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Vehicle Dynamics: Why are Tires so Important?

Saied Taheri, Associate Professor
Director, Intelligent Transportation Laboratory
Mechanical Engineering Department
Virginia Polytechnic Institute and State University
Blacksburg, VA, USA

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Content

- A Brief History
- Advanced Technologies
- Intelligent Tires
- Conclusions

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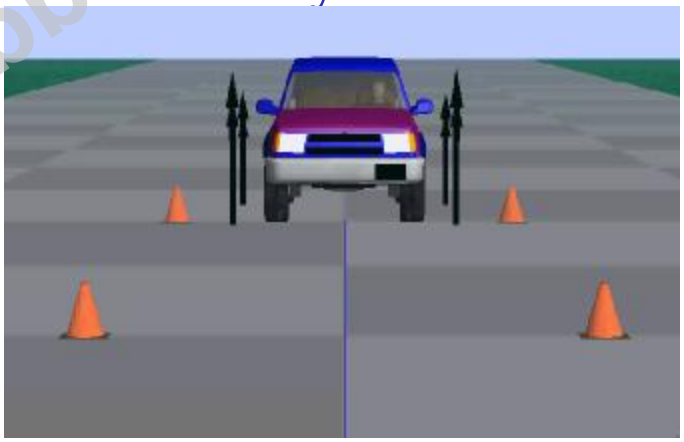
Why are Tires So Important?

- Vehicle Dynamics Encompasses
  - Acceleration and Braking
  - Cornering (Handling)
  - Ride
- Tires
  - The primary source of force
  - Most important to vehicle dynamists



History

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- 120 years of History
- First engineers had no questions about tires but were worried about where to put the wheels

Cugnot tractor

1769

1901 Mabley

1 in the front

1 in back

1 on each side

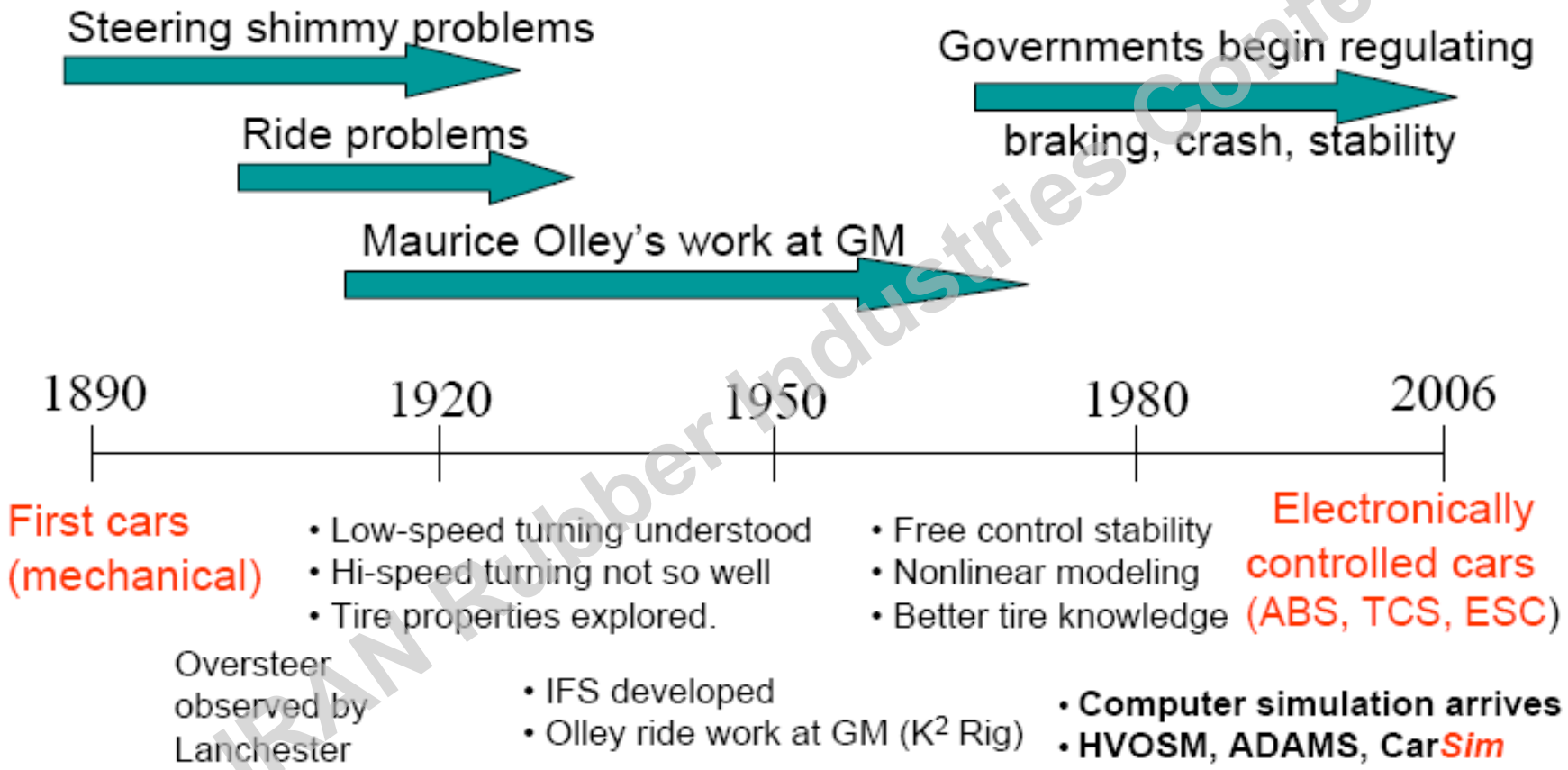
3 wheels

2 in the front

3 wheels

2 in the rear

History



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State of Knowledge-1930s

- Knowledge of Vehicle Dynamics
  - Mechanics of low speed turning
  - Stability
  - Mechanisms of front wheel shimmy
- Knowledge of Tire Behavior
  - Growing awareness of slip angle in cornering
  - First tire dynamometer developed at the University of Berlin in 1931
  - Focus on cornering force and aligning moment

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State of Knowledge-1950s

- Vehicle Dynamics-Linear Models
  - Understeer/Oversteer understood
  - Critical speed was explained
  - Natural frequency of yaw and lateral acceleration were known
  - Influence of suspension properties
  - Interest in modeling transient response
- Knowledge of tire behavior
  - Tire Relaxation length understood
  - Turning frequency response up to 2HZ

History

State of Knowledge-1970s

- Free-control stability and response
- Modeling nonlinear response up to turning limits
- Influence of steering feedback on driver opinion
- Better understanding of tires
- GM establishes Tire Performance Criteria
  - Endurance
  - Handling
  - Speed Rating
  - Traction
  - Ride
  - Uniformity

History

1970s-Present

- Vehicle dynamics is controlled by electronics
  - Response is “tuned” to driving situation
  - Intervention at the brakes, suspension, steering
    - ABS and Traction Control
    - Electronic Stability Control
    - Active Suspension
    - Active Roll Control
    - Adaptive Cruise Control
    - Active Crash Avoidance
    - Lane Departure Detection
- Tire Dynamics
  - FE models were developed and are used on the daily basis
  - Analytical and semi-empirical models were developed

Advanced Technologies

- Advanced Measurement & Hardware-in-the-loop systems
- Fast and reliable FEA tools
- Direct synthesis through optimization
- Intelligent Transportation/Autonomous Driving
  - Intelligent Tires
  - Integrated Chassis Control
  - IVS

Conclusions

- High Fidelity tire/vehicle models have become part of the tire design process
  - Analytical models
  - FE models
- Hardware-in-the-loop systems are finding their ways to the tire industry
  - Static simulators
  - Motion base simulators
  - ABS/VSC HIL systems
- The tire industry is moving toward smart and intelligent tires
  - Reduce rolling resistance
  - Improve performance
  - Predict tire load (for truck applications)
  - Predict road friction (for chassis control)

Thank You!
Questions?