Empowering Engineering Refinement

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<th>Aerospace</th>
<th>Automotive Industries</th>
<th>Mechanical &amp; Process Industries</th>
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<tr>
<td>Acoustics, Motion, Structural Dynamics &amp; Fatigue Engineering</td>
<td>NVH, Durability and Motion Engineering</td>
<td>Noise, Vibration &amp; Fatigue Engineering</td>
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Optimizing tasks & creating process-centric solutions
Enabling a “Process-Centric” Approach...

Supporting engineering decisions for critical design attributes throughout the entire process
Empowering Engineering Refinement
Based on Test & Simulation

Forces From Test
FE Model
Synthesis
Test Model
Simulation Model

VIRTUAL REFINEMENT

Best of both worlds: loads, models, methodologies

ARC - May 1999
Engineering Refinement Process

Concept
- TARGET
- CONCEPT
- REFINE

Virtual Prototype
- DESIGN
- MODEL
- ANALYZE
- REFINE

Physical Prototype
- BUILD
- TEST
- ANALYZE
- REFINE

Engineering Refinement Process

 ARC - May 1999
Empowering Engineering Refinement

Best-of-Class Solutions for MTEST & MCAE

- Physical Prototype Testing
  - Mobile Testing
  - Acoustic testing
  - Structural Testing
  - Durability Lab Testing Simulation

- Virtual Prototype Simulation
  - Vibro-acoustic simulation
  - Fatigue simulation
  - Motion Simulation
  - Structural Integrity Simulation
LMS International  -  Leading by Innovation

The fastest growing provider of engineering solutions

Market leader in Physical Test

Technology leader in multi-disciplinary Virtual Prototyping
A Track Record of Growth, Profitability, and Business Transformation

- 500 people in 15 offices worldwide
- $100m revenues
- expanding by organic growth and acquisitions
- partnering with the best in the industry
Preferred Partner For
Leading Manufacturers Worldwide

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<td>AUDI</td>
<td>VOLKSWAGEN</td>
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<td>BENDIX</td>
<td>NAVISTAR</td>
<td>HARRIS CORPORATION</td>
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| HYUNDAI          | BORG WARNER      | PIRELLI          | HUGHES AIRCRAFT-
| ISUZU            | BOSCH            | RIETER           | IABG             |
| JAGUAR           | BRIDGESTONE      | VALEO            | LOCKHEED MARTIN  |
| LOTUS            | CALSONIC         | WALKER           | LORAL            |
| MITSUBISHI       | COLLINS & AIKMAN | ZF               | NASA             |
| NISSAN           | CONTINENTAL      | AERODYNE         | NASDA            |
| PORSCHE          | DAYCO            | AEROSPATIALE     | NORTHROP         |
| PSA              | DELPHI           | AGUSTA           | ORBITAL SCIENCES CORP. |
| RENAULT          | DONALDSON        | ALENIA           | PRATT & WHITNEY  |
| ROVER            | DUNLOP           | BMW ROLES ROYCE  | RAYTHEON         |
| SAMSUNG MOTOR    | EATON            | BOEING           | ROCKWELL ROCKETDYNE |
| SKODA            | FIRESTONE        | BRITISH AEROSPACE | SIKORSKY        |
| SUBARU           | GILLET           | CASA             | SNECMA           |
| SUZUKI           | GKN              | CESSNA           | TRW              |
| TOYOTA           |                  |                  | WESTLAND HELICOPTER |
Why Mechanical Simulation?

- Inexpensive vs. physical testing
- More versatile than testing
  - hazardous conditions
  - “what if” testing
- Visualize system performance
- Increase knowledge of system performance
- Integration with CAD/CAE enables collaborative engineering
- Improve product quality
- Shorten time to market

www.lmscadsi.com
Key Vehicle Applications

- Stability
- Performance
- Durability
DADS Consulting for Deere

*Deere agricultural vehicles*

- Enhanced tire model to simulate soil interaction
- Simulated new Deere rubber tracked system
- Modeled details of track lugs and soil deformation using custom consulting solution
Flexible Rear Axle Simulation
TACOM Truck Models

- Tacom has used DADS for nearly 16 years
- Standard for vendor simulation on proposed vehicle designs & remanufacture
- Recognized as simulation leader throughout the Army and other military sites
Fifth Wheel Lock Mechanism

- Complex contact events occur as the handle releases the 5th wheel coupler
- Predict force to open latch and how quickly it closes
DADS/Plant

Simulating Controlled Mechanisms
DADS/Plant

Integrated with Matlab, MATRIXx, EASY5

- Pass position and velocity of points on specific bodies from DADS/Plant to Matlab
- Forces and torques from Matlab act on DADS/Plant bodies
- Call DADS/Plant as a subroutine
- Numerical integration performed in Matlab
**Tank Mounted Gun Barrel**

- **Objective:** Design motor drivers to move gun barrel quickly, but with minimal vibration
- Gimbal assembly with flexible gun barrel modeled in DADS/Plant
- Flex modes imported from ANSYS
- Simulation performed in SIMULINK
- Compare rigid vs. flexible models
  - Animation
  - Plots: Torque on elevation axis
  - Torque on azimuth axis
**DADS/Plant**

*Integrated with MATLAB*

- DADS mechanical system coupled with MATLAB control system model
- Simulation performed in SIMULINK
- Photo-realistic animation of mechanical system motion
- Calculate/plot reaction loads
- Verify controller design
SYSNOISE
System for Computational Vibro-Acoustics
What is Acoustics?

**Source**
- vibrating body
- speaker

**Propagation**
- sound path & absorption
  - airborne
  - structure-borne
  - mixed

**Receiver**
- microphone
- ear
SYSNOISE/FEM Transient

- Extension of SYSNOISE/FEM Harmonic
  - to the time-domain
- Absorbing panels
- Vibrating panels (accelerations)
- Acoustic sources
- Calculation
  - Transient response
**SYSNOISE/BEM & FEM Harmonic Coupling**

- **Complement of SYSNOISE/BEM or FEM Harmonic**
  - see SYSNOISE/BEM or FEM for the fluid
  - acoustic BEM or FEM model is coupled to a structure

- **Structure**
  - modeled by finite elements
    - modal coordinates
    - physical coordinates
  - structural modal damping

- **Coupling**
  - weak or strong fluid-structure link

- **Possibility of random analysis**
  - random acoustic and mechanical excitations, diffuse field, ...
Multi-Domain Capabilities

- Acoustic FEM + Direct BEM
  - fluid-fluid link
  - forced frequency response
- Multiple Direct BEM
  - fluid-fluid link
  - forced frequency response