NASA
Jet Propulsion Laboratory
Mars Science Laboratory Project

Mission Scenario
Development Workbench

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Agenda

- **Overview**
- **Application**
- **Tool Description**
- **Tool Architecture**
- **Results**
- **Benefits**
- **Summary**

Overview

- The Mars Science Laboratory Project team has developed a capability that enables rapid
  - Scenario development for space mission planning
  - Hardware trades
  - Provides a means to accurately evaluate the spacecraft performance
- The Mission Scenario Development tool was created to
  - Reduce risk (understand ability to meet mission success criteria)
  - Understand design sensitivities
  - Maximize the use of limited spacecraft resources
- The objective of the MSL mission is to measure the potential habitability of life on the surface of Mars for about 2 Earth years.
- Capability focused on surface ops but will be used for other mission phases.
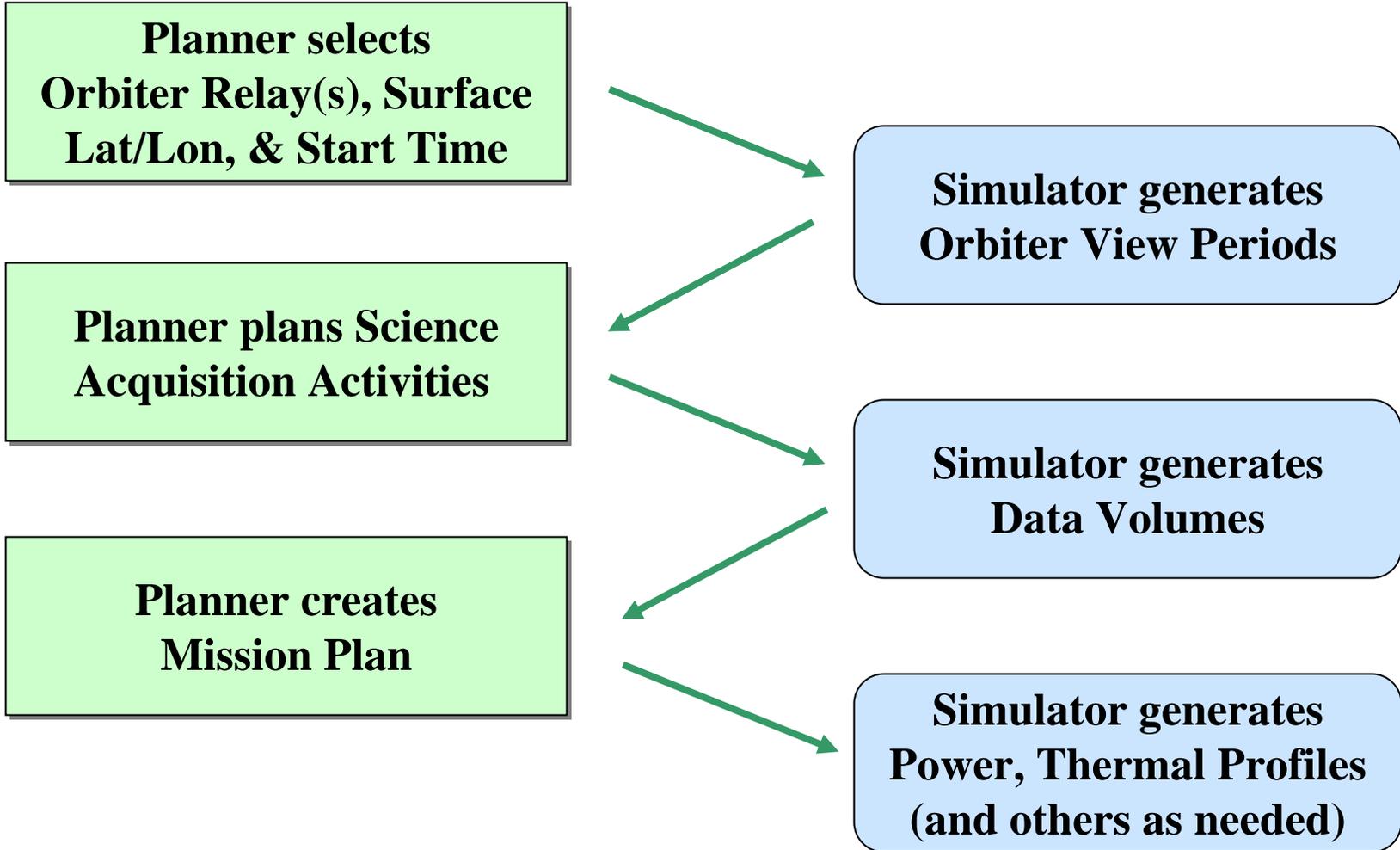
Application

- One key mission success criteria is the amount of science data returned to Earth.

- Mars rovers rely heavily on orbiting communication assets to relay large data volumes back to Earth which makes end-to-end analysis complex.

- Space vehicle science measurement acquisition, data compression & storage and then relay of data is modeled using this tool.

- The results tell the team if the mission, as currently designed, can be successful and operate with sufficient resources (power, thermal, data memory, telecom link performance, etc.).

Mission Scenario Development Workbench Planning Process

Planner selects Orbiter Relay(s), Surface Lat/Lon, & Start Time

Simulator generates Orbiter View Periods

Planner plans Science Acquisition Activities

Simulator generates Data Volumes

Planner creates Mission Plan

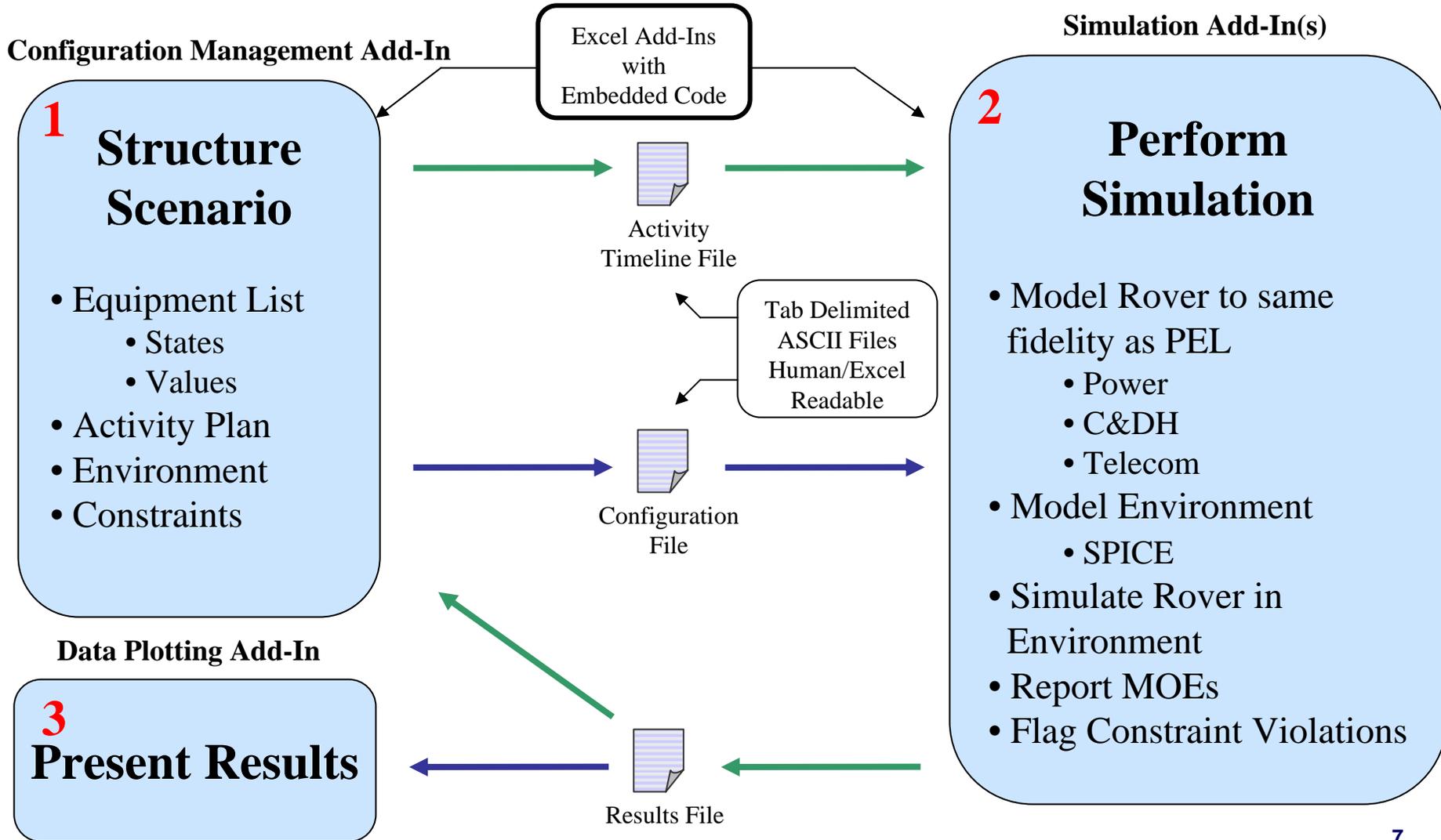**Simulator generates Power, Thermal Profiles (and others as needed)**

About the Tool

- Previously, standalone PC based simulation tools were developed to support high-fidelity spacecraft performance analysis such as on the Mars Exploration Rover and Deep Impact space missions.

- Using heritage simulators with models that had been validated added to the value and credibility of the toll results

- Microsoft Excel was used to integrate all of these existing simulators and provide a user-friendly front-end for the tool.

- Using Excel also allowed for the tool to be run on Mac or PC

- Custom Excel 'add-ins' were constructed to provide configuration management of scenarios and spacecraft configurations/equipment lists.

- Activity templates were also constructed to make construction and changes to scenarios easier.

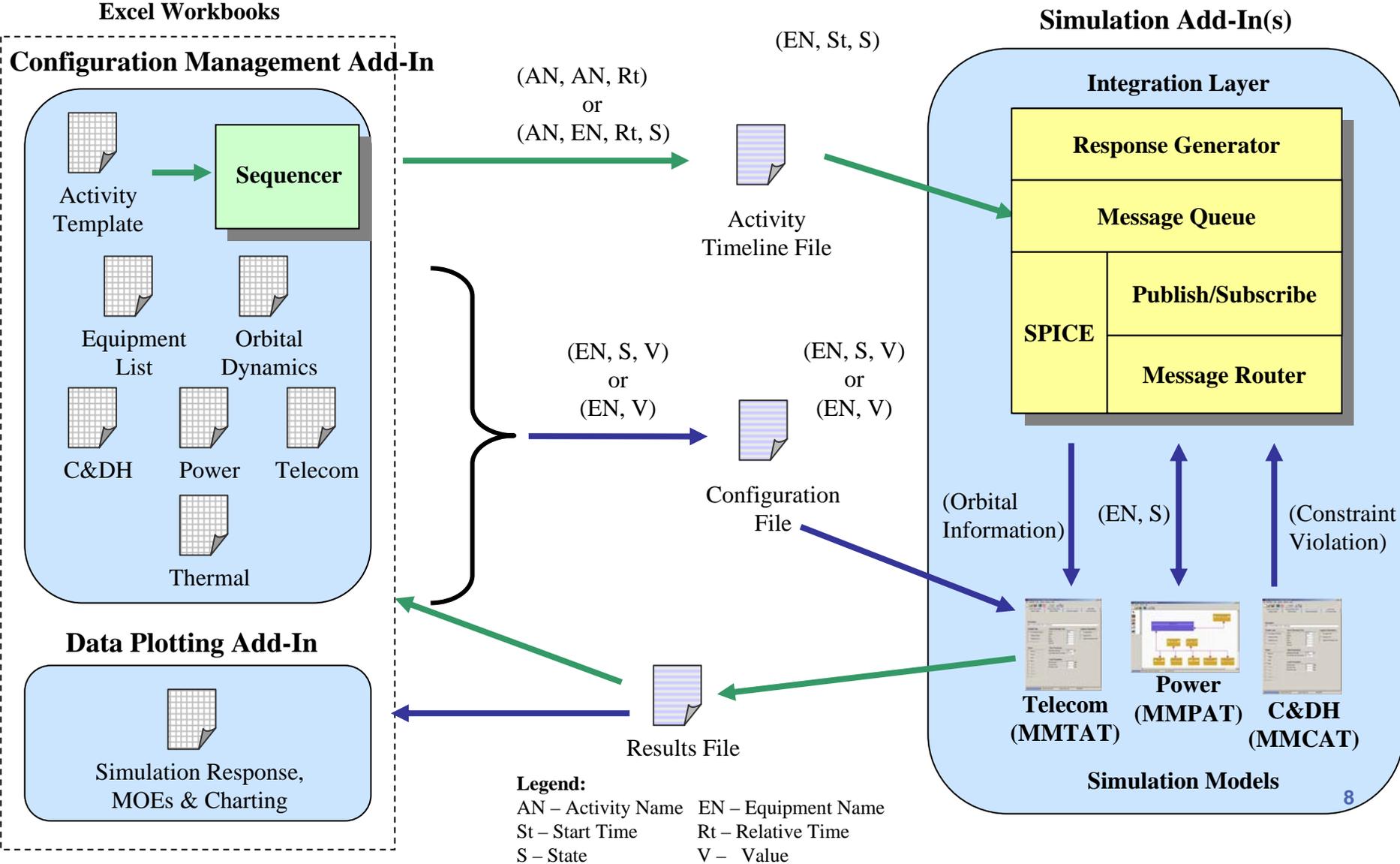# Mission Scenario Development Workbench Architecture

Configuration Management Add-In

Simulation Add-In(s)

Excel Add-Ins with Embedded Code

1 Structure Scenario

- Equipment List
  - States
  - Values
- Activity Plan
- Environment
- Constraints

Activity Timeline File

Tab Delimited ASCII Files Human/Excel Readable

Configuration File

2 Perform Simulation

- Model Rover to same fidelity as PEL
  - Power
  - C&DH
  - Telecom
- Model Environment
  - SPICE
- Simulate Rover in Environment
- Report MOEs
- Flag Constraint Violations

Data Plotting Add-In

3 Present Results

Results File

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Mission Scenario Development Workbench Architecture Detail

Excel Workbooks

Simulation Add-In(s)

Configuration Management Add-In

Sequencer

Activity Template

Equipment List

Orbital Dynamics

C&DH   Power   Telecom

Thermal

(AN, AN, Rt)
or
(AN, EN, Rt, S)

(EN, St, S)

Activity Timeline File

(EN, S, V)
or
(EN, V)

(EN, S, V)
or
(EN, V)

Configuration File

Integration Layer

Response Generator

Message Queue

SPICE

Publish/Subscribe

Message Router

(Orbital Information)   (EN, S)   (Constraint Violation)

Telecom (MMTAT)   **Power (MMPAT)**   **C&DH (MMCAT)**

Simulation Models

Data Plotting Add-In

Simulation Response, MOEs & Charting

Results File

Legend:
AN – Activity Name   EN – Equipment Name
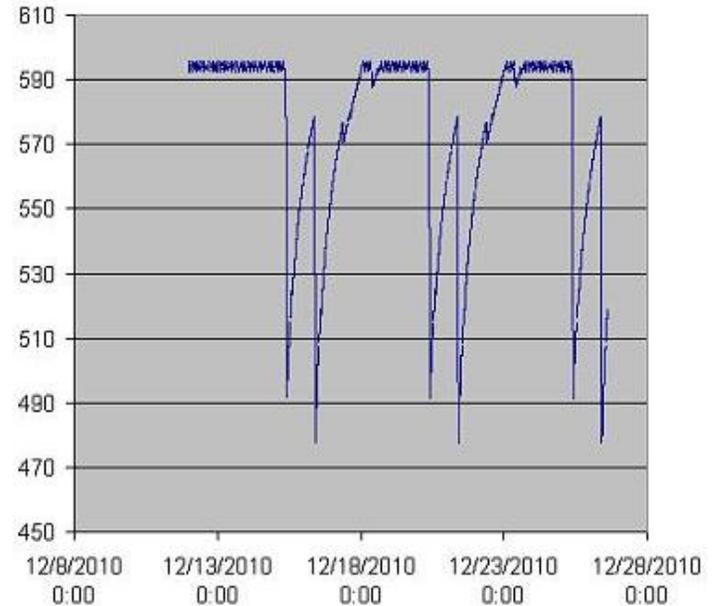St – Start Time   Rt – Relative Time
S – State   V – Value

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Results

- Typical results are shown on the right for a data relay pass

  - Secondary battery state-of-charge profile in watt-hours

  - Relay orbiter view periods and estimated data volume throughput

Time (UTC)	Time (LMST)	Duration (sec)	Data Volume (Mbits)	Orbiter
	0:00:00			
2010-12-09T21:53:08.999	3:11:18	578	261.448	MRO
2010-12-09T22:14:25.999	3:32:01	4897	84.224	MTO
2010-12-09T23:05:12.999	4:21:27	674	149.184	ODY
2010-12-10T01:02:52.999	6:15:58	687	11.424	ODY
2010-12-10T08:42:55.999	13:43:42	447	155.632	MRO
2010-12-10T10:33:56.999	15:31:45	502	136.012	MRO
2010-12-10T11:23:24.999	16:19:54	532	121.212	ODY
2010-12-10T12:05:20.999	17:00:42	1268		MTO
2010-12-10T13:20:01.999	18:13:23	749	516.48	ODY
2010-12-10T17:43:17.999	22:29:37	2173	4.808	MTO

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Benefits

- Early and credible results tell designers where the spacecraft may need to be re-sized to meet success criteria or other trades performed

- Quick changes allow for multiple options to be studied and assessed.

- Microsoft Excel allows for cross-platform application and ease of multiple tool integration

- Analysis tools run 500-700 times faster than previous methods on standard PCs and MACs.

- Using proven models instead of worst-case estimates has allowed designers to appropriately size rover systems to meet mission requirements.

Summary

- Currently, MSL is the only mission using this new capability. We expect this will provide value to other missions once it has been deployed.

- The increased performance, ease of use, and credible results will allow for the design and operation of more robust spacecraft.

- As a result of the above, we expect that there will be more opportunities for scientific discoveries on the Martian Surface.

Acknowledgements

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