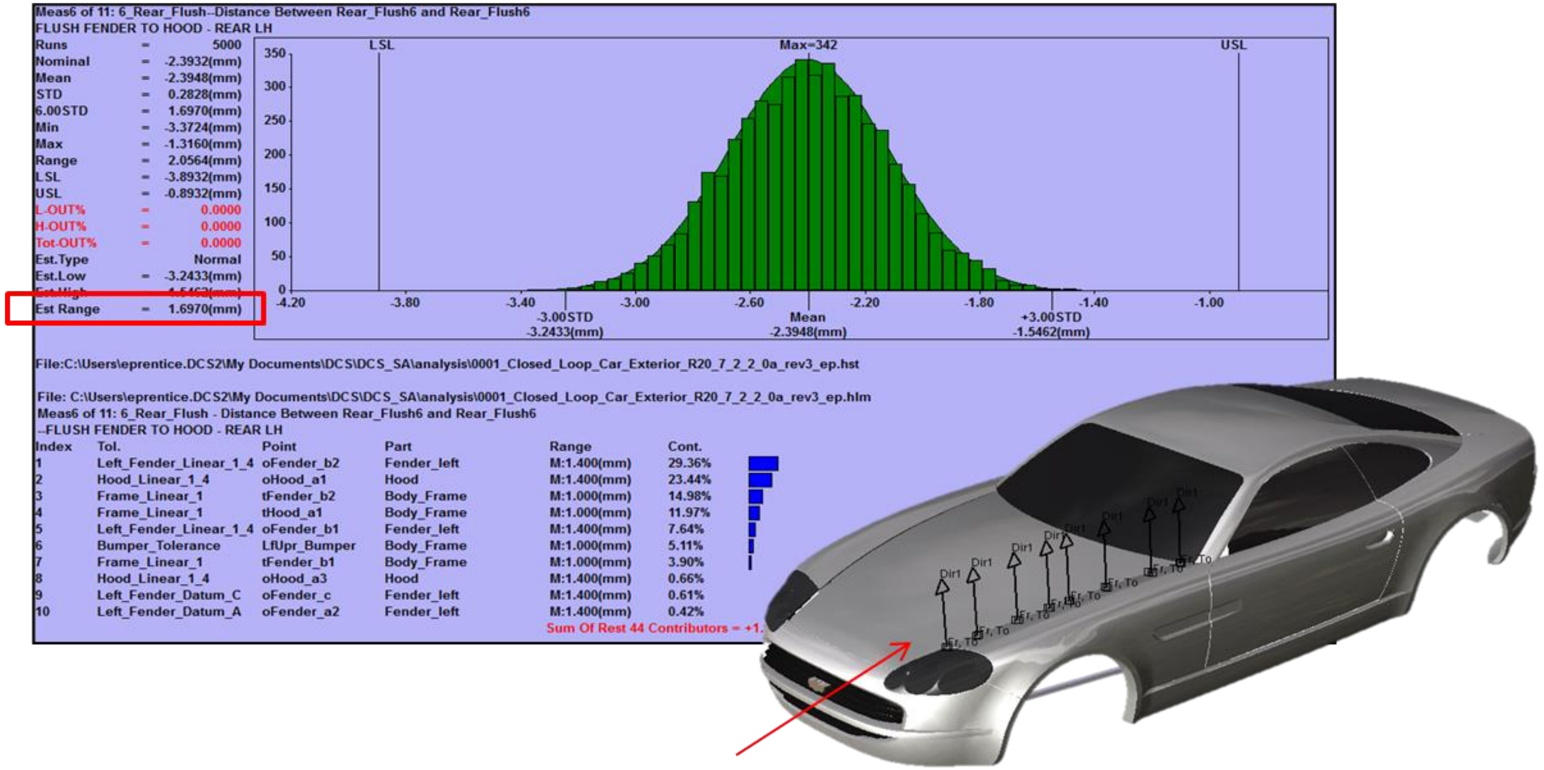
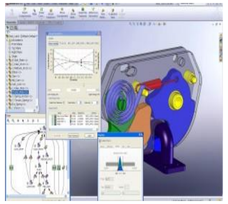
Non-Rigid Tolerance Variation



TES-RnD מי אנחנו?

תחומי פעילות



- פתוח השתלמויות בתחום הטולרנסים הגיאומטריים
- יעוץ והדרכה בתחום הטולרנסים הגיאומטריים לחברות בארץ ובחו"ל
- שירותי הנדסה, תכן ואנליזה (Tolerance Analysis)

רקע ונסיון בטולרנסים גיאומטריים

- מוסמך ASME ברמת סניור, GDTP S-0716
- נציג ישראל ב ISO TC213
- מעל עשר שנות ניסיון בהדרכה ויעוץ לחברות מובילות בארץ ובחו"ל

הסמכות

- ISO 9001 - 2008
- ספק מוכר משהב"ט דרג A

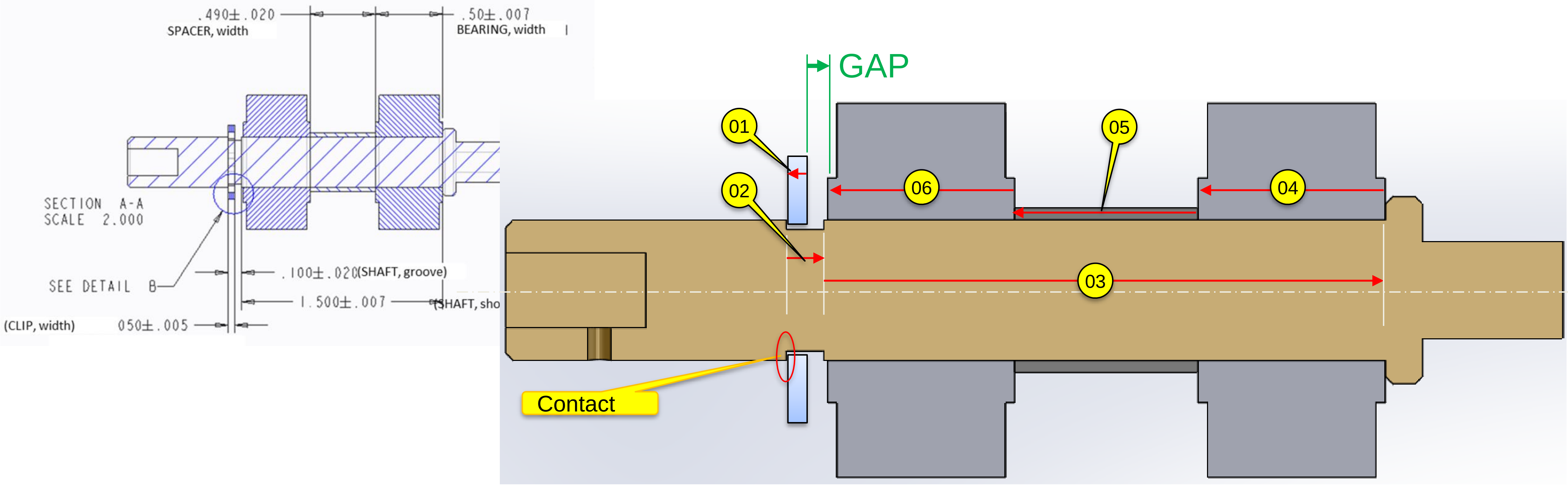
יצוג שרות ותמיכה - תוכנה

- Tolerance Analysis 3DCS-DCS
- Tolerance Analysis CETOL-Sigmetrix
- Smart Profile -Kotem -ניתוח תוצאות מדידה

Non-Rigid Tolerance Variation

- Tolerance Calculation & Simulation
- FEM – Rigid – Compliant
- Daimler Study
- Conclusions

Tolerance Stack



Vector Direction
To be used with the
nominal values

Sum up all the
tolerance values

1. Clip Width	−	0.050	± 0.005
2. Shaft Groove Width (Size)	+	0.100	± 0.020
3. Shaft Groove Location	+	1.500	± 0.007
4. Bearing Width (Size)	−	0.500	± 0.007
5. Spacer Length (Size)	−	0.490	± 0.020
6. Bearing Width (Size)	−	0.500	± 0.007

NOMINAL GAP = (1.500+0.100)-(0.050+0.500+0.490+0.500) = 0.060

GAP = 0.06 ±0.066 in

Variation Simulation

Part

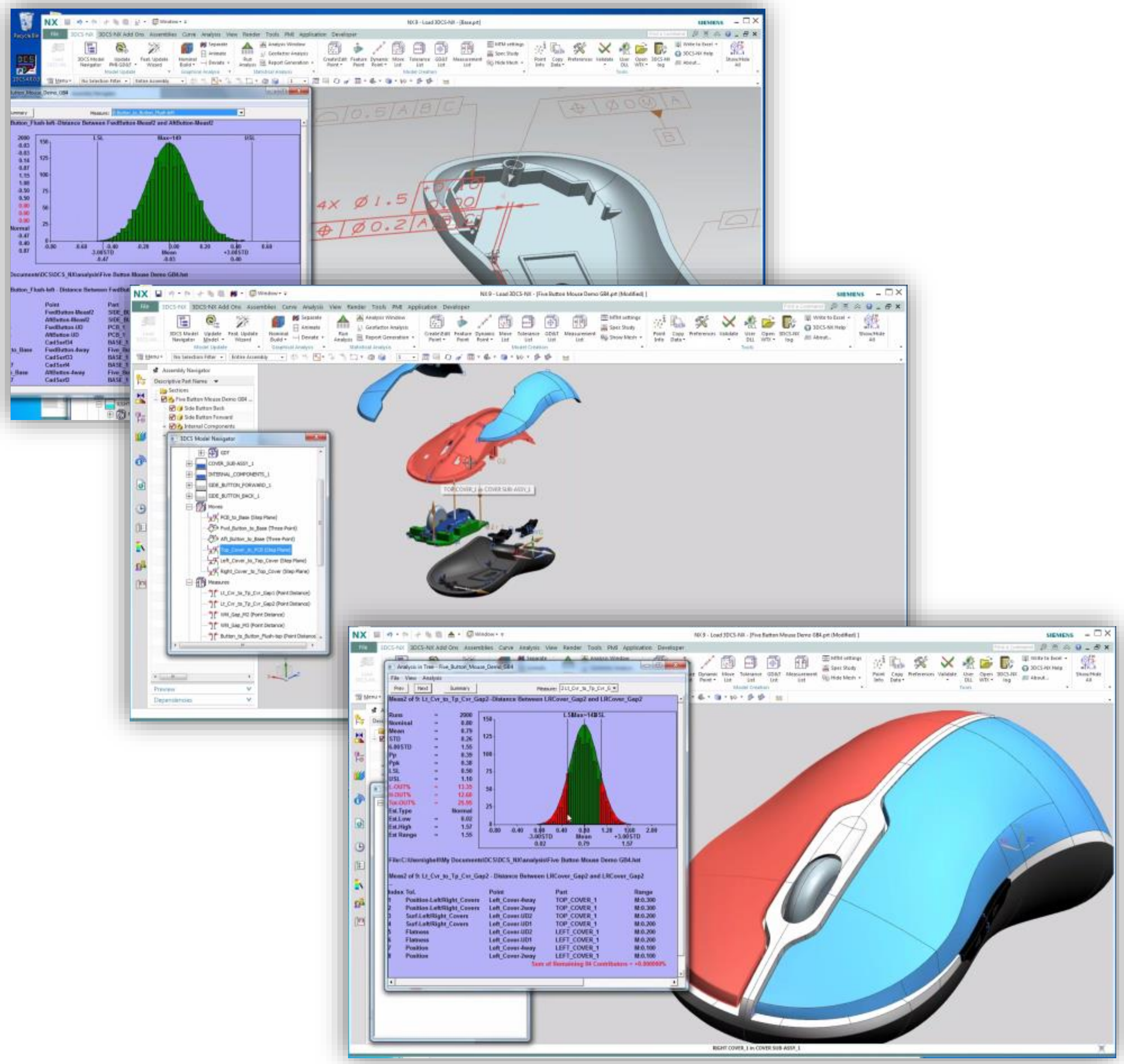
- *Geometry*
- GD&T
- Variation

Assembly Sequence

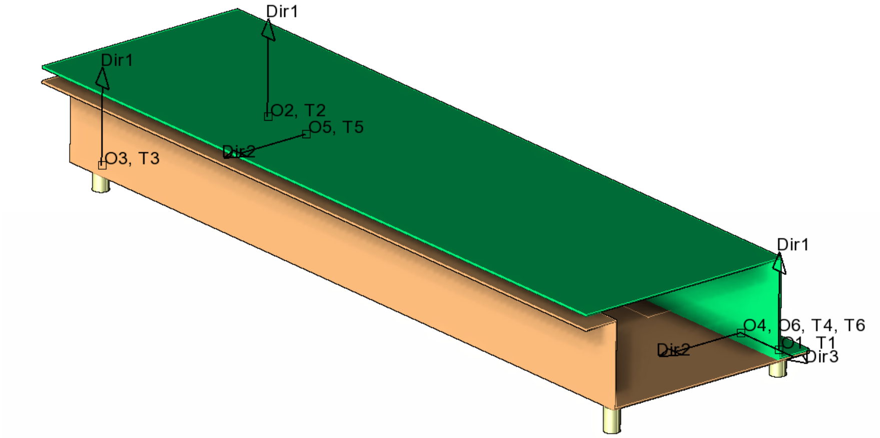
- Moves to assemble the parts

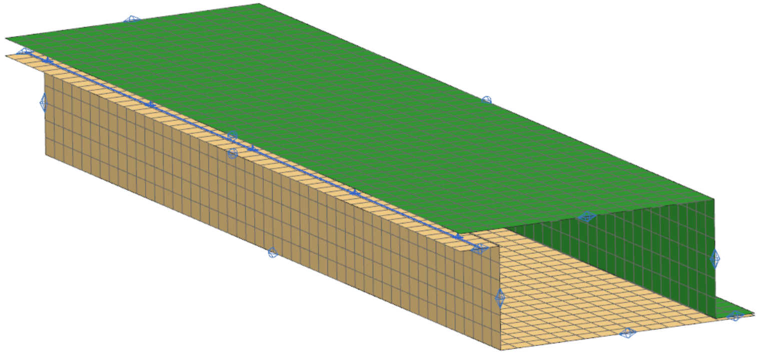
Measurements

- Areas to analyze during simulation



Rigid & FEM Variation Simulation





Rigid Tolerance Simulation
Simulates Tolerance Variation
Ignores Elastic Constraints

FEM Simulation
Simulates Elastic Constraints
Ignores Tolerance Variation

Compliant Tolerance Simulation
Simulates Elastic Constraints
Simulates Tolerance Variation

The Need

Simulate variation due to

- Process (welding, clamping, bolting and riveting)
- Environmental forces (Gravity, Heat)

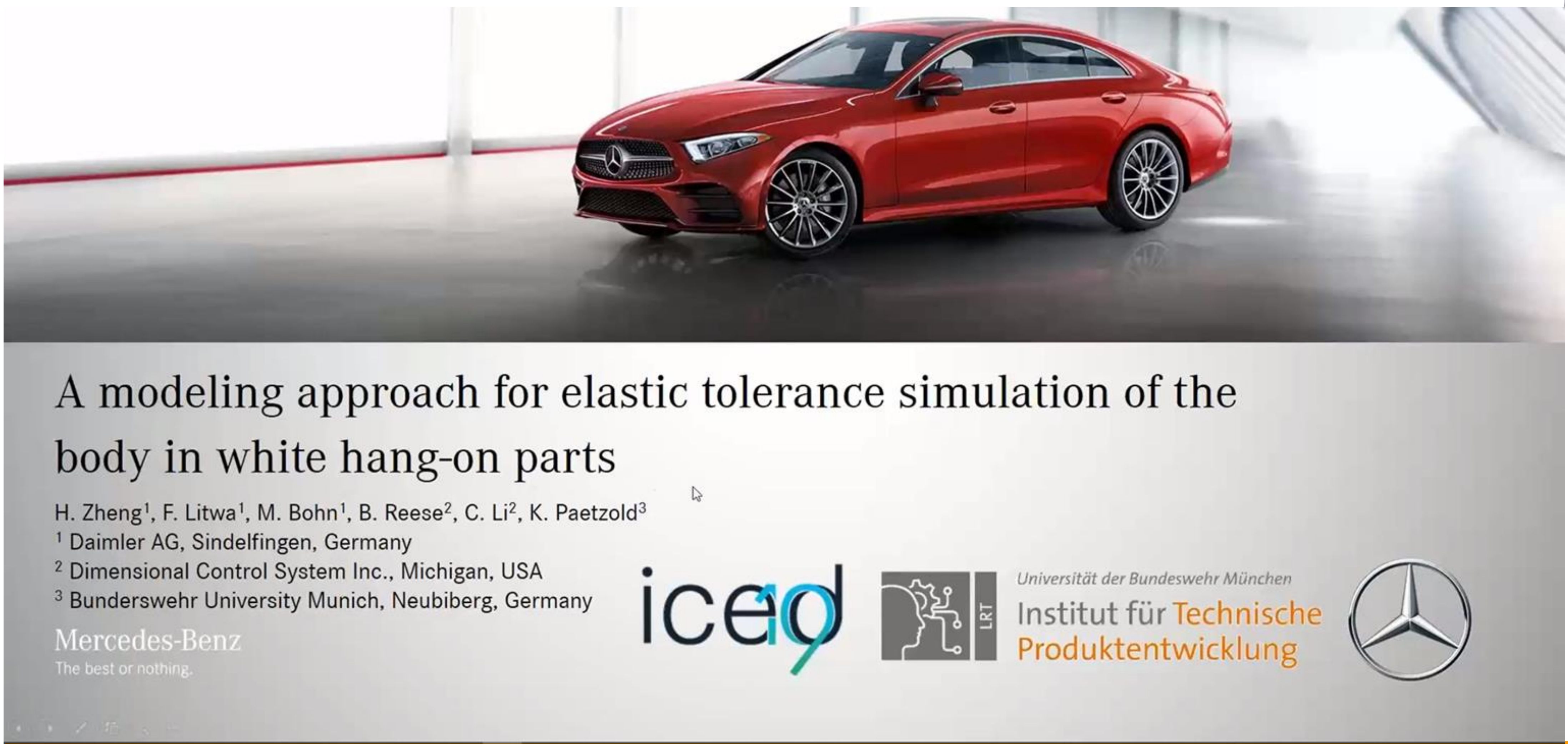
Design to account for Variation

Optimize to reduce Process variation:

- Riveting sequences
- Clamps
- Bending.

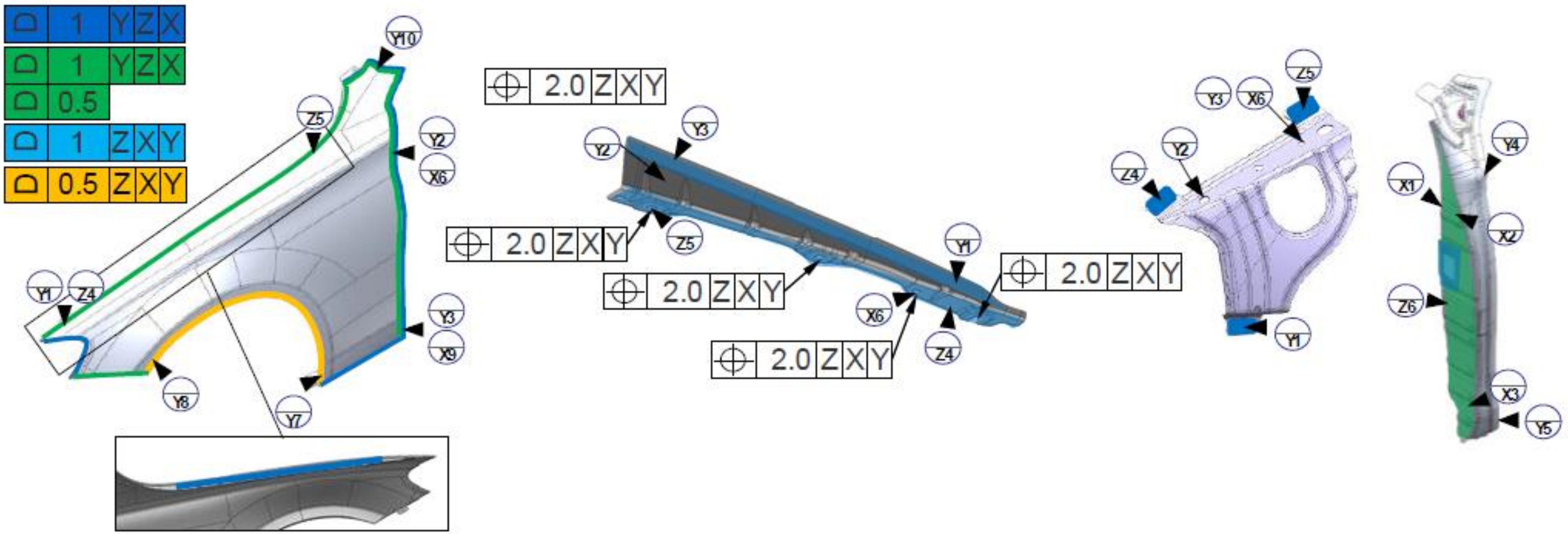
Daimler Study

ICED19 - International Conference on Engineering Design
5-8 AUGUST 2019
DELFT, THE NETHERLANDS



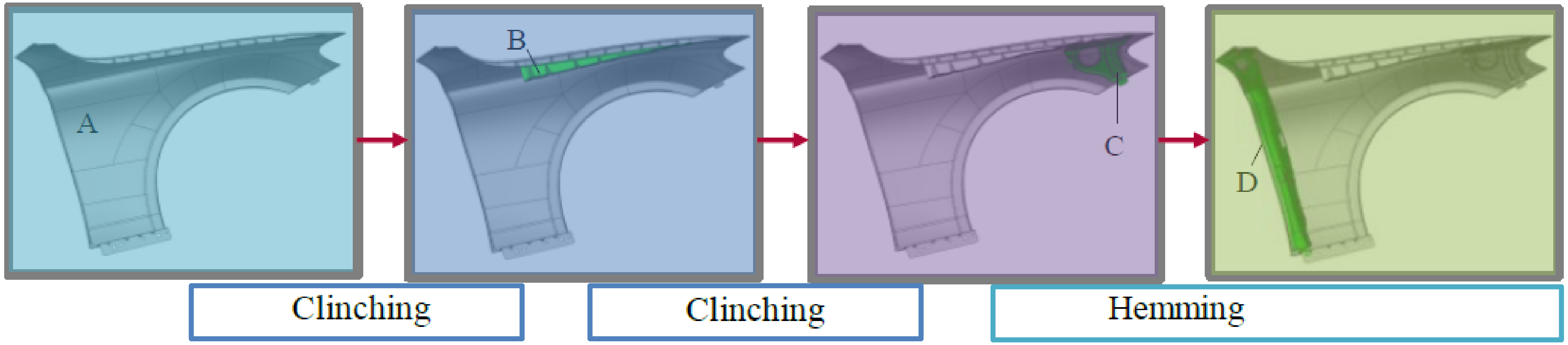
Fender – Simulate Two Production Scenarios

Fender part Tolerances



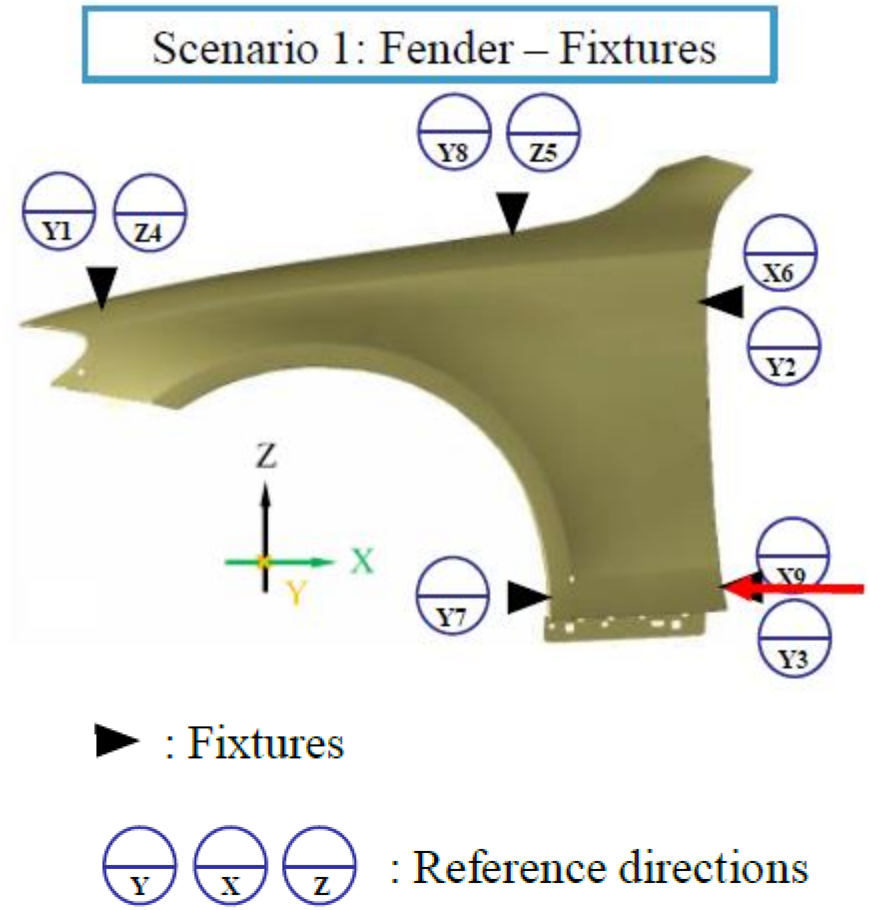
Fender Assembly – Modeling

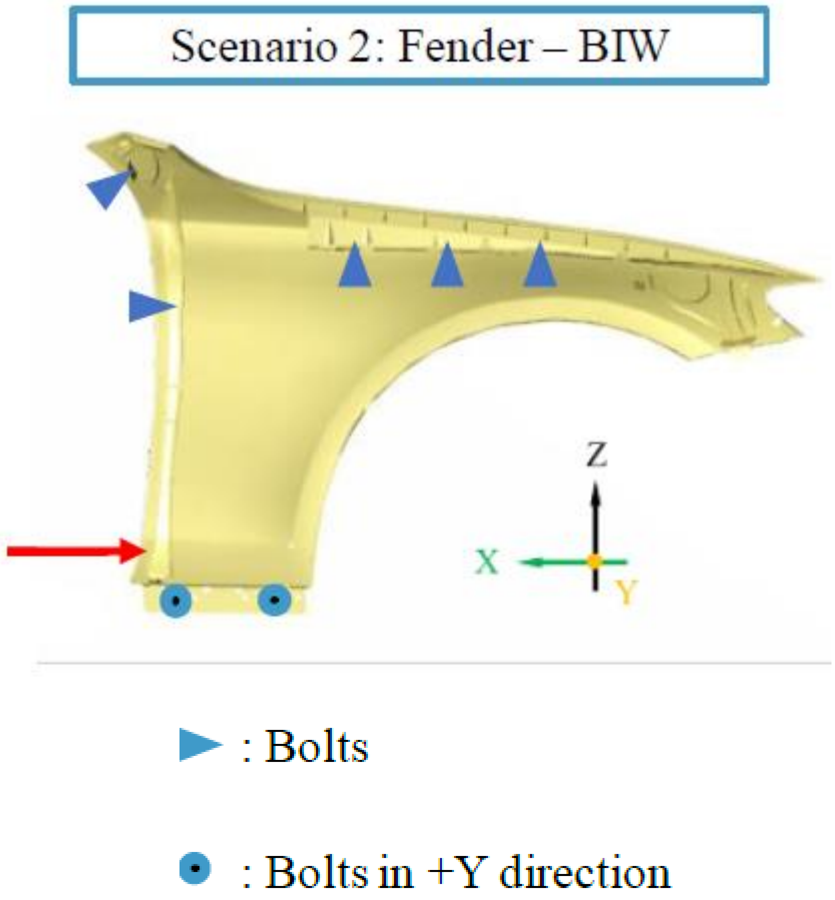
- Fender-BIW system
  - BIW
  - Fixtures
  - Fender Assembly
    - Panel A
    - Support B
    - Reinforcement C
    - Support D
    - Fixtures



Manufacturing process	Compliant moves	Actions in the simulation model
Clinching	Join	Combine the stiffness
Fixturing close/release	Clamp	Fix the degree of freedom (DOF)
Hemming	Join	Combine the stiffness

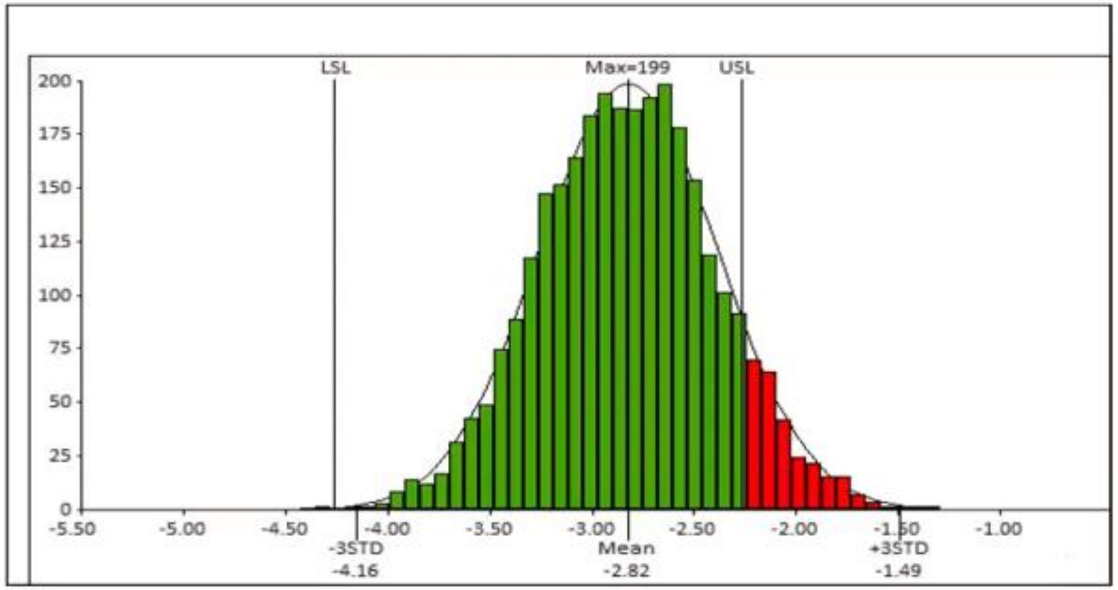
Scenario Study

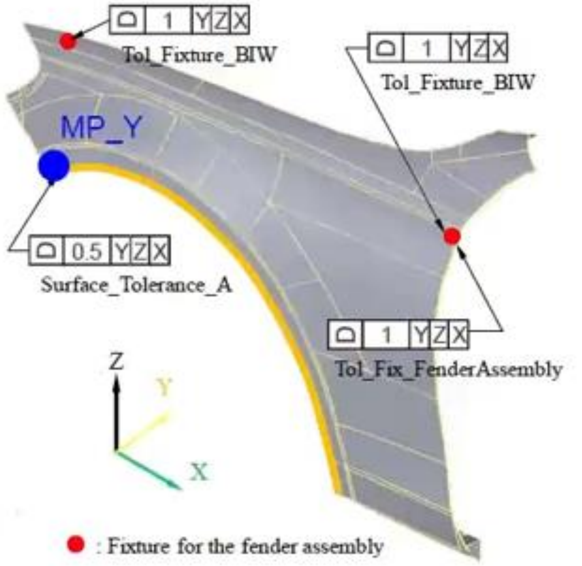




2 mm deviation in (-X) direction
is constantly observed at the bottom of the fender (the red arrow)

Scenario 1: Fixture



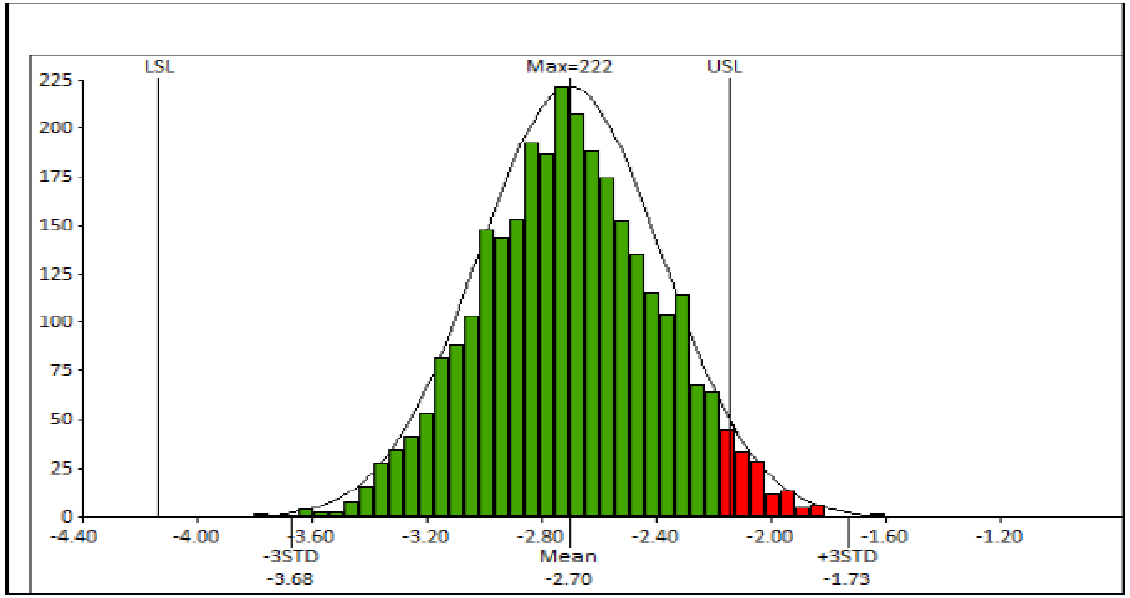


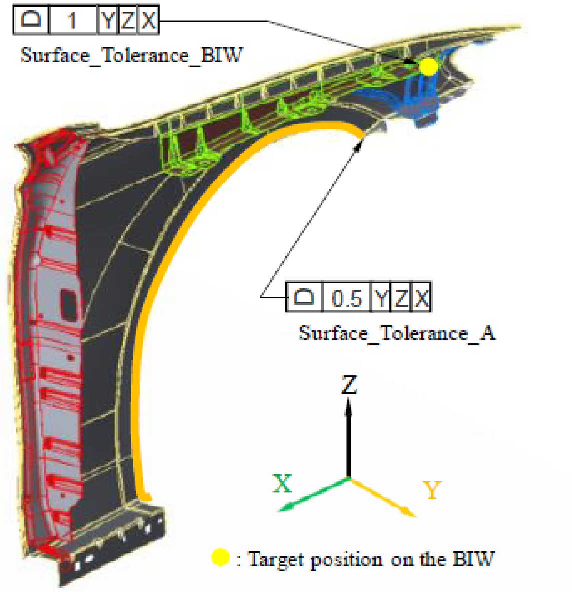
MP_Y		
Runs	=	3000
Nominal	=	-3.26
Mean	=	-2.82
STD	=	0.44
6STD	=	2.67
LSL	=	-4.26
USL	=	-2.26
Est.Type	=	Normal
Est.Low	=	-4.16
Est.High	=	-1.49
Est.Range	=	2.67

Index	Contributor	Feature	Part	Range	Contribution
1	Tol_Fixture_BIW	X22_AL_X6_BIW	BIW_Fix	M:1.000	58.18%
2	Tol_Fix_FenderAssembly	X22_AL_X6_Fen_10	ZB_Fender_Fix	M:1.000	11.06%
3	Surface_Tolerance_A	Y14_AS_Y8_Fen_10	Fender_Panel_A	M:0.500	10.59%
4	Tol_Fixture_BIW	Z10_AL_Z4_BIW	ZB_Fender_Fix	M:1.000	10.43%
5	Tol_Fixture_BIW	Y11_AL_Y1_BIW	ZB_Fender_Fix	M:1.000	5.39%
6	Tol_Fix_FenderAssembly	Y11_AL_Y1_Fen_10	ZB_Fender_Fix	M:1.000	0.61%
7	Tol_Fixture_BIW	Y26_AS_Fen_10_Y8_ZB	BIW_Fix	M:1.000	0.56%
8	Tol_Fixture_BIW	Z27_AL_Z5_BiW	BIW_Fix	M:1.000	0.51%
9	Tol_Fix_FenderAssembly	X19_AL_X9_Fen_10	ZB_Fender_Fix	M:1.000	0.32%
10	Tol_Fix_FenderAssembly	Z10_AL_Z4_Fen_10	ZB_Fender_Fix	M:1.000	0.30%

Sum of Remaining 50 Contributors = 2.02%

Scenario 2: Bolting BIW





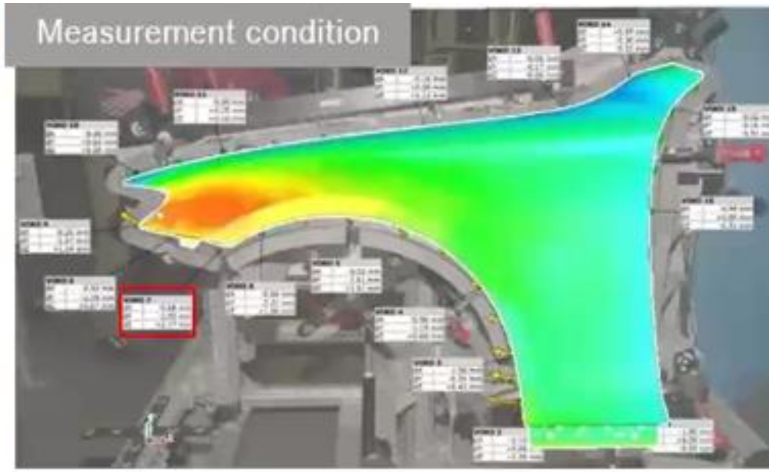
MP_Y		
Runs	=	3000
Nominal	=	-3.14
Mean	=	-2.70
STD	=	0.33
6STD	=	1.95
LSL	=	-4.14
USL	=	-2.14
Est.Type	=	Normal
Est.Low	=	-3.68
Est.High	=	-1.73
Est.Range	=	1.95

Index	Contributor	Feature	Part	Range	Contribution
1	Surface_tolerance_A	Y14_AS_Y8_Fen_10	Fender_Panel_A	M:0.500	19.14%
2	Surface_tolerance_BIW	Tol5_RF_10	BIW_Body	M:1.000	13.78%
3	Surface_tolerance_CP	Join13_Fend_to_RF	Fender_Panel_A	M:1.000	8.53%
4	Surface_tolerance_CP	Join13_Fend_to_RF	Fender_Support_B	M:1.000	8.53%
5	Tol_Fix_FenderAssembly	Z10_AL_Z4_Fen_10	ZB_Fender_Fix	M:1.000	7.29%
6	Tol_Fix_FenderAssembly	Y14_AS_Y8_Fen_10	ZB_Fender_Fix	M:1.000	6.89%
7	Position_tolerance_B	Tol5_RF_10	Fender_Support_B	M:1.000	6.12%
8	Tol_Fix_FenderAssembly	X22_AL_X6_Fen_10	ZB_Fender_Fix	M:1.000	5.06%
9	Tol_Fix_FenderAssembly	Y11_AL_Y1_Fen_10	ZB_Fender_Fix	M:1.000	4.13%
10	Surface_tolerance_D	Join20_RF_to_SC	Fender_Support_D	M:1.000	2.31%

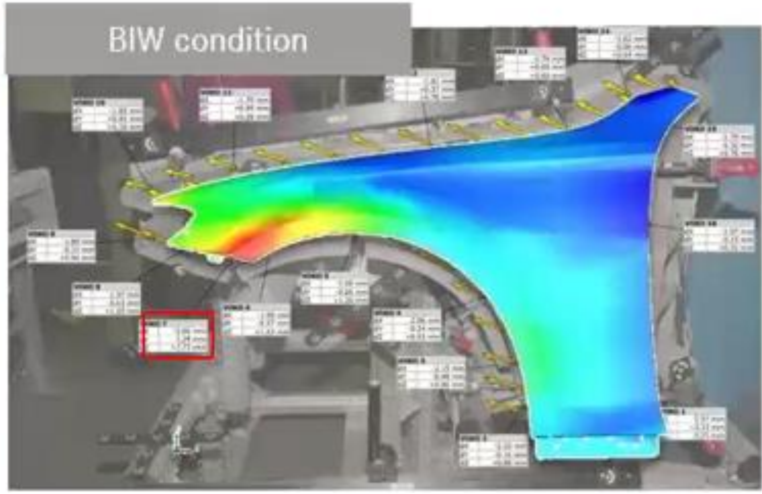
Sum of Remaining 49 Contributors = 18.23%

Simulation Validation

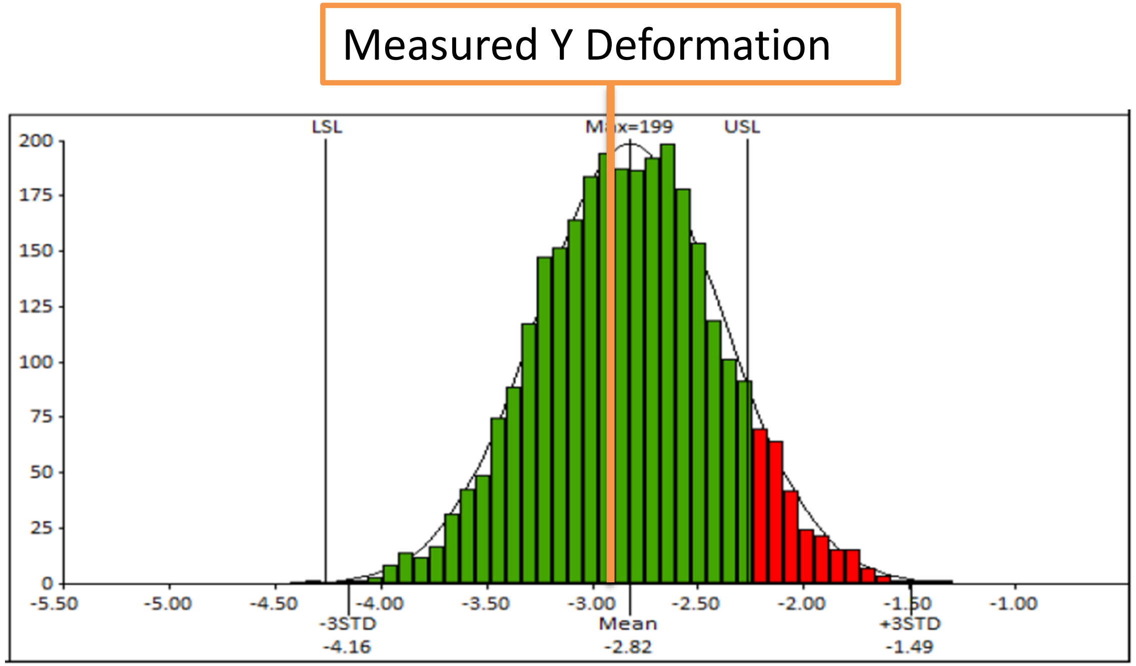
Results for MP in Scenario 1	Measurement			Simulation		
	X	Y	Z	X	Y	Z
Displacement at X9 [mm]	-1.80	+0.09	-0.59	-2.00	0.00	0.00
Nominal	0.00	0.00	0.00	-0.63	**-3.26**	+2.12
Deformation [mm]	-0.68	**-2.93**	+2.17			
Mean value [mm]				-0.61	**-2.82**	+2.13
Deviation range [mm]				0.52	**2.67**	1.97



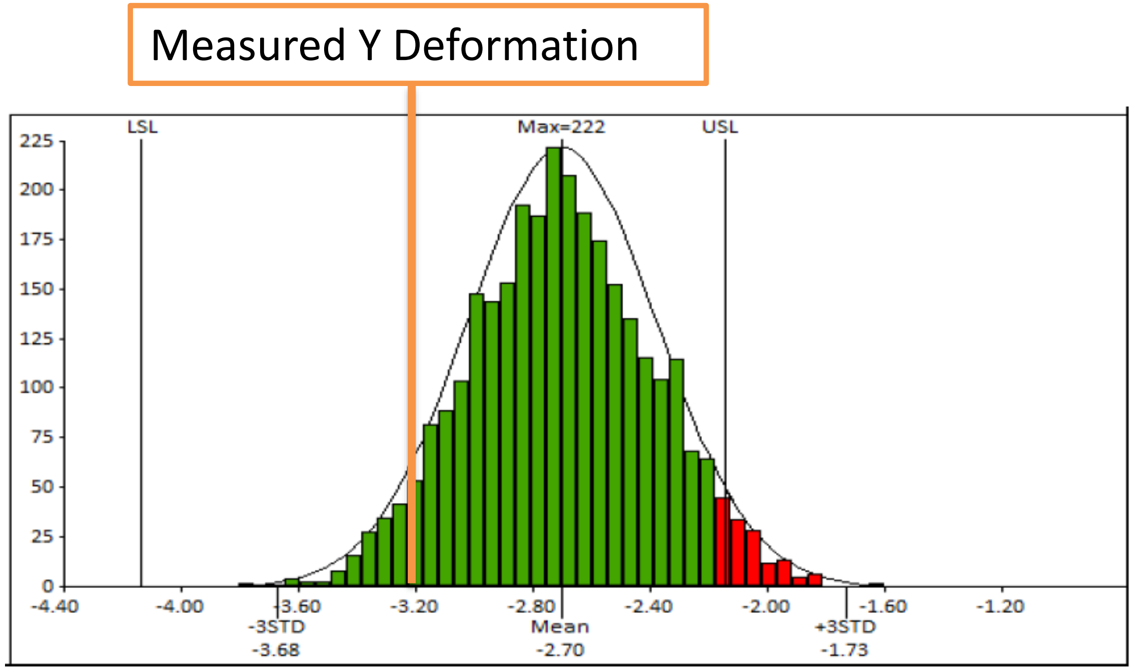
Results for MP in Scenario 2	Measurement			Simulation		
	X	Y	Z	X	Y	Z
Displacement at X9 [mm]	-1.97	+0.11	-0.25	-2.00	0.00	0.00
Nominal	0.00	0.00	0.00	-0.58	**-3.14**	+2.45
Deformation [mm]	-0.64	**-3.24**	+2.72			
Mean value [mm]				-0.56	**-2.70**	+2.46
Deviation range [mm]				0.28	**1.95**	1.18



Simulation & Measurement



Scenario 1



Scenario 2

Daimler Conclusions & Outlook

Conclusions:

- An approach is developed to implement the Elastic Tolerance Simulation
- Proposed modeling approach is applied in industrial scenarios & Validated by real measurement data

Outlook

- Automatic integration process of the CAD points to Simulation System
- A Simulation System Containing more compliant parts
- Non Linear effects of the clinching/hemming process

Questions?