# STEERING PERFORMACE SIMULATION OF AGRICULTURAL TRACKED TRACTORS USING ADAMS

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Abstract

The development of rubber tracks has made attractive the use of tracked vehicles for agricultural purpose. One important point in the design of these vehicles is the steering system due to the high turning resistance of tracked machines. In this paper a model for steering performance simulation of agricultural tracked vehicles is presented. The model was developed using ADAMS (Automatic Dynamic Analysis of Mechanical System). A set of FORTRAN subroutines and macros was developed to create a parametric model of the vehicle to simulate the power train system and to calculate the forces in the track-soil interface. From the characteristics of the system and the soil, the user can predict the trajectory of the vehicle in the field as a function of the input to the steering wheel. This permits a designer to change components in the vehicle and see what influence this has on steering. The model has shown to be flexible and very ease to use. This model is going to be validated in the future based on experimental tests.

# ADAMS Applications at John Deere

by
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Abstract

This oral only video presentation will briefly cover several recent ADAMS applications within John Deere with an emphasis on vehicle dynamics. Included will be examples of ride simulation, load prediction, lateral stability, handling, power hop, power train modeling, inclusion of friction forces in joints, hydraulic system modeling and clearance checking within the ProE environment.

Notes:

For each of the examples, I'd like to start with video footage of an actual machine and follow that with an animation of the ADAMS model of that machine.

| | |
|---|---|
| ride simulation - | row crop tractor on rough track followed by one third octave acceleration plot and then animated tractor vibration modes |
| load prediction - | use combine footage with actual test followed by simulation model |
| lateral stability - | combine on tilt table (quasi static analysis followed by Gator making a hard turn |
| handling - | lane change maneuver, first of production tractor, seeder and cart (stable) followed by a concept configuration that was unstable - then show related model of lightweight five gang fairway mower making a 180 degree turn |
| power hop - | animation of unstable and stable configurations, plot of root locus for unstable mode and animation of unstable mode |
| power train modeling - | industrial four wheel drive loader model that had models of engine, torque converter and axle differentials |
| friction - | transmission shift analysis including joint friction effects |
| hydraulic system modeling - | model of bucket leveling system on backhoe loaders |
| clearance checking - | use of MDI's MECHANISM/Pro product to define ADAMS model from within ProE, resultant clearance checking analysis and animation of model using the log skidder grapple as an example |

# 1995 INTERNATIONAL ADAMS CONFERENCE

## INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

K. D. BOWLAND

# INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

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ADAMS is a proven tool for design and analysis of vehicle dynamics. Specifically, there has been much success in modeling off-highway equipment to determine design parameters such as hydraulics, operator visibility, vehicle stability and much more.

In general, the designer and engineer are responsible for creating an off-road vehicle with superior performance, handling and ride characteristics. These characteristics determine the behavior of the vehicle but are impacted by inputs from the driver as well as the physical environment.

In many cases, the ADAMS model of these vehicles represent a validated prototype of the vehicle itself with all the suspension, linkage, hydraulic, tire and even driver elements; however, the physical environment such as soil characteristics is rarely included.

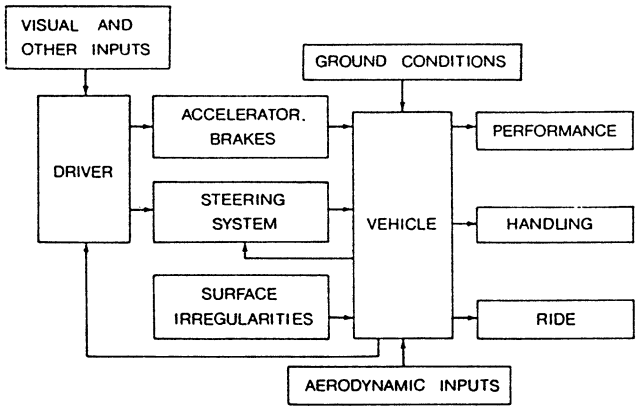


**Fig. 1** The driver-vehicle-ground system.
(Reference: "Theory of Ground Vehicles", J.Y. Wong, Ph.D.)

Whether the running gear is a tire or track, an ADAMS model which incorporates the interaction between an off-road vehicle and its physical environment, a study called terramechanics, would create more realistic conditions and allow for better design evaluation of the overall system.

# INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

# GENERAL OVERVIEW

## ASSUMPTIONS

- -- Homogeneous Material/Soil
- -- Elasto-plastic Material

## SOIL VARIATIONS

- -- Disturbed vs. Undisturbed
- -- Cohesion vs. Friction

## SOIL CATEGORIZATION

- -- Hard/Dry
- -- Fairly Moist
- -- Wet

## SOIL CHARACTERISTICS

- -- Elastic
- -- Plastic Equilibrium
- -- Plastic

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# INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

# TRACK ELEMENT

## ASSUMPTIONS

- -- Non-flexible Track
- -- Homogeneous Material/Soil
- -- Uniform Pressure Distribution
- -- Plate

## BEARING CAPACITY/CRITICAL LOAD

- -- Load Per Unit Contact Area at Failure
- -- Non-cohesive Soils / Width
- -- Cohesive Soils / Contact Area

## MOTION RESISTANCE

- -- Sinkage / Soil Characteristics
- -- Bulldozing Resistance (Frontal Drag)

## TRACTIVE EFFORT

- -- Non-cohesive Soil / Vehicle Weight
- -- Cohesive Soil / Contact Area
- -- Thrust and Slip
- -- Drawbar Pull

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# INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

## DESIGN APPLICATIONS

### CUTTING BLADES
- -- Vertical Blade vs. Inclined
- -- Power Requirements / Blade Force

### TRACK DIMENSIONS
- -- Contact Area
- -- Width
- -- Length

### TIRE PARAMETERS
- -- Wheel Diameter
- -- Pressure Requirements

### LUGS / GROUSER DESIGN
- -- Spacing
- -- Dimensions

### MATERIAL SPECIFICATIONS
- -- Smoothness of Surface

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# INTRODUCING TERRAMECHANICS INTO ADAMS MODELS OF OFF-HIGHWAY VEHICLES

## MODELING IN ADAMS

**Introducing terramechanics into ADAMS models of off-road vehicles allows both the designer and engineer to predict and tune the performance characteristics of their system with an even more realistic environment.**

### DESIGN OF EXPERIMENTS / OPTIMIZATION
- -- Determine Soil Categories
- -- Design Objective Based on Sinkage Limit

### WHEEL TORQUE / ENGINE INPUTS
- -- Consideration of Soil and Sinkage

### TIRE INTERACTION
- -- Tapping into Current Tire Algorithms

### FRICTION ANALYSIS
- -- Model Friction of Surface and Soil

### 2D ANALYSIS IN COMPUTER
- -- Bring to 3D with full vehicle

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