

# Iterative Mechanism Solutions with Scenario and ADAMS

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Premium Partners:



Microsoft

# What We'll Cover

- Introduce legacy processes and associated pains
- Present what we're doing today using NX Scenario for Motion
- Share a vision of future processes we'd like to use and what we need to get there

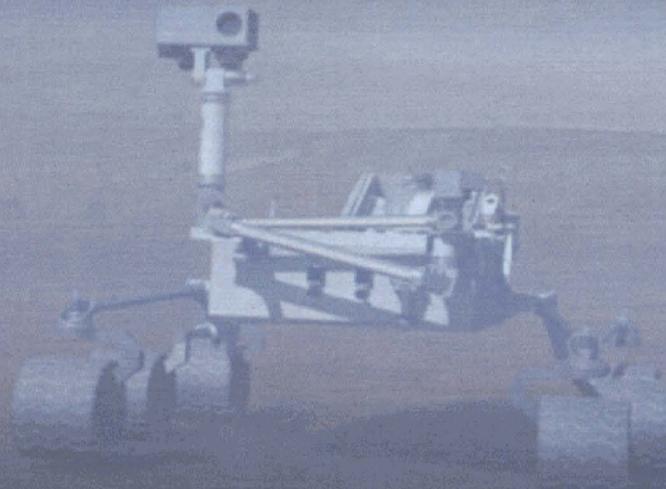
# The Project



- Mars Science Laboratory (MSL)
  - New mission launches in 2009 to continue exploration for life on Mars
  - Currently in Preliminary Design phase
  - Single, larger rover
    - “Skycrane” landing
    - “Rocker-Bogie” suspension system with 6 wheel drive
  - <http://mars.jpl.nasa.gov/msl>

# The Load Cases

## Mars Science Laboratory



# Overview

- Key Rover Mechanical Design Requirements
  - Landing and driving (traverse) loads on rover
  - Rover to land on “mobility” system (wheels and suspension)
  - Able to accommodate high uncertainty in landing site (rocks, slope, etc.)
  - Rover mobility system articulation and functionality
  - Design loads based on dynamic events

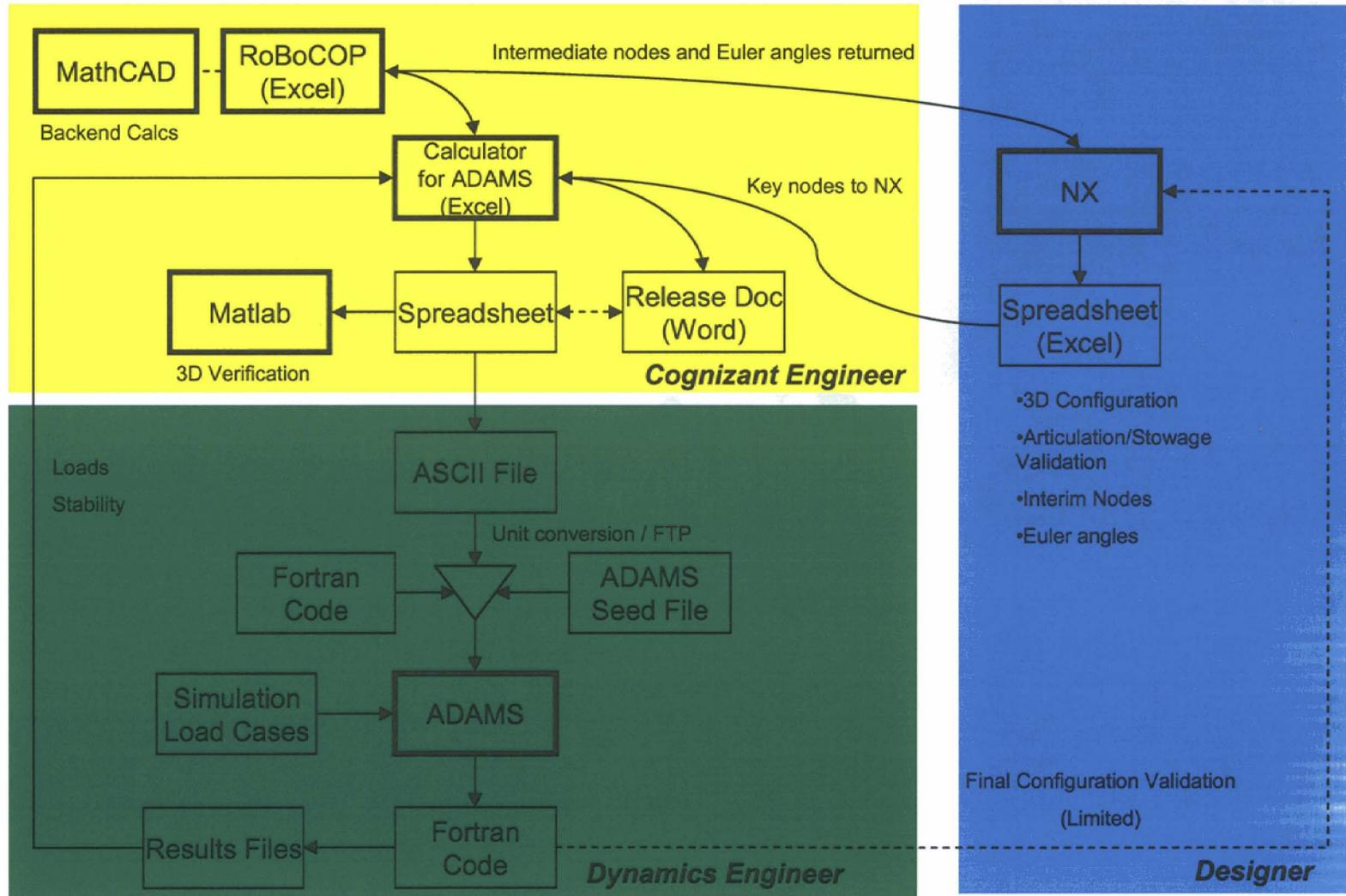
# Overview

- Overview of design process
  - Design for static stability
  - Simulate mechanism kinematics
  - Simulate dynamic behavior in multiple cases and extract loads
  - Reconfigure design as required
  - Reiterate

# The Legacy Process

- Process was used on the Mars Exploration Rovers, Spirit and Opportunity
  - It works- 2 years and still going!
- But... it's cumbersome
  - Distributed team
  - Difficult functional interaction
  - Manual "over-the-fence" processes
  - Limited designer tools- only dynamics engineer has insight to dynamic behavior

# The Legacy Process- Process Map



# Where we are...

- **Multiple tools**
  - Mathcad, Excel, Matlab, UGS NX 3, Teamcenter Engineering, ADAMS 2005, Custom Scripts, Custom Fortran applications
- **Limited configuration control**
- **Manual processes and communication**
  - Inherent human errors
- **Multiple steps**
- **Distributed Team**
- **Cumbersome data validation methods**

# Where we are...

- Limited data distribution
  - Text file with summary of key results
  - Dissemination via email
  - No visualization
- Analysis Model
  - Manually maintained
  - Over 2000 combinations of test parameters!
  - Simplifications manually correlated and documented

# Where we're going...

- Reduce turn around time
  - More iterations possible
- Reduce labor costs
- Improve quality of available data
  - More reliable information – capture and validate assumptions
- Improve quantity of available data
  - More usable information for decision making
- Enhanced Configuration Control
  - Reusability
  - Quality
  - Accountability
  - Troubleshooting

# Where we're going...

- Toolset Reduction
  - Less maintenance, cost, and training
- Data Validation
  - Quick validity checks and visualization
- Data Dissemination
  - Access to data consumers in a configuration controlled, easily visualized environment
- Data Management
  - Tools for querying thousands of results files

# Future Process Map

*Cognizant Engineer*

Configuration Spreadsheet

*Excel*

*Designer*

3D Assembly

*Dynamics Engineer*

Simplified Dynamics Model

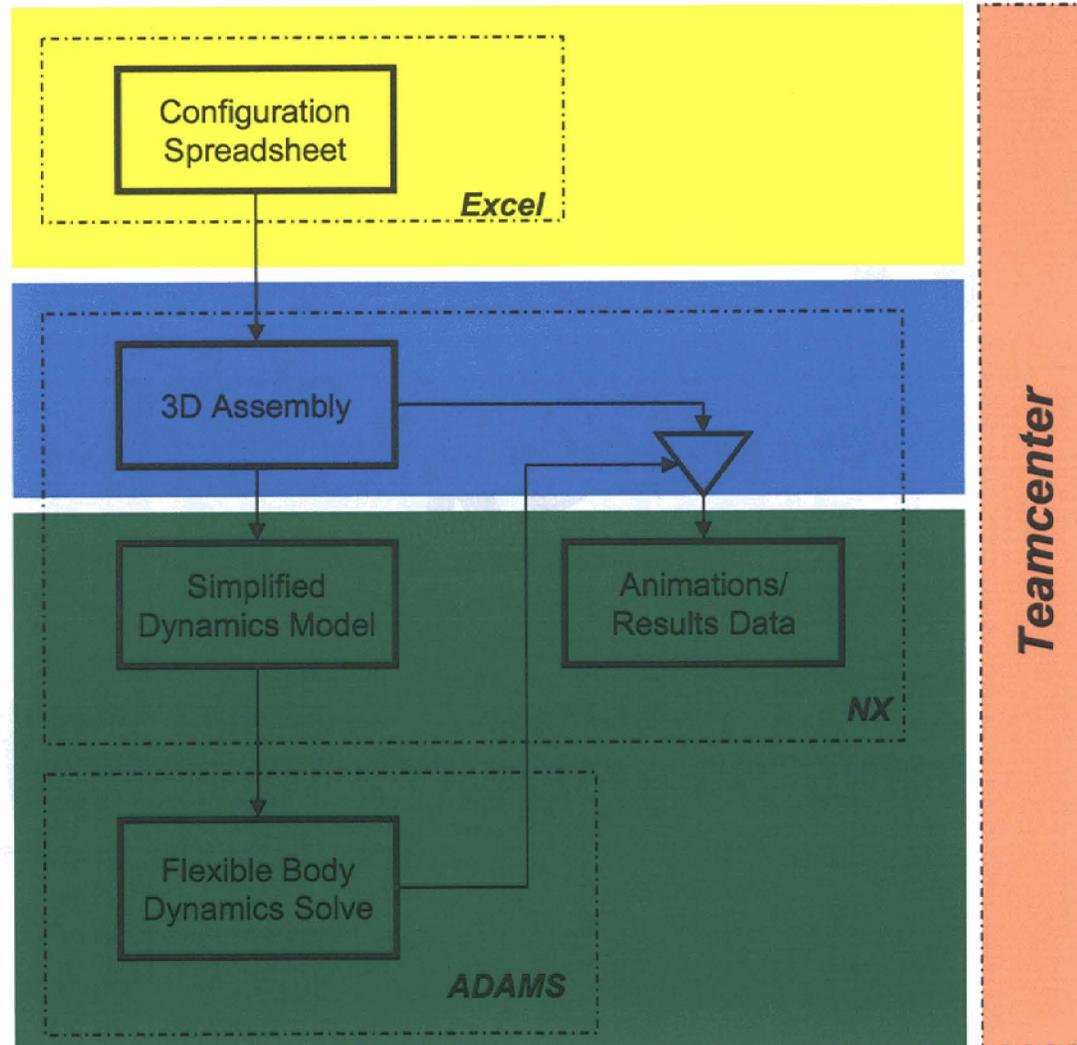
Animations/  
Results Data

Flexible Body Dynamics Solve

*ADAMS*

*NX*

*Teamcenter*



# Current uses for NX Scenario for Motion

- Articulation studies
  - Joint Rotations to determine hard-stops
  - Reachability
  - Keep out volumes
- Traverse simulations
  - Hazard negotiation
  - Visual insight
- Subsystem simulations
  - Mobility system deployment
  - Camera mast deployment

# Rover Traverse Model

- Simple model
  - Rigid body links with asserted mass properties
  - Revolute and spherical joints
  - Solid body contact with friction
- *Insert Video of Traverse Here*

# Rover Landing Model

- For accurate results, requires flexible elements, such as beams
- Must use full ADAMS solver
- Over 2000 iterations using repositioned contact surface
  - “Worst-on-worst” simulation
- *Insert video of landing event here*

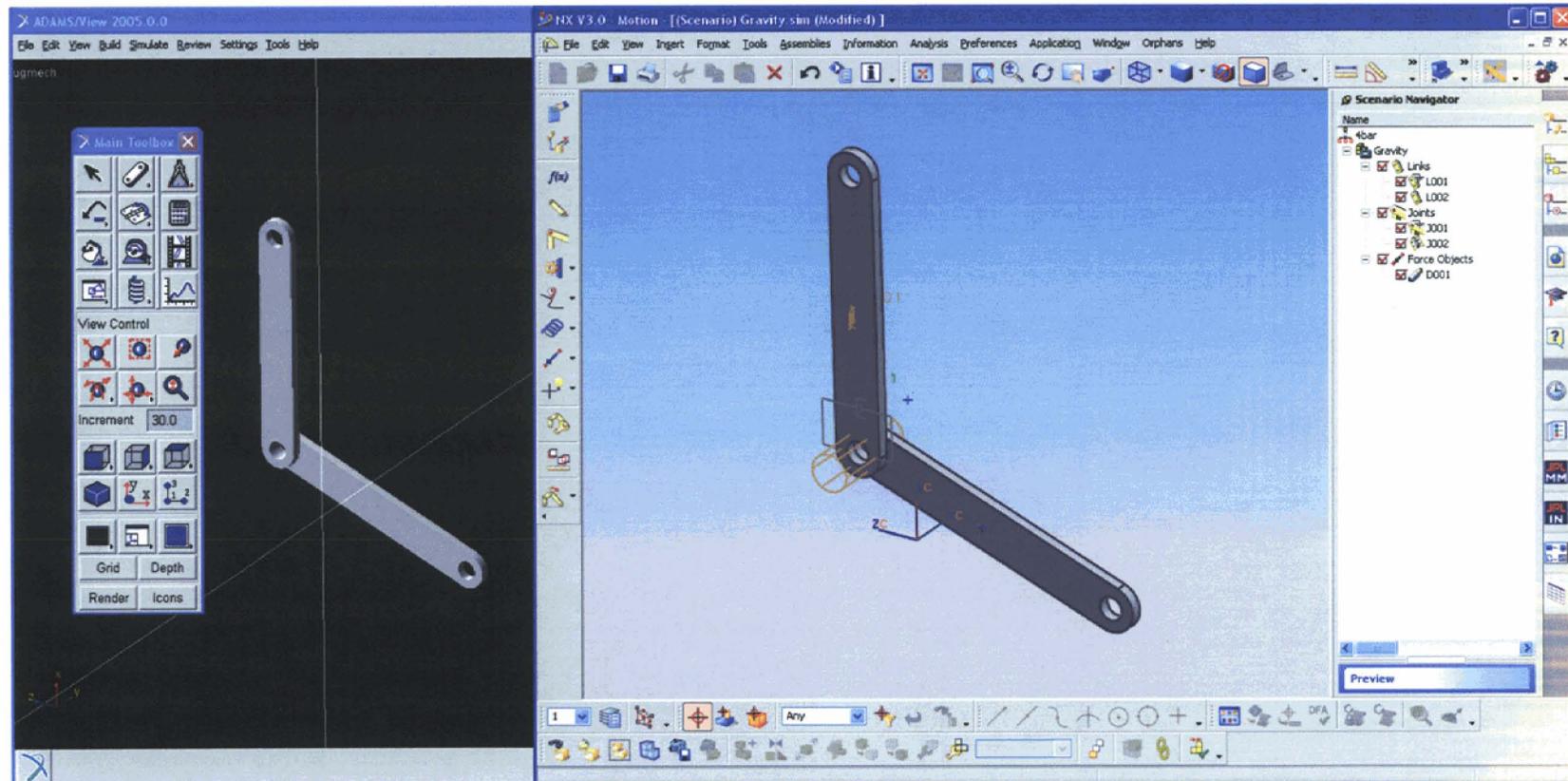
# Process Implementation

- Maintain all data in standard tools
  - NX 3 / Teamcenter Engineering
- Embedded and linked spreadsheets
  - Managed by Teamcenter
- Direct solutions using Scenario for Motion, when feasible
  - Kinematic simulations
  - Multi-body dynamics simulations (vs. flexible body dynamics)

# Process Implementation

- Direct translation from Scenario to ADAMS
  - When required
  - Append additional data in ascii format to ADAMS solution file exported from NX
  - Manage data not supported by Scenario in integrated spreadsheet
- Custom applications for
  - Appending unsupported data info to ADAMS solution file
  - Interrogating multiple results sets

# Getting from NX to ADAMS



# NX to ADAMS- Process

1. Create Scenario Model
2. Export to ADAMS
  - “.anl” is same as “.adm” file
  - Include geometry if necessary
3. Edit .anl file manually as required
4. Solve with ADAMS
5. Export results file (.xml supported)
6. “Animation- Review Results” in Scenario
7. Visualize in Scenario

# Managing Data

- Integrated Teamcenter Management:
  - Parts
  - Assemblies
  - Scenarios
- Manual Teamcenter Management:
  - Spreadsheets (unless embedded in part file)
  - ADAMS solver (.adm) files
  - Results files created in ADAMS (.res)
  - Animation files (.avi, .mpg, .mov)

# Future Direction for Scenario for Motion

- Functional request wish list goes here...
- Flexible body support (NX6 ?)
- Flexible beam support (NX5 ?)
- Additional classes supported in Knowledge Fusion in NX4
  - Springs
  - Dampers
  - General Bushings

# Summary

- Legacy process was a painful, distributed process... but it worked
- Scenario for Motion currently in use for limited analysis
- Working toward a fully integrated solution
- Many hurdles to overcome
  - Additional functionality and processes needed
  - Cultural shift
  - Must demonstrate value, reliability, of process