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Suspension Geometry Sensitivity Analysis using Adams/Insight

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Introduction

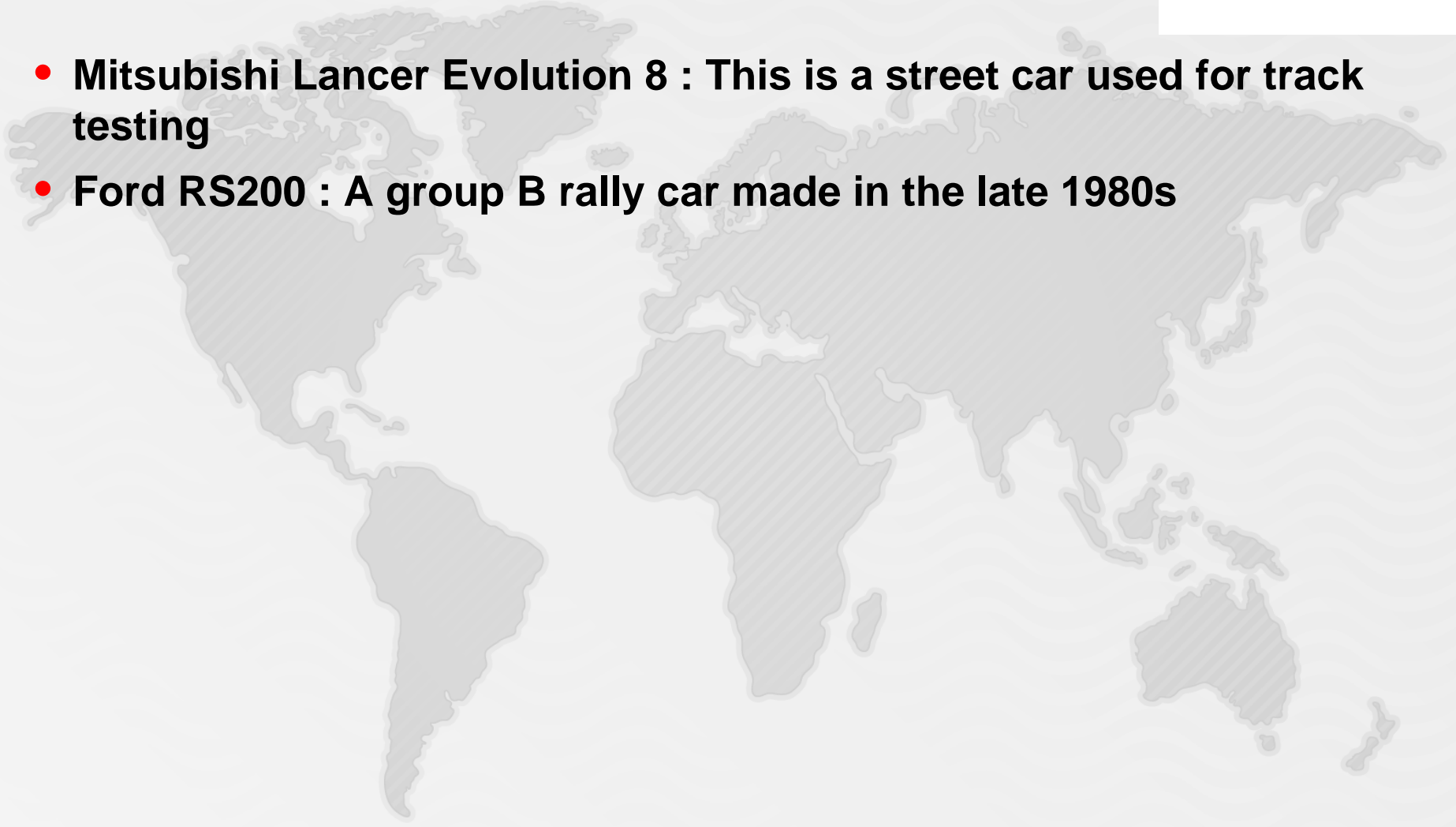
- There are inherent errors in measuring suspension geometry.
- The objective is to find out how the variations in these measurements affect camber, toe and caster
- Adams/Insight's DOE capabilities help in characterizing the variability and the effects on suspension response

Suspension types

- There were two types of Front and Rear Suspension chosen for this analysis :
- McPherson Strut suspension (Front)
- SLA suspension (Front and Rear)
- Multi-link suspension (Front)

Cars Used

- **Mitsubishi Lancer Evolution 8** : This is a street car used for track testing
- **Ford RS200** : A group B rally car made in the late 1980s



Evo



Measurement Methods

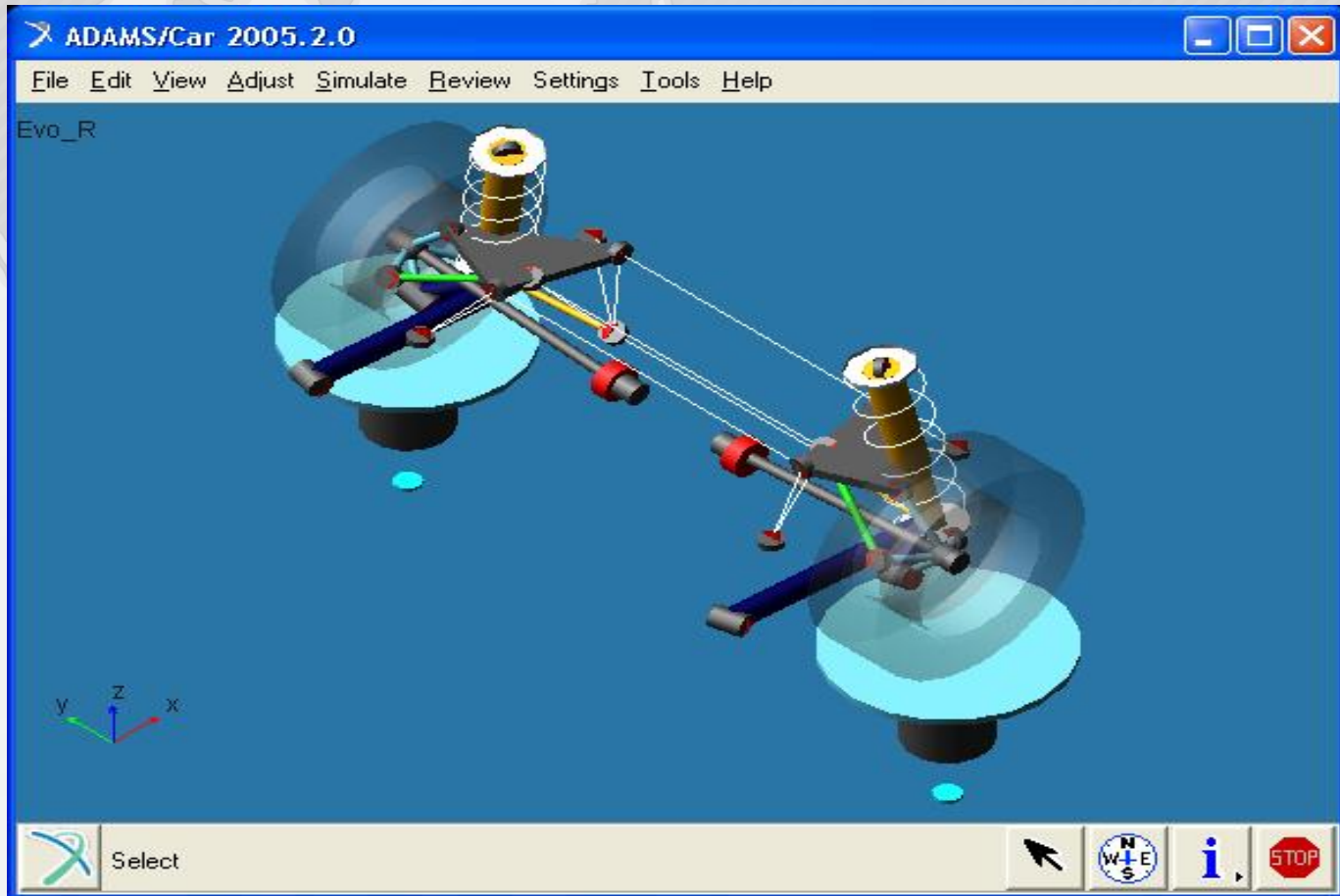
- Initial measurements were taken using tape measure and strings
- Error $\leq 1/16^{\text{th}}$ inch
- The measurement process was then improved using Lasers
- Error $\leq 1/32^{\text{nd}}$ inch

Suspension Modeling

- Adams/Car was used to create the suspension model
- Hardpoints from the measurements entered into Adams/Car
- Opposite Wheel Travel Analysis run
- Displacement : 1.5 inches in each Bump and Rebound

Adams/Insight DOE

- The experiment was created and exported to Adams/Insight
- Each point on the geometry was set to vary independently in X, Y and Z





DOE Design Specification

The screenshot shows the ADAMS/Insight (2005.2.0) - LLI_all interface. The left-hand tree view shows a hierarchy: LLI_all > Design > Specification (highlighted). The main window displays the 'Design Specification' dialog box with the following settings:

- Investigation Strategy:**
 - Study - Perimeter
 - Study - Sweep
 - DOE Screening (2 Level)
 - DOE Response Surface
 - Variation - Monte Carlo
 - Variation - Latin Hypercube
- Model:**
 - Linear
 - Interactions
 - Quadratic
 - Cubic
 - None
- DOE Design Type:**
 - Plackett Burman
 - Fractional Factorial
 - Full Factorial
 - Box Behnken
 - CCF
 - D-Optimal
 - Latin Hypercube
- Candidate Runs:**
 - All
 - Random
- Run Order:**
 - Standard
 - Random
 - Ease of Adjustment
- Number of Runs:** 8
- Number of Center Points:** [Empty field]
- Number of Candidate Runs:** [Empty field]

Buttons at the bottom: Help, Apply, Cancel.





DOE Results

- McPherson Strut (Front)

Suspension Geometry Hardpoint	Direction and response most affected
LCA Outer	Z (Toe, Camber, Caster)
LCA Front	Z (Toe, Camber, Caster)
LCA Rear	Z (Caster, Toe, Camber)
Strut Upper	Y (Camber, Toe) X (Caster)
Strut Lower	Y (Camber, Caster, Toe)
Tierod Inner	Z (Toe, Camber, Caster)
Tierod Outer	Z (Toe, Camber, Caster)



DOE Results

- SLA (Front and Rear)

Suspension Geometry Hardpoint	Direction and response most affected
UCA Front	Z (Toe, Caster, Camber)
UCA Rear	Z (Toe, Camber) Y (Caster)
UCA Outer	Z (Camber, Toe) X (Caster)
LCA Front	Z (Caster, Camber, Toe)
LCA Rear	Z (Camber, Toe, Caster)
LCA Outer	X (Caster, Toe) Z (Camber)
Toe Link Inner	Z (Toe, Camber, Caster)
Toe Link Outer	Z (Toe, Camber, Caster)



DOE Results

- Multi-Link (Rear)

Suspension Geometry Hardpoint	Direction and response most affected
Trailing Link Inner	Z (Caster, Toe, Camber)
Trailing Link Outer	Y (Toe, Camber) Z (Caster)
Toe Link Inner	X (Caster, Toe, Camber)
Toe Link Outer	Z (Caster, Toe) X (Camber)
Lateral Link Inner	Z (Toe, Caster, Camber)
Lateral Link Outer	Z (Caster, Toe) X (Camber)
UCA Front	Z (Camber, Caster, Toe)
UCA Rear	Z (Camber, Toe, Caster)
UCA Outer	X (Caster, Toe) Z (Camber)

Conclusions

- **Using Adams/Insight to study the suspension geometry sensitivity helps us in identifying and improving measurement accuracy in the areas most needed.**
- **It can also be used to design adjustments into suspension geometry that might be made at different tracks for better handling.**

Future Work

- Look at interaction between all the geometry hardpoints and see how they affect the response curve as a whole.
- Refine and improve the current DOE process to create better experiments and obtain a wider range of results



Questions ?