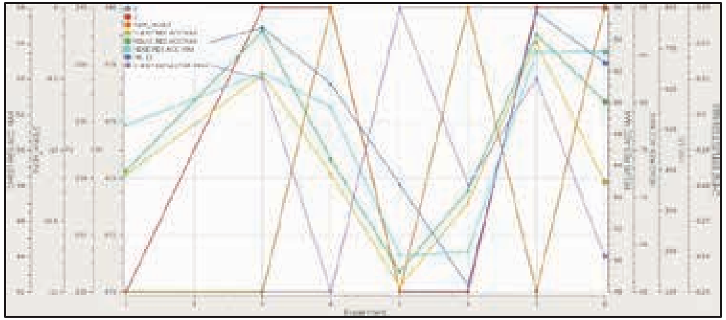
#Experimen		Z	INCR_ANGL	CHEST RES ACC MAX	PELVIS RES ACC MAX	HEAD RES ACC MAX	HIC 1	CHEST DEFLECTION MAX
1	470	230	-11	48.59	55.65	77.57	659.03	-0.32
2	470	230	-9	1.04	0.93	1.14	0.01	0
3	470	240	-11	54.23	64.54	83.12	751.11	-0.31
4	470	240	-9	48.65	56.38	79.52	612.25	-0.25
5	480	230	-11	42.26	49.25	63.8	364.65	-0.33
6	480	230	-9	47.03	54.39	64.24	114.01	-0.28
7	480	240	-11	56.07	64.33	85.33	787.8	-0.31
8	480	240	-9	48.2	60.06	85.41	663.97	-0.26



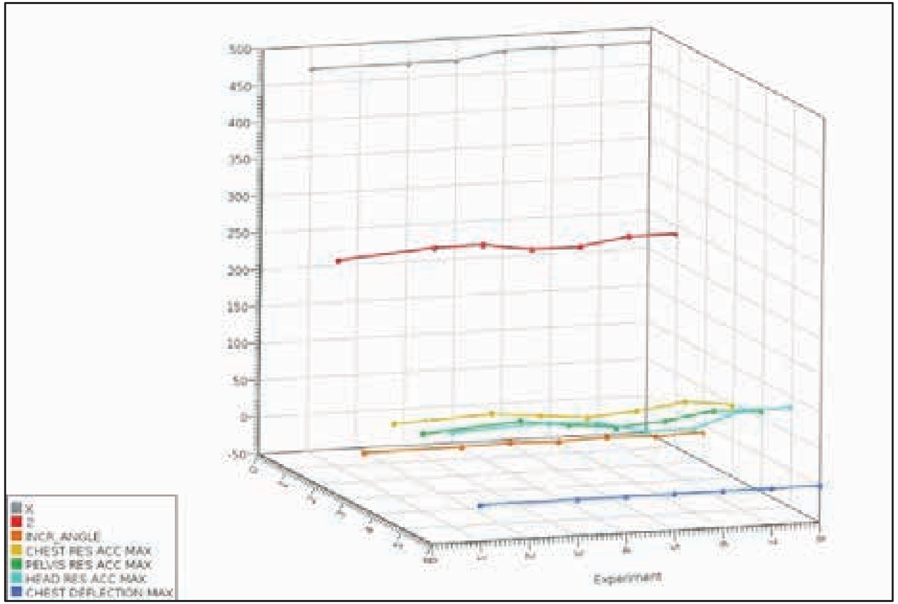
SLED TEST – DOE Results

Point Chart – Response Vs Exp





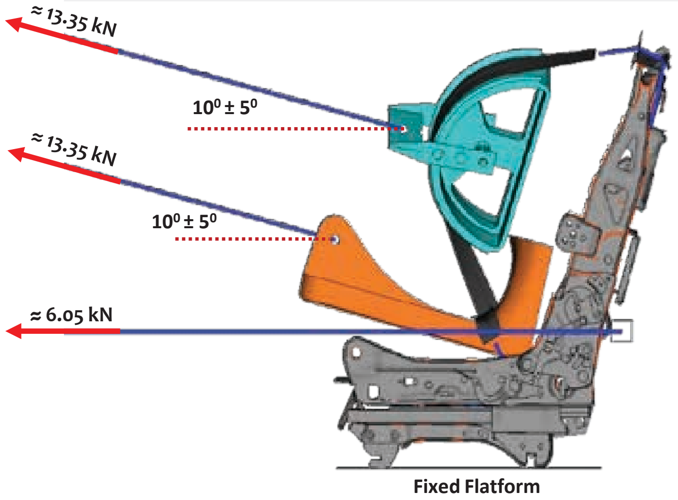
Line Chart – Multiple Responses Vs Exp



3D line chart– Multiple Responses Vs Exp

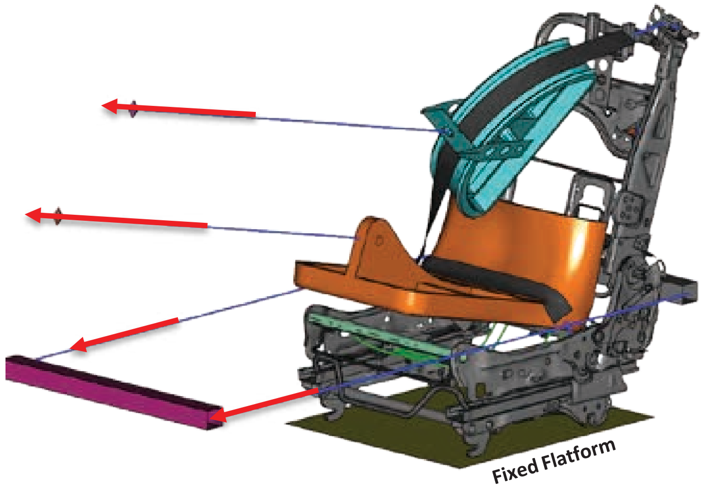
Loadcase 02 -SEAT BELT ANCHORAGE TEST

Load Case Setup



- Load case setup is similar to FMVSS207/210 test load case.
- Test load applied on the torso block, lap block, and CG bar in the forward direction with respective angles as shown

Baseline Simulation

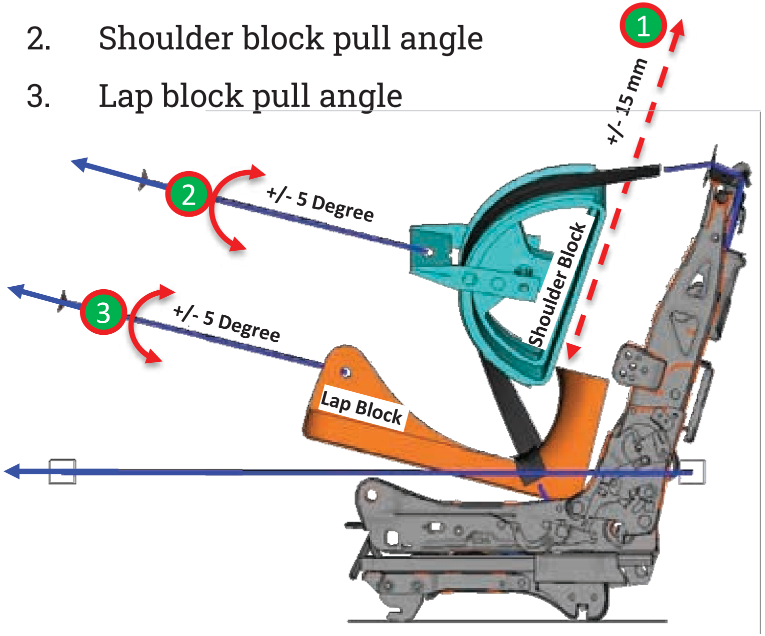


- **Design Requirement** : All components of the system namely seats & belt anchorage must resist the test loads without any failure

SEAT BELT ANCHORAGE TEST – Design Variables

The test set up variation parameters considered are

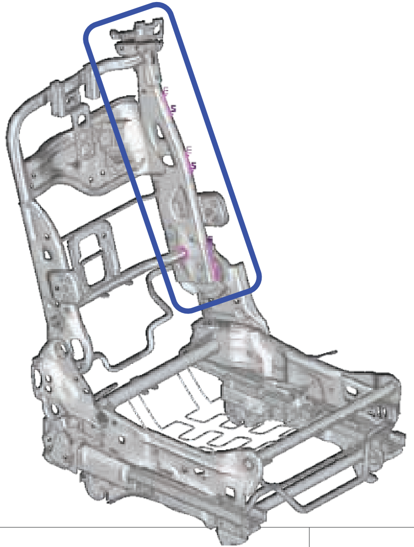
1. Shoulder block position
2. Shoulder block pull angle
3. Lap block pull angle

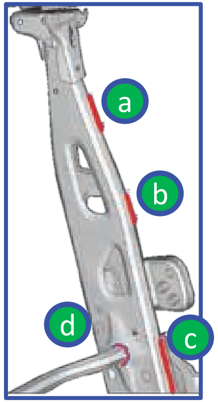


The manufacturing variation parameters considered for are

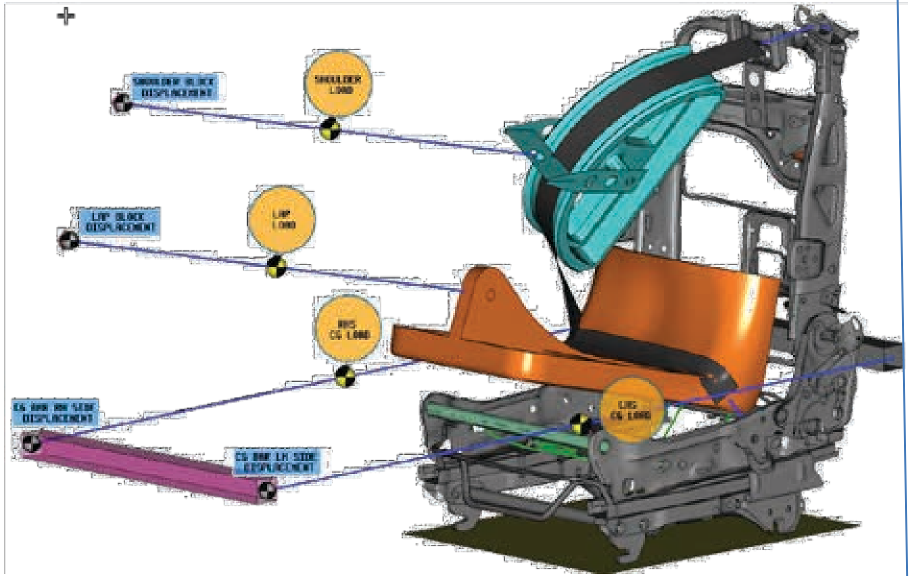
a) Weld lines positions and length as shown below

b) Four laser welds a, b ,c & d as shown with different shapes are considered here this study





SEAT BELT ANCHORAGE TEST - Responses



Monitored Responses :Forces & Displacement

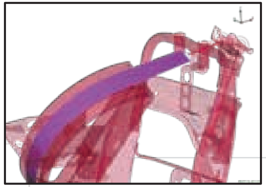
Force

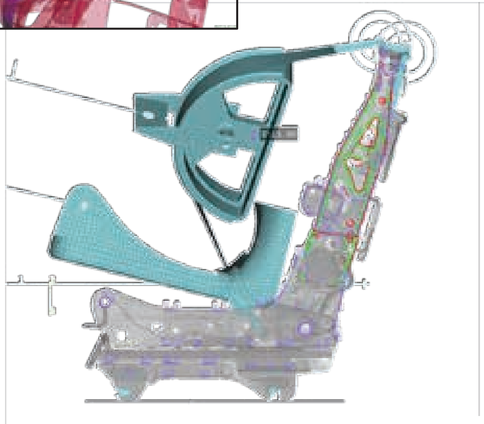
1. Shoulder load
2. Lap load
3. Right side CG load
4. Left side CG load

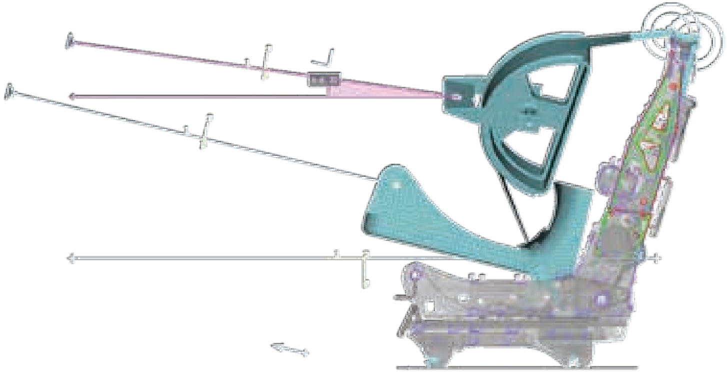
Displacement measured @

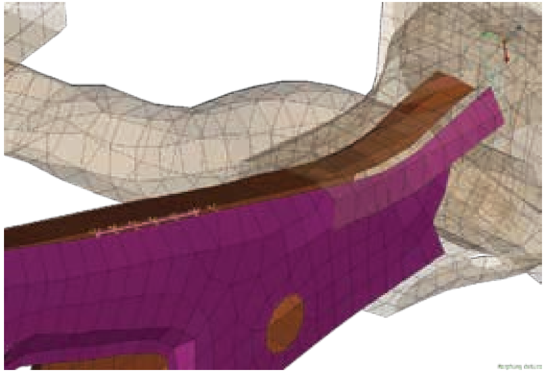
1. Shoulder
2. Lap
3. Right side CG Bar
4. Left side CG Bar

SEAT BELT ANCHORAGE TEST – Design Variables in ANSA









Shoulder block Variations

ANSA kinetic configuration tool was used to manipulate the shoulder block to required position

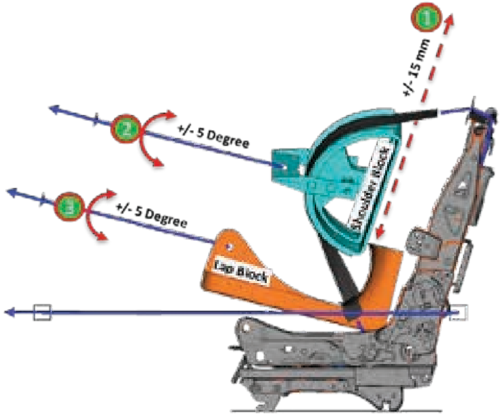
Shoulder block & Lap block pull angle Variations

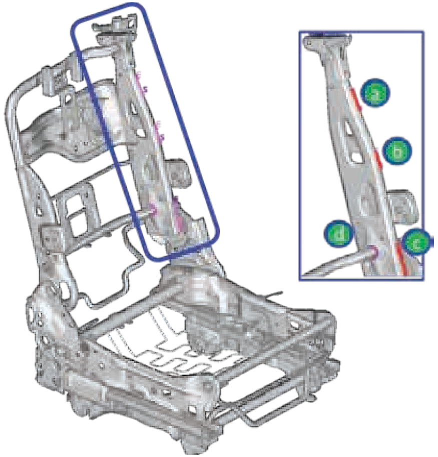
using 1D morph boxes pull cables were morphed to change the angle of pull as shown.

Laser weld Variations

- Required weld locations variations were morphed using DFM tool.
- Variations in the weld length was accomplished using weld length as A-parameter available in Ansa weld connection options

SEAT BELT ANCHORAGE TEST – Setup of Design Variables

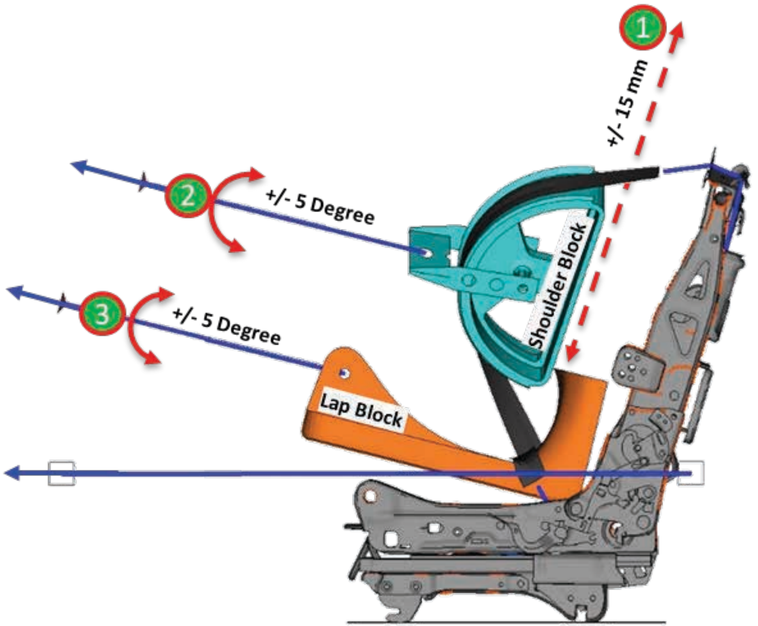




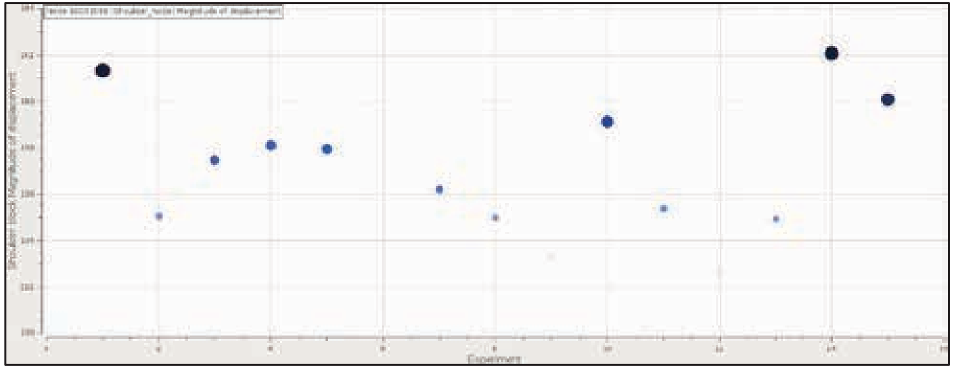
ID	Name	TYPE	RANGE	Nominal Value	Min Value	Max Value
1	Shoulder block position	REAL	BOUNDS	0	-15	15
2	Shoulder block pull angle	REAL	BOUNDS	0	-5	5
3	Lap block pull angle	REAL	BOUNDS	0	-5	5
4	Laser_weld_2_location	REAL	BOUNDS	0	-7	23
5	Laser_weld_3_location	REAL	BOUNDS	0	-14	57
6	Laser_weld_1_length	REAL	BOUNDS	0	-20	0
7	Laser_weld_4_length	REAL	BOUNDS	10	10	30

SEAT BELT ANCHORAGE TEST – Test Variations DOE

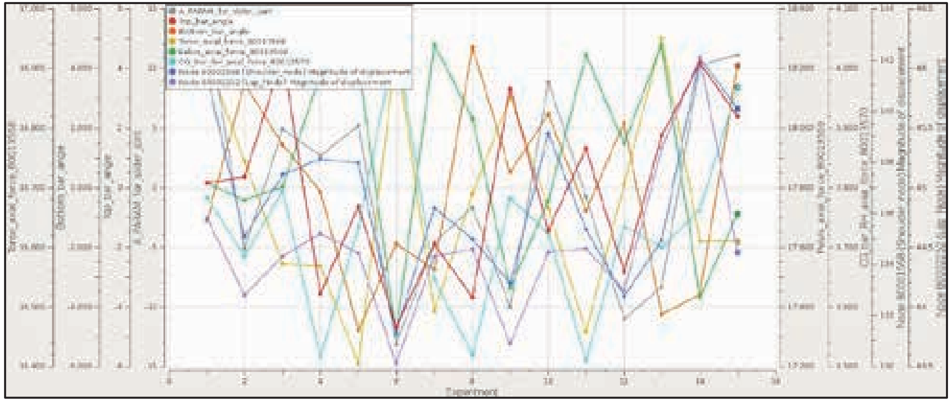
No.	Shoulder block position	Shoulder block pull angle	Lap block pull angle	Shoulder Load	Lap Load	RHS CG Load	RHS CG Disp	Shoulder Disp	Lap Disp
1	14.08	0.16	-1.11	16913.51	17815.78	3782.80	14.71	141.35	44.74
2	-5.17	0.35	3.48	16743.91	17756.58	3683.98	14.08	135.06	44.09
3	4.87	4.38	1.43	16571.15	17802.39	3794.47	14.28	137.49	44.42
4	2.62	-3.57	-0.15	16568.27	18178.62	3514.85	14.53	138.12	44.61
5	5.16	-0.63	-4.79	16404.29	18211.79	3733.76	14.39	137.96	44.45
6	-13.13	-4.69	-1.89	16930.45	17308.53	4049.04	13.74	131.33	43.53
7	-4.62	-1.92	-2.76	16492.52	18279.42	3644.86	14.52	136.20	44.42
8	-1.70	-3.69	4.71	16689.37	18031.61	3518.84	14.25	134.98	44.48
9	-10.05	3.32	0.51	16851.28	17462.08	3781.35	13.90	133.25	43.69
10	8.86	-1.45	2.45	16665.85	17754.91	3723.30	14.43	139.12	44.46
11	-0.78	1.31	-0.79	16457.33	18245.56	3508.87	14.32	135.36	44.49
12	-11.04	-2.84	2.18	16704.30	17947.25	3734.13	14.06	132.74	44.13
13	-8.33	1.73	-4.26	16950.13	18280.53	3699.43	14.51	134.93	45.33
14	10.30	4.17	-3.59	16609.48	17428.12	3762.93	14.93	142.06	46.09
15	11.10	2.38	4.10	16609.72	17712.32	3968.94	14.48	140.08	44.46



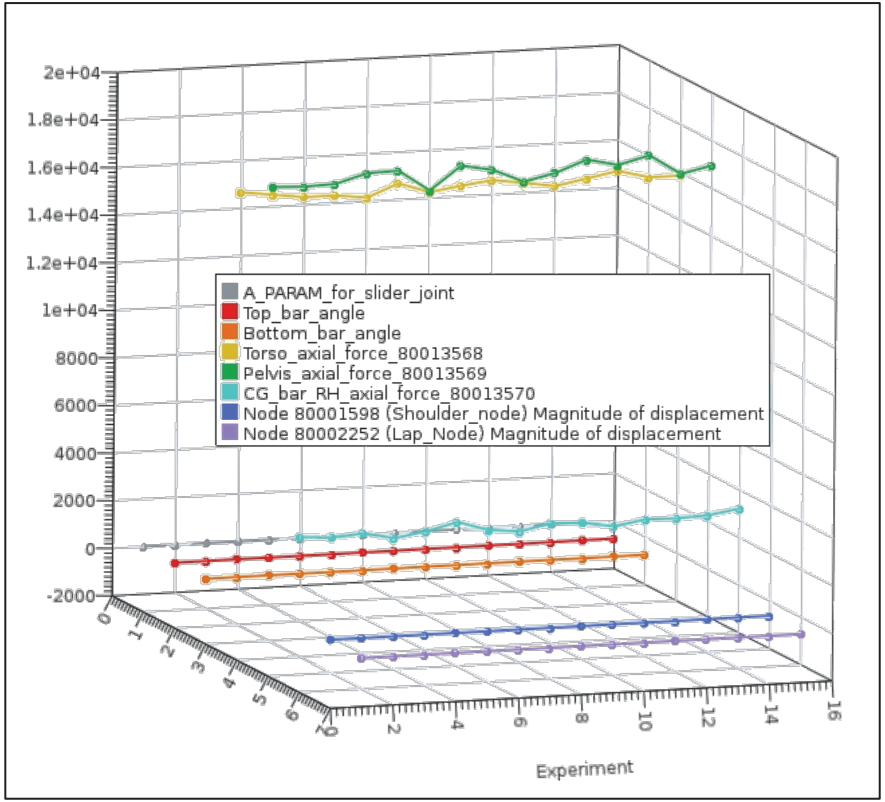
SEAT BELT ANCHORAGE TEST – Test Variations Response



Point Chart – Response Vs Exp



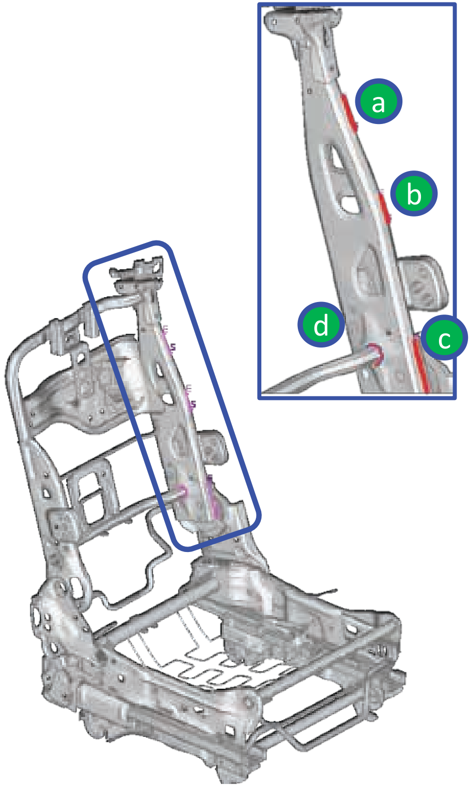
Line Chart – Multiple Responses Vs Exp



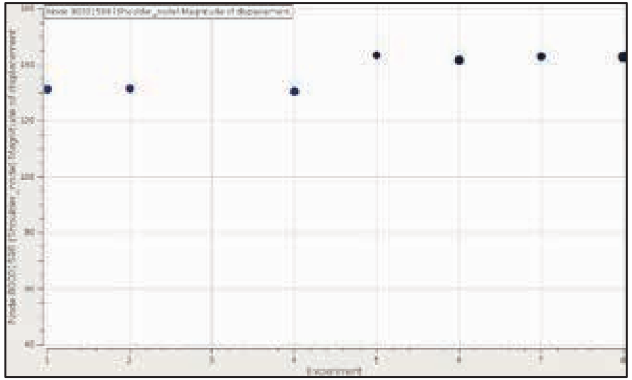
3D line chart– Multiple Responses Vs Exp

SEAT BELT ANCHORAGE TEST – Manufacturing Variations

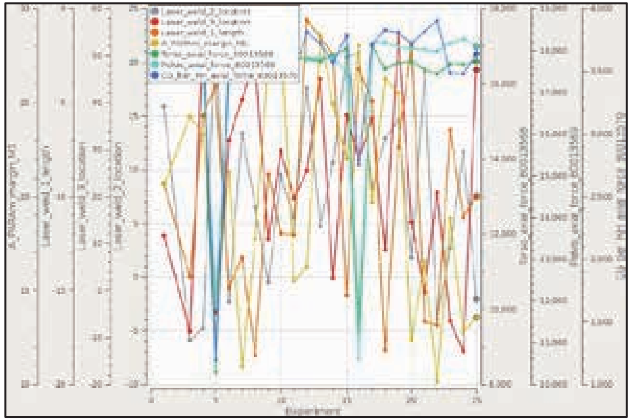
No.	Weld 1 Length	Weld 2 Position	Weld 3 Location	Weld 4 Length	Shoulder Load	Lap Load	RHS CG Load	RHS CG Disp	Shoulder Disp	Lap Disp
1	-9.31	15.9	11.65	20.6	16630.71	18051.59	3645.14	14.35	136.56	44.23
2	-19.36	0.86	4.83	18.34	16534.73	18203.95	3552.38	14.5	139.65	44.66
3	-14.3	-5.92	-8.82	24.26	16595.13	18119.67	3637.77	14.44	136.69	44.62
4	-5.71	-4.8	51.91	23.31	16477.91	17806.07	3814.72	14.17	134.81	44.32
5	-4.13	22.77	-4.58	14.1	8310.09	11842.8	1194.36	2.89	53.95	35.29
6	-14.88	-2.35	32.01	21.27	16344.18	17763.71	3558.4	14.3	138.28	44.84
7	-13.26	13.42	40.68	10.93	16503.11	17963.63	3632.96	14.33	135.87	44.32
8	-18.46	6.46	49.24	17.76	16506.88	18318.55	3525.82	14.28	138.86	44.7
9	-8.8	-0.54	10.87	27	16938.67	18302.9	3707.88	14.79	138.58	45.41
10	-12	9.53	29.78	29.54	16583.81	18086.41	3704.06	14.37	137.29	44.92
11	-12.06	5.53	19.72	15.52	16715.66	17771.57	3506.4	14.38	134.6	45.32
12	-0.6	17.62	25.55	16.27	16665.38	17810.03	3807.48	15.05	139.39	46.01
13	-1.54	4.74	44.98	28.59	16598.45	17818.65	3725.22	14.32	135.66	44.38
14	-2.44	10.63	2.57	24.89	16763.27	17824.5	3571.71	15.02	139.5	45.54
15	-15.27	20.42	37.26	22.01	16936.06	17470.33	3782.83	14.77	137.87	45.33
16	-3.2	20.89	27.76	28.04	9390.97	10620.61	2751.25	6.35	71.2	35.43
17	-4.9	8.26	36.69	19.7	17005.5	18171.67	3713.8	14.77	138.1	45.57
18	-18.21	12.88	8.57	26.25	16394.96	18191.83	3831.35	14.25	137.66	44.43
19	-7.36	14.66	54.87	25.5	16570.77	18080.94	3804.55	14.44	136.88	44.5
20	-2.02	1.83	14.58	12.37	16596.87	18043.24	3725.13	14.33	136.47	44.83
21	-16.66	19.07	-0.48	16.54	16377.29	18022.38	3813.43	14.27	137.99	44.38
22	-16.86	-3.99	20.84	10.14	16262.33	17976.61	3902.43	14.59	137.28	46.15
23	-6.44	2.71	-6.57	18.86	16523.95	18178.54	3484.12	14.41	136.15	44.57
24	-11.11	11.7	-13.02	12.76	16519.86	18279	3476.87	14.34	137.53	44.56
25	-9.97	-2.06	47	13.58	16594.48	18101.79	3640.32	14.34	136.32	44.77



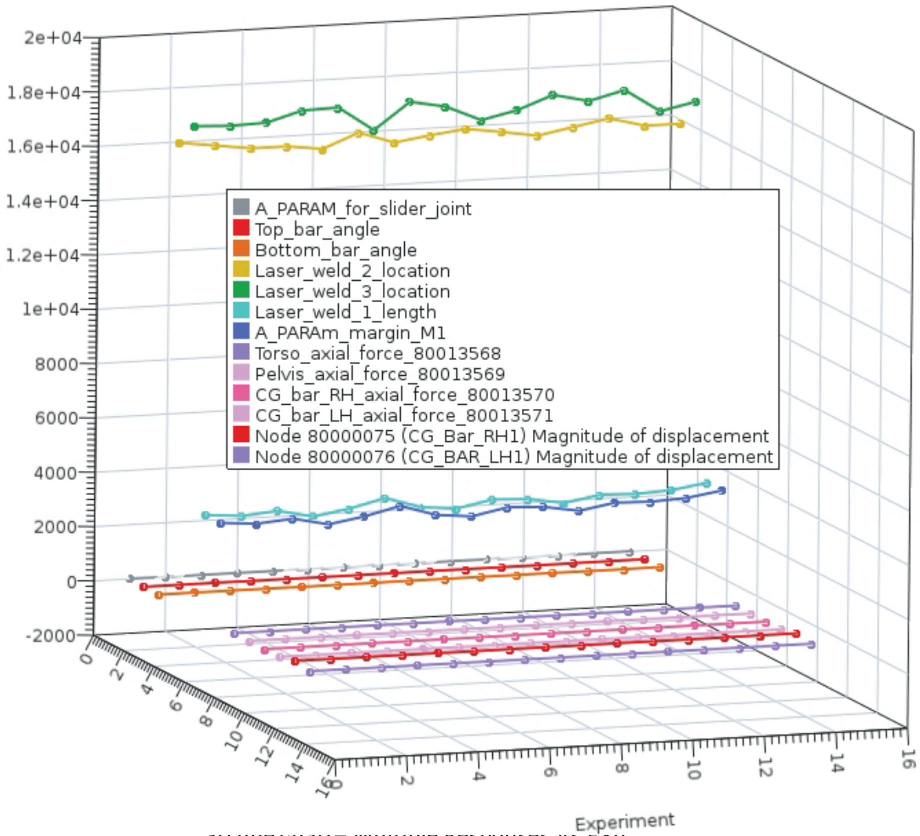
SEAT BELT ANCHORAGE TEST - Manufacturing Variations Response



Point Chart – Response Vs Exp



Line Chart – Multiple Responses Vs Exp



3D line chart – Multiple Responses Vs Exp

Summary

- The process to set up DOE for determining the robustness of the seating structure taking into consideration the real uncertainties of test condition and manufacturing variation is demonstrated.
- The use of ANSA’s inbuilt functionality for Crash and Safety, Optimization Tool, Morphing Capability, Python APIs, META tools and session files are critical to the process and used to completely automate the process.
- The itemized execution of the DOE process allows a user to review the model changes before submitting the model to a solver and a postprocessor. These experiments can then be automatically sent to any of the available solvers and subsequently have the desired responses extracted using META.
- The process outlined is not only limited to the seating system and can be extended to other product development and evaluation studies.

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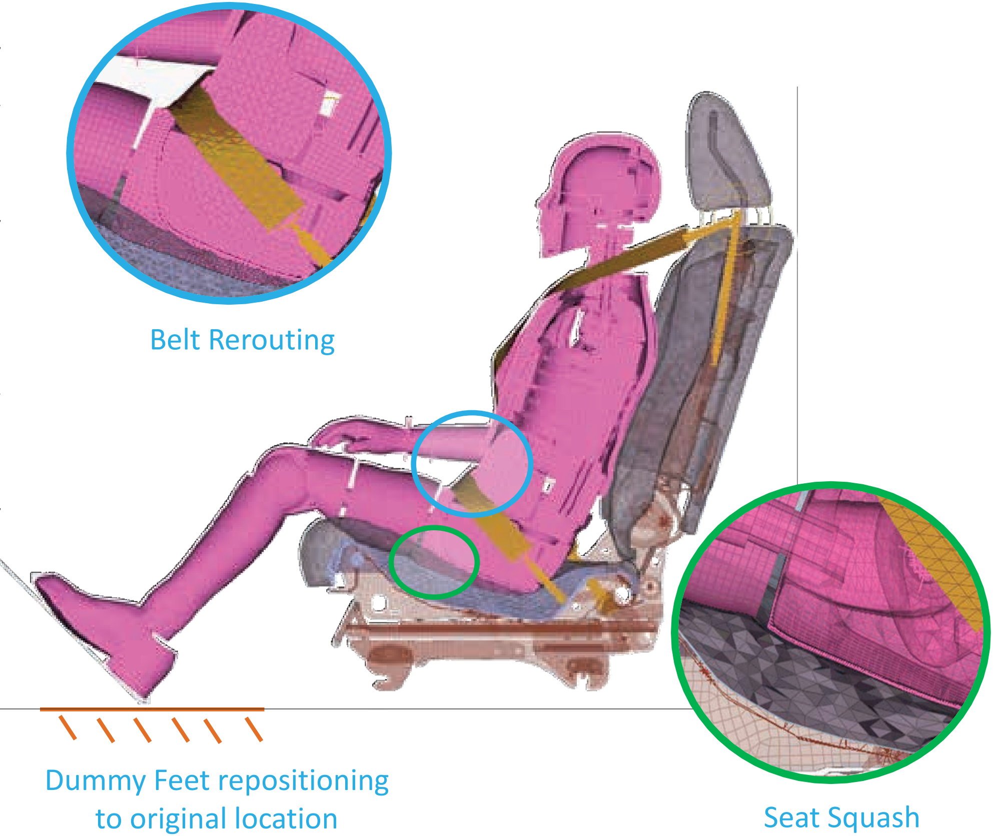
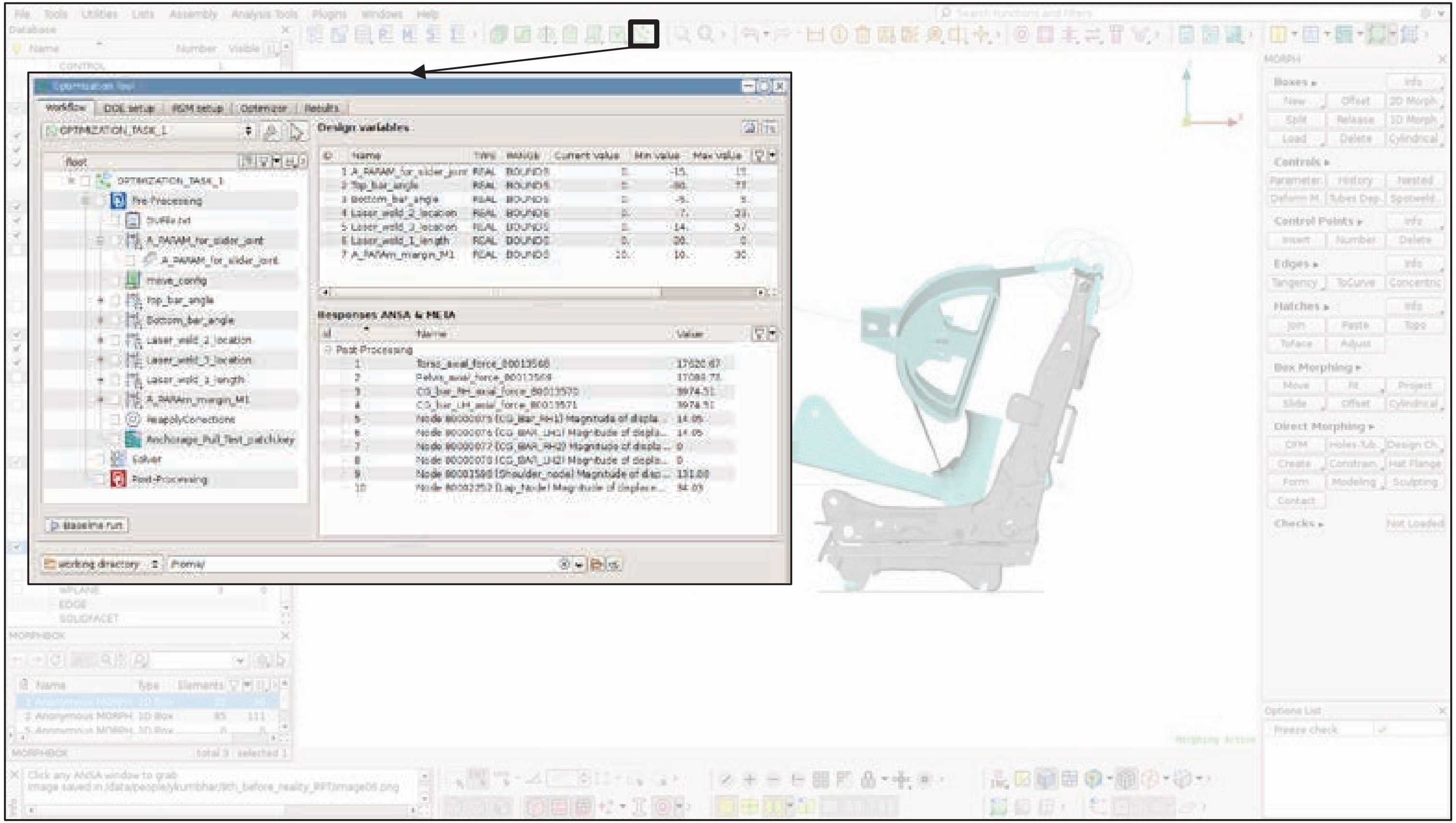
APPLICATION EXAMPLE 01 – SLED TEST MODEL

1. Alterations in H point and back angle of dummy at every variation create a repetitive task to redo the dummy positioning and in turn redo the belt fitting and seat squash.
2. This repetitive task was automated in ANSA DOE by employing Python Script. The details of the Python script integration are given below
    a) The belt rerouting was accomplished by selecting Auto create function in Ansa seat belt tool
    b) The required foam compression was accomplished by invoking the Ansa seat squash tool using API functions.
    c) Finally, the required dummy feet repositioning to original location was accomplished using API functions to activate Kinematic configuration.



ANSA Optimization Tool



ANSA Optimization Tool