FE-Model Summary

• Vehicle Structure, Interior, and Suspension
• Model size:
  • ~ 2.25 million elements
  • ~ 1000 Parts
• Average element size: 6-8 mm
• Time step: 0.7 microseconds
Physical Vehicle and FE-Model

VIN 4T1BF1FK2CU079329

Detailed Finite Element Model
Mass, Inertias, CG Location

- Mass difference is less than 1%
- Inertia differences is less than 3%
- Vehicle CG difference is less than 3%

<table>
<thead>
<tr>
<th></th>
<th>Physical vehicle</th>
<th>FE model</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass [kg]</td>
<td>1452</td>
<td>1462</td>
<td>0.7 %</td>
</tr>
<tr>
<td>Pitch inertia [kg*m²]</td>
<td>2519</td>
<td>2524</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Yaw inertia [kg*m²]</td>
<td>2796</td>
<td>2807</td>
<td>0.4 %</td>
</tr>
<tr>
<td>Roll inertia [kg*m²]</td>
<td>560</td>
<td>572</td>
<td>2.1 %</td>
</tr>
<tr>
<td>Vehicle CG x [mm]</td>
<td>1063</td>
<td>1086</td>
<td>2.2 %</td>
</tr>
<tr>
<td>Vehicle CG y [mm]</td>
<td>-9</td>
<td>-1</td>
<td>n/a</td>
</tr>
<tr>
<td>Vehicle CG z [mm]</td>
<td>561</td>
<td>560</td>
<td>0.2 %</td>
</tr>
</tbody>
</table>
Frontal 56 km/h NCAP - t=100ms
Frontal 56 km/h NCAP - Results

Barrier Force vs Displacement
- Vehicle Displacement within 1%
- Maximum barrier force within 10%
- CORA Rating: 0.88

Vehicle Pulse
- CORA (Acceleration): 0.84
- CORA (Velocity): 0.98
Frontal 40 km/h NCAP - t=100ms
Frontal 40 km/h NCAP - Results

Limitation
• Test: Hybrid Synergy Drive®
• Simulation: Conventional Engine

Vehicle Pulse
• Acceleration Peak within 3%
• CORA (Acceleration): 0.81
Frontal Left Oblique 90 km/h - t=100ms
Frontal Left Oblique 90 km/h - Results

Vehicle Kinematics & Pulse
- Kinematics well captured
- Peak well captured
- CORA-Rating: 0.93

Barrier Pulse
- Good Correlation
- CORA-Rating: 0.95
Frontal Right Oblique 90 km/h - t=100ms
Frontal Right Oblique 90 km/h - Results

Vehicle Kinematics & Pulse
- Wheel kinematics influence pulse
- Peak maximum value well captured
- CORA-Rating: 0.80

Barrier Pulse
- CORA-Rating: 0.90
Side NCAP Barrier 62 km/h  t=100ms
Side NCAP Barrier 62 km/h - Results

Vehicle Kinematics and Pulse
- Similar overall vehicle kinematics
- Vehicle accelerates to 23 km/h
- CORA-Rating: 0.92

Vehicle Damage Comparison
- Post crash intrusion measurements at 5 different heights
  (sill top, occupant hip point, mid door, window sill, and window top)
  compare well in test and simulation
Side NCAP Pole 32 km/h  t=100ms
Vehicle Damage Comparison

- Post crash intrusion measurements at 5 different heights (sill top, occupant hip point, mid door, window sill, and window top) compare well in test and simulation.
Roof Crush Resistance - Results

Test
• Quasi-static
• Front windshield failure occurs after 3.2 inches
• IIHS rating: GOOD

Simulation
• Dynamic
• Material strain rate effects affect S-to-W ratio
• IIHS rating: GOOD
Summary

FE Model Development & Availability
• A detailed Finite Element Model of a 2012 Toyota Camry has been developed using a reverse engineering process
• Model has been validated using test data from available full scale crash tests including frontal, side, and roof crush configurations
• Toyota Camry is the latest in a fleet of FE full vehicle models, developed and publicly available through the Center for Collision Safety and Analysis

Acknowledgment
• The effort was sponsored by the Federal Highway Administration (FHWA)