Future Spaceflight Computing
Performance Needs

Dr. Richard Doyle

Jet Propulsion Laboratory

California Institute of Technology

Panel on

Meeting Mission Needs for the Coming Decade

Space Computing 2012

Sandia National Laboratories, Albuquerque, New Mexico

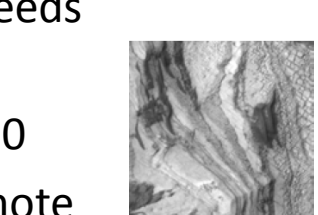
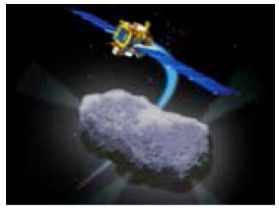
May 31, 2012

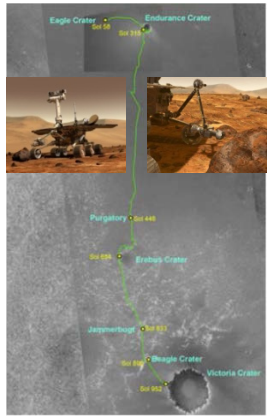
The Need

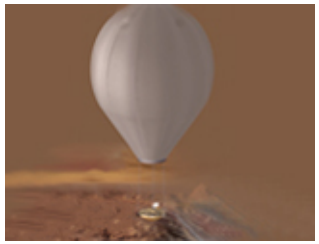
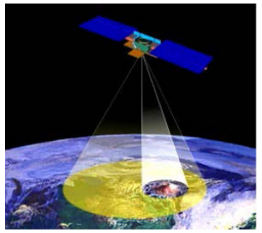
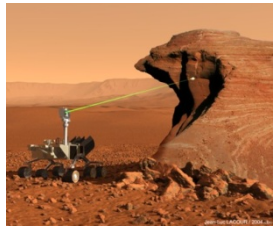
There are important future planetary mission scenarios that today cannot be accomplished robustly and cost-effectively

- Flight computing capability has not kept up with the needs of current and future planetary missions
- Many current NASA missions use the 1990s era RAD750
- Future planetary missions are pushing further into remote and uncertain environments, which results in unique and extreme requirements for operating safely while increasing science return

- Planetary Mission Scenarios
  - Entry, Descent & Landing
  - Small Body Proximity Operations
  - Fast Surface Mobility
  - Surface Science During Traverse
  - Onboard Data Product Generation
  - Science Event Detection and Response



The Benefit

Enable new mission capabilities and increase science return

- ***Entry, Descent & Landing***
  - Mars Program benchmarked algorithms for Terrain Relative Navigation (TRN) and Hazard Detection and Avoidance (HDA) as requiring six (6) dedicated RAD750s
- ***Small Body Proximity Operations***
  - Similar real-time GN&C requirements, 5X less than EDL, but still beyond a RAD750
- ***Fast Surface Mobility***
  - Remove computation as a limiting factor – drive 10X faster or more, safely
- ***Surface Science During Traverse***
  - Continuous, concurrent science operations – "walk and chew gum at the same time"
- ***Onboard Science Data Product Generation***
  - Decrease downlink requirement for high data rate instruments by several orders of magnitude
- ***Science Event Detection and Response***
  - Increase capture rate for dynamic, transient events (e.g., plumes, dust devils) from ~10% to ~75%, with no false identifications

Break the pattern of limiting science and mission scope to available flight computing capability

Future NASA Flight Computing

Architecture Drivers

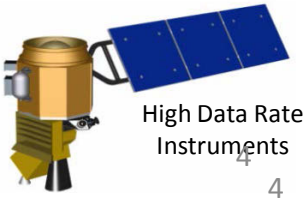
Computational Technique	Mission Need	Objective of Computation	Flight Computing Architecture
Vision-based Algorithms with Real-Time Requirements	• Terrain Relative Navigation (TRN) • Hazard Detection & Avoidance (HDA) • Entry, Descent & Landing (EDL) • Pinpoint Landing	• Conduct safe proximity operations around primitive bodies • Land safely and accurately • Achieve robust results within available timeframe as input to control decisions	• Severe fault tolerance and real-time requirements • Fail-operational • High peak power needs
High Rate Instrument Data Processing	High resolution sensors, e.g., SAR, Hyper-spectral	• Downlink images and products rather than raw data • Opportunistic science	• Distributed, dedicated processors at sensors • Less stringent fault tolerance
Model-Based Reasoning Techniques for Autonomous Systems	• Mission planning, scheduling and resource management • Fault management in uncertain and/or high radiation environments	• Contingency planning to mitigate execution failures • Detect, diagnose and recover from faults	• High computational complexity • Graceful degradation • Memory usage (data movement) impacts energy management

Flight computing capacity is a technology *multiplier* for *other* capabilities

Proximity Operations

Safe Landing

High Radiation Environments



High Data Rate Instruments