



A Simulation Environment for Excavator Dynamics

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Excavator

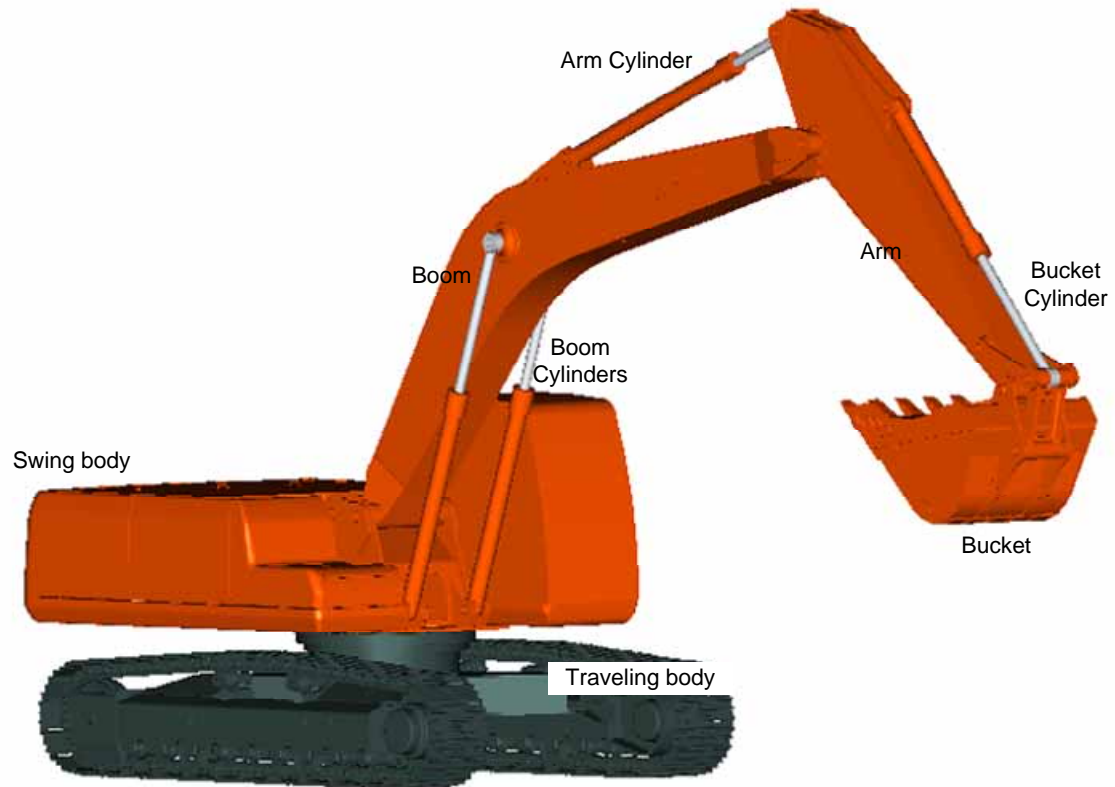


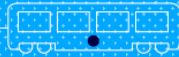
Mechanical Structure

- Travelling body
- Swing body
- Front manipulator

Driving Mechanism

- Hydraulic system
 - Pumps
 - Valves
 - Actuators





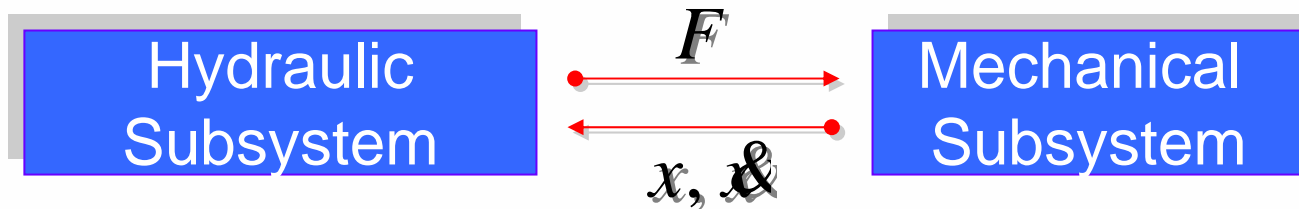
Excavator Dynamics



Why Coupled Dynamics?

- Mechanical dynamics associated with swing, boom, arm & bucket motions
- Hydraulic system dynamics due to compressibility of hydraulic oil

Dynamic Coupling between Mechanical & Hydraulic system





Coupled Excavator Dynamics



Action items under Virtual Product Development

- Improving dynamic performances
- Improving ride quality
- Optimizing structure shapes
- Model-based control system design

Reduces development cost & shortens time-to-market



Requirements for Software Tools



Multi-body Dynamics Software

- Flexible bodies
- Wheeled & tracked excavators
- Seamless interfaces to other analysis tools such as durability analysis

Hydraulic System Software

- Interfaces to multi-body dynamics software
- Can cope with stiff & nonlinear models



Software Tools



MSC.ADAMS

- Various modules to aid the modeling process
 - ADAMS/Flex, ADAMS/Tire, ATV
- 3 different simulation methods through ADAMS/Controls
 - Continuous, discrete, control system import

MATLAB/Simulink

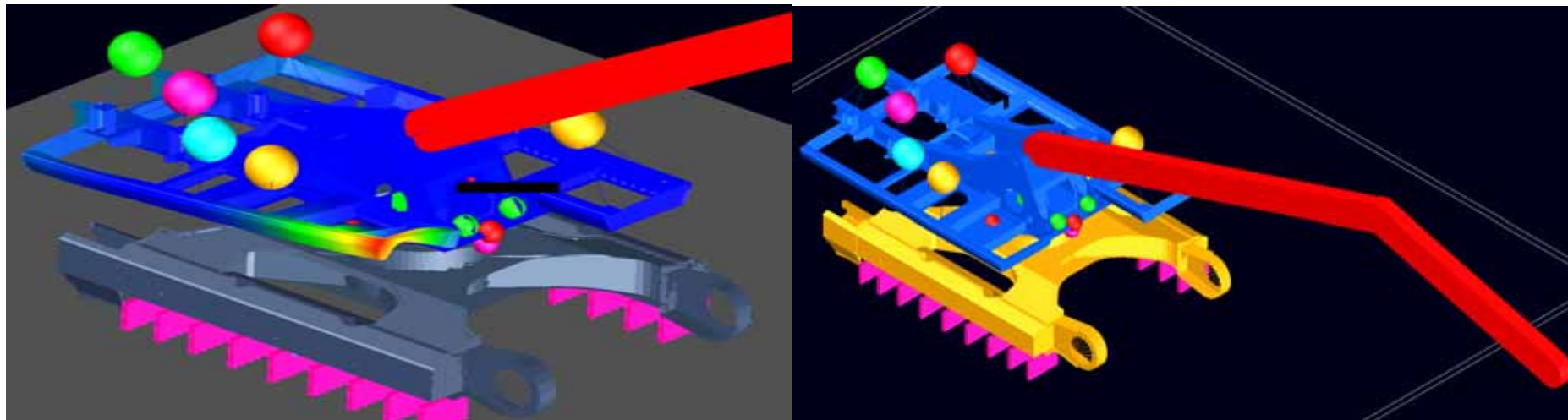
- General purpose simulation tool
- Interfaces to various commercial engineering tools
- Easy to implement advanced control schemes

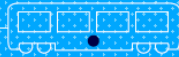


MSC.ADAMS Model



- Includes flexible bodies for swing & track frames
- Uses contact element array for the ground contact
- Uses SFORCE elements for plant input forces from hydraulic system

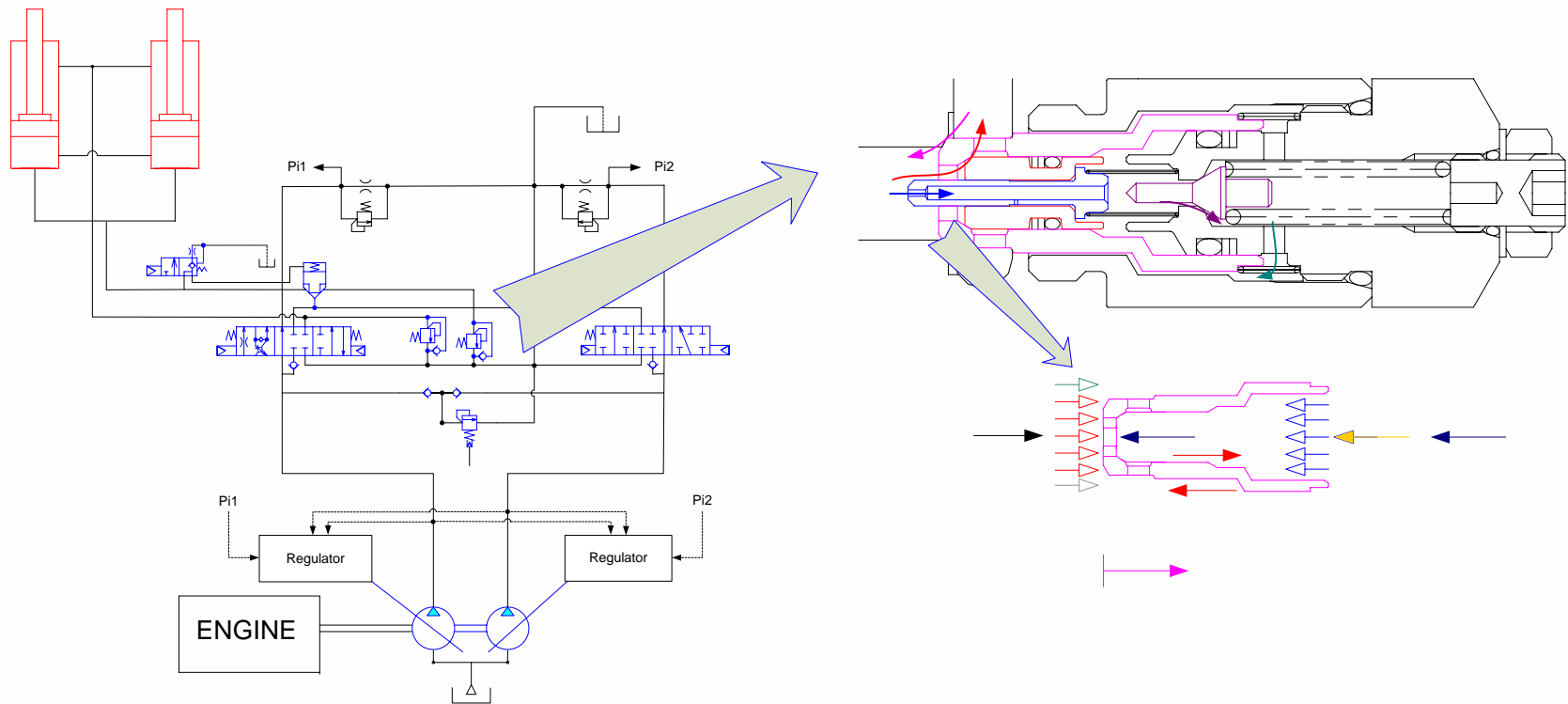




Hydraulic System Model



Hydraulic circuit for boom motion



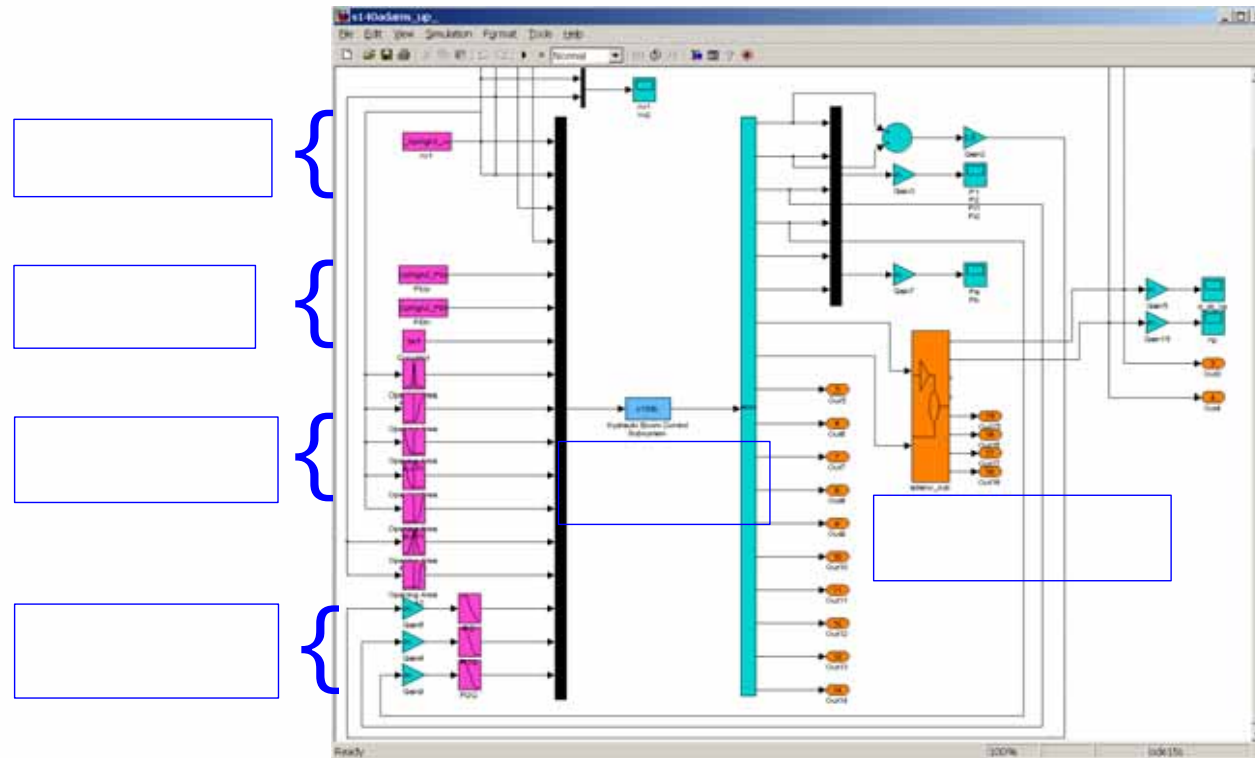
PRODUCT DEVELOPMENT CONFERENCE



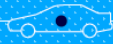
Simulation Environment



ADAMS-Simulink
Co-simulation
Environment



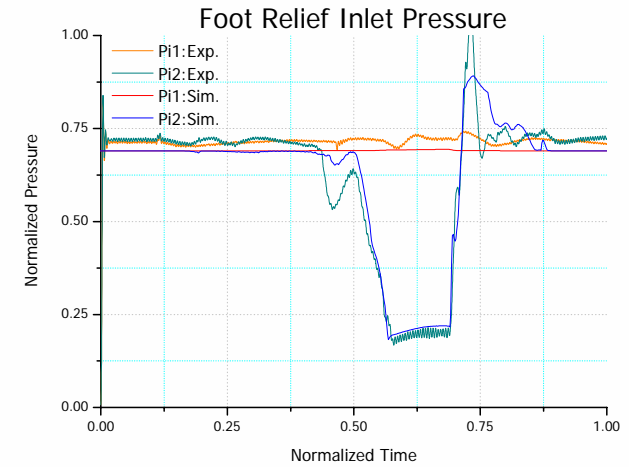
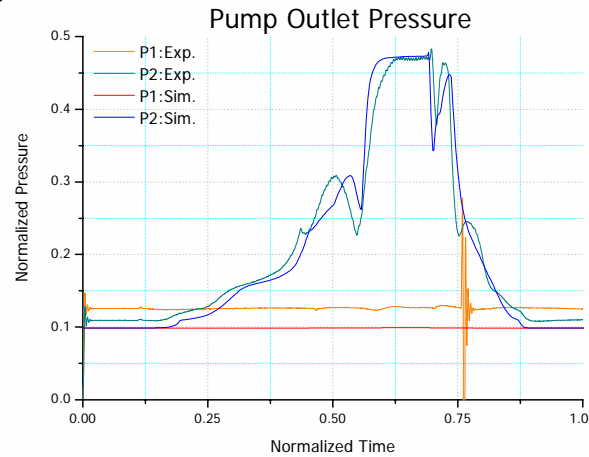
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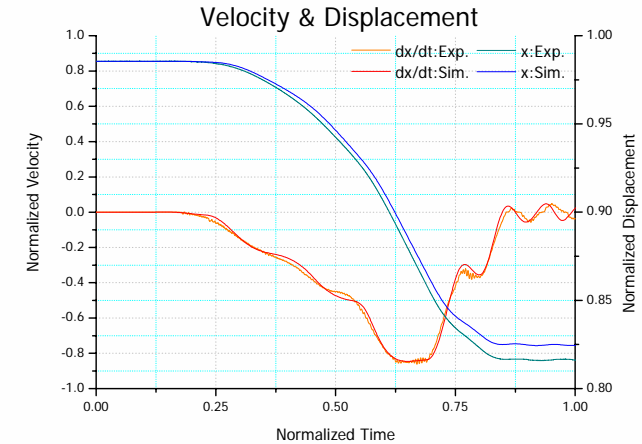
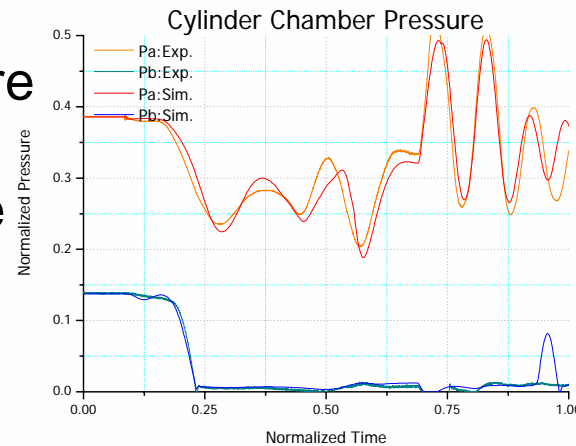
Simulation: Hydraulic System



- Pump related pressures

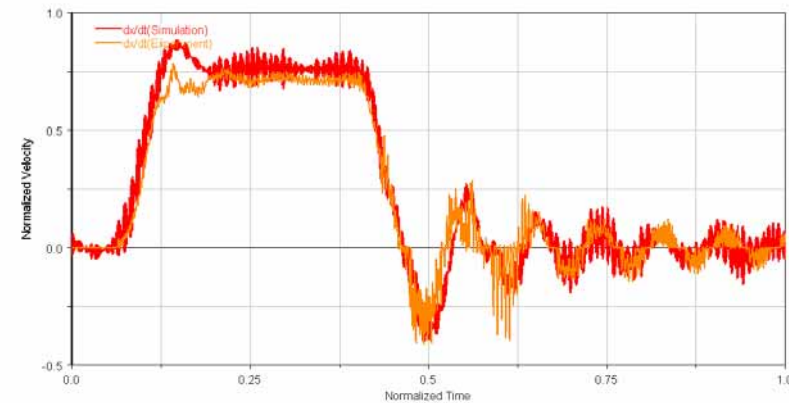
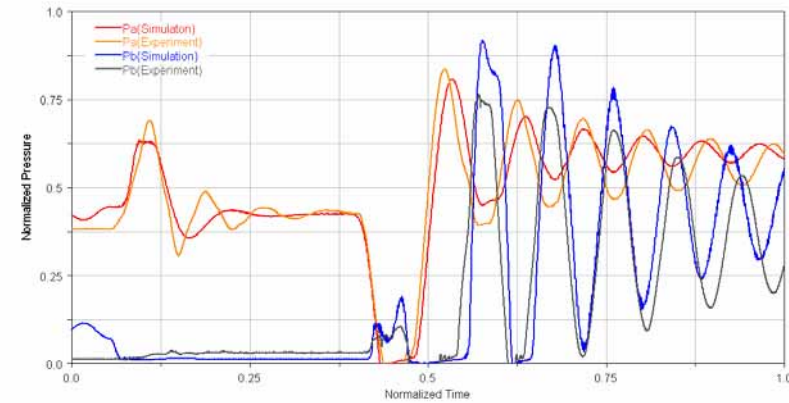
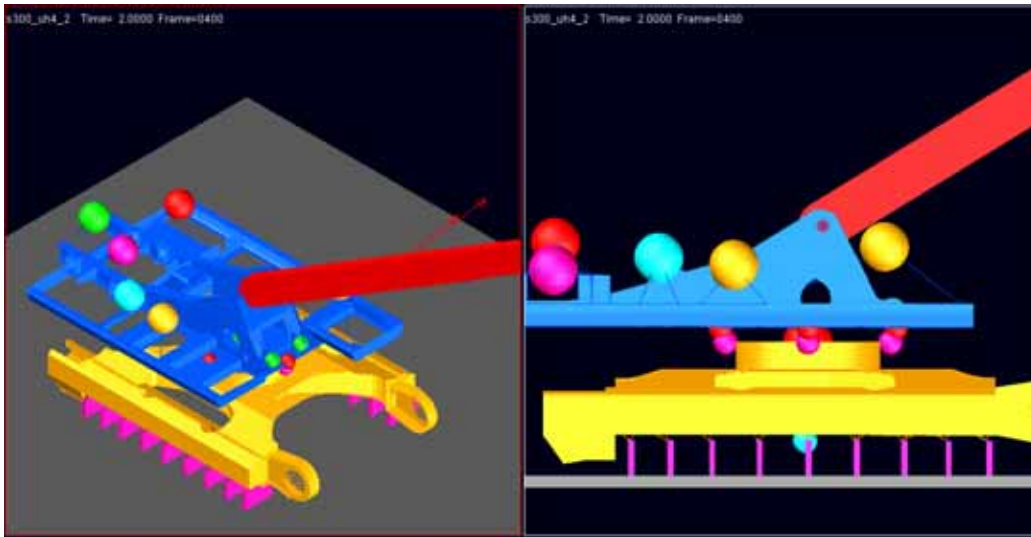


- Cylinder pressure & velocity/displacement





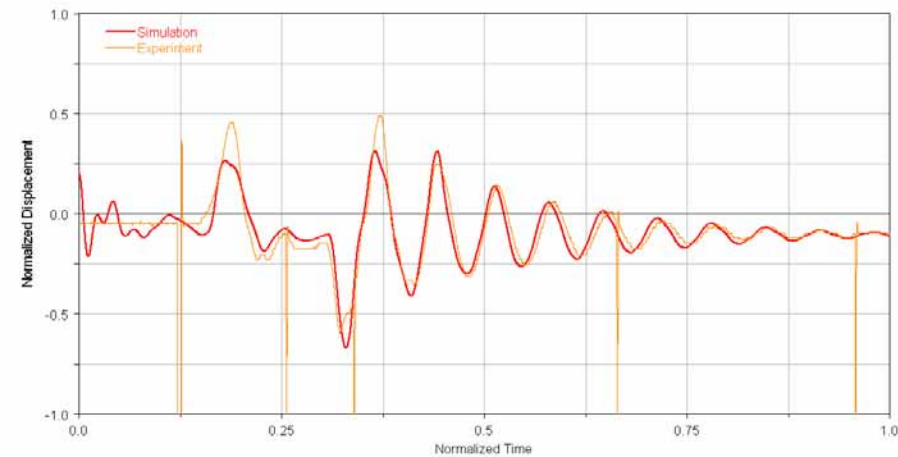
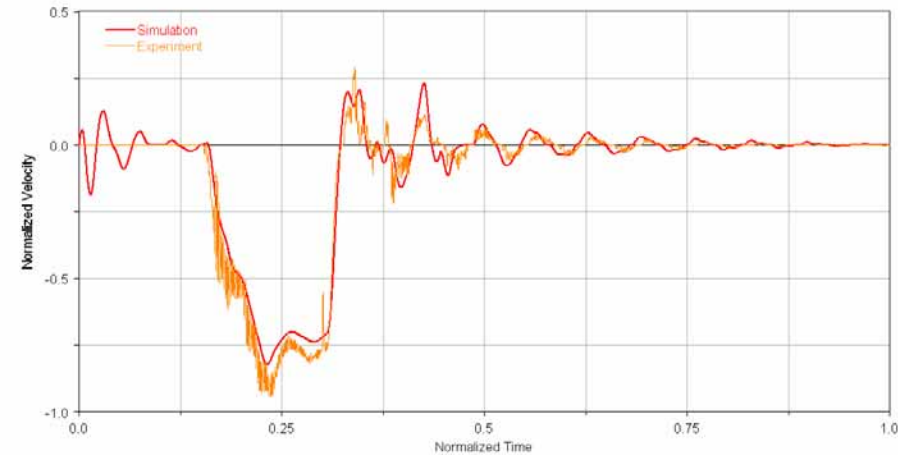
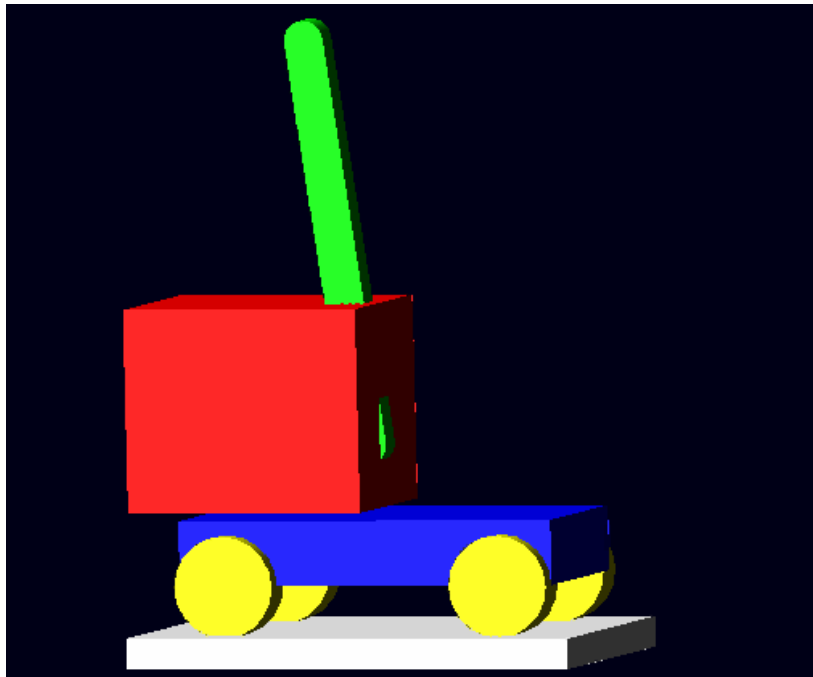
Simulation: Overall Dynamic Behavior



PRODUCT DEVELOPMENT CONFERENCE



Simulation: Wheeled Excavator



PRODUCT DEVELOPMENT CONFERENCE



Concluding Remarks



Simulation Environment for Excavator Dynamics

- Uses MSC.ADAMS-Simulink co-simulation
- Shows reasonable simulation accuracy
- Can be substituted for ADAMS-EASY5 environment

Simulation of Simultaneous Motion is On-going