Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

AIAA Space 2012

Next Generation Simulation Framework for Robotic and Human Space Missions

Jonathan M. Cameron, J. Balaram, Abhinandan Jain, Calvin Kuo, Christopher Lim, and Steven Myint

Mobility and Robotic Systems

Jet Propulsion Laboratory

California Institute of Technology

Pasadena, CA, 91109

Contact: Jonathan.M.Cameron@jpl.nasa.gov

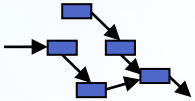
Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

The research in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

What is DSENDS?

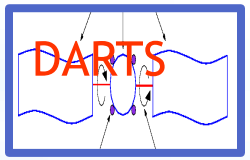
- Physics-based engineering simulation for space missions
- Developed by DARTS lab team at JPL
- Applied to wide range of missions



Models & Data Flows

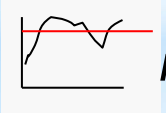
Atmosphere

3D Graphics, GPU Shaders



Flex-body O(n) Multibody Dynamics

Terrain Geometry



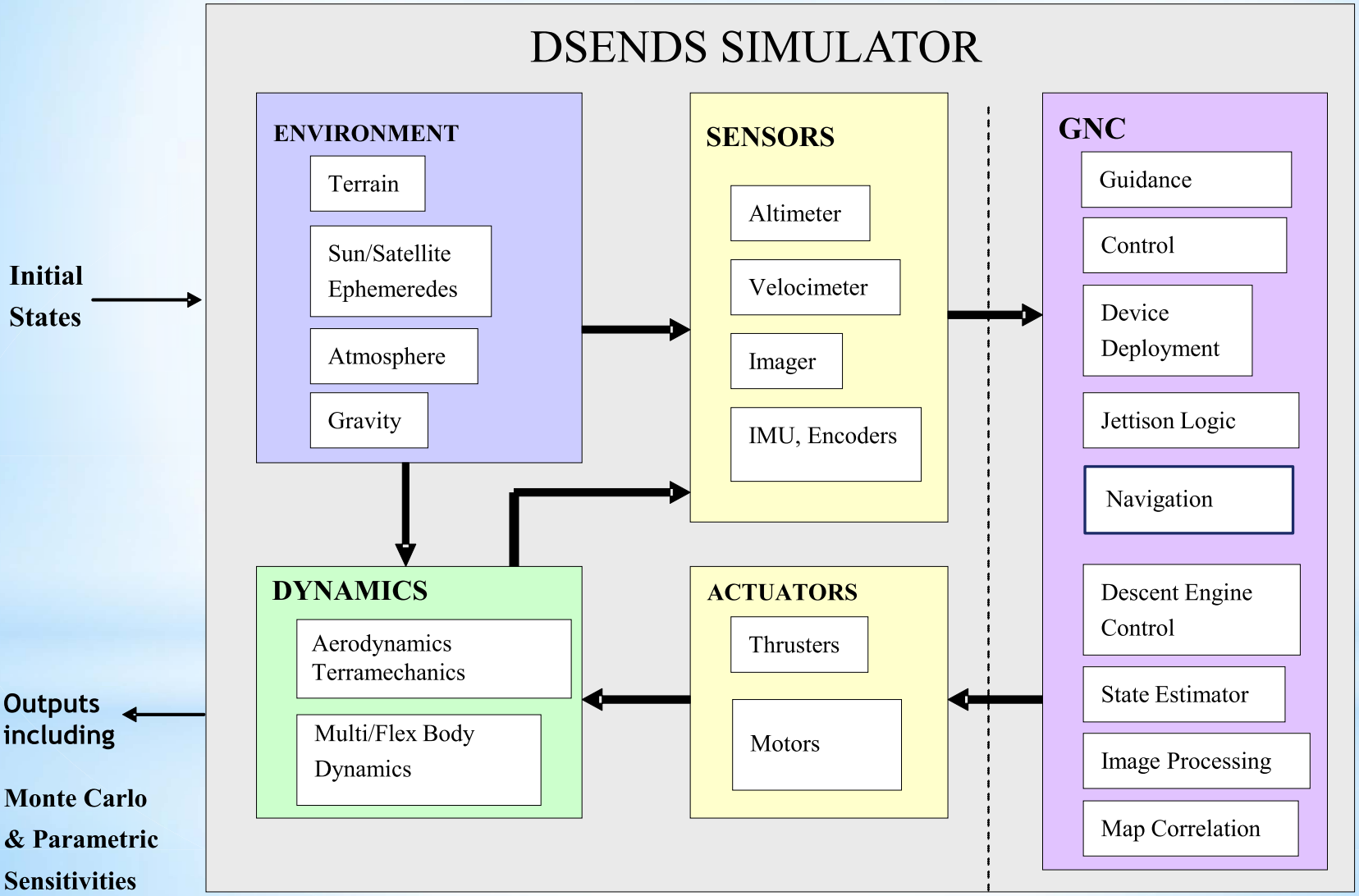
Event Manager

Sequencing State-Machine

Ephemerides

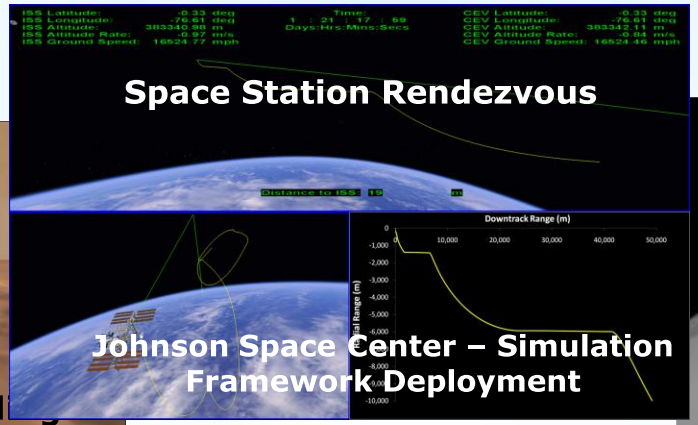
DSENDS - Functional Block Diagram

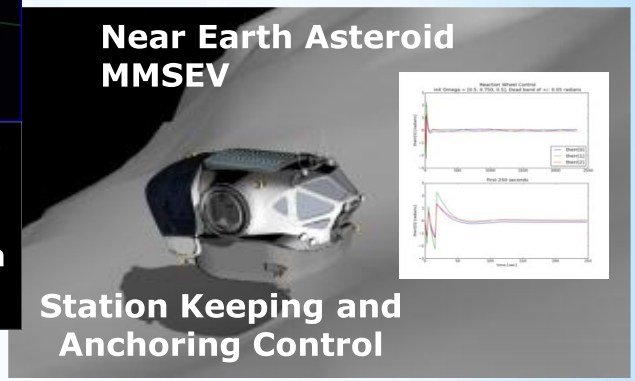
Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

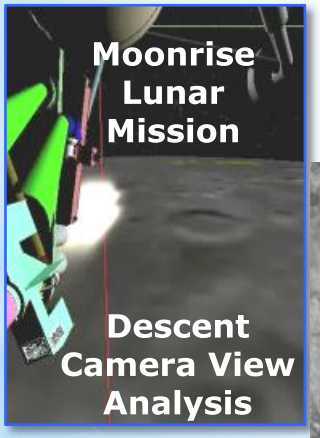


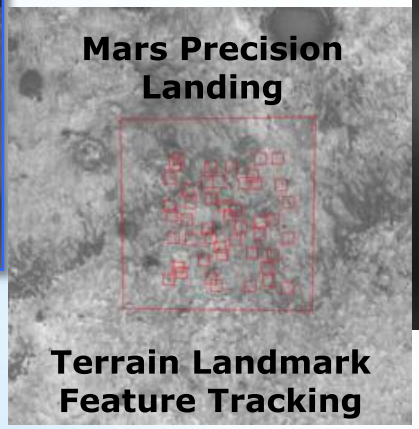
Examples of Use

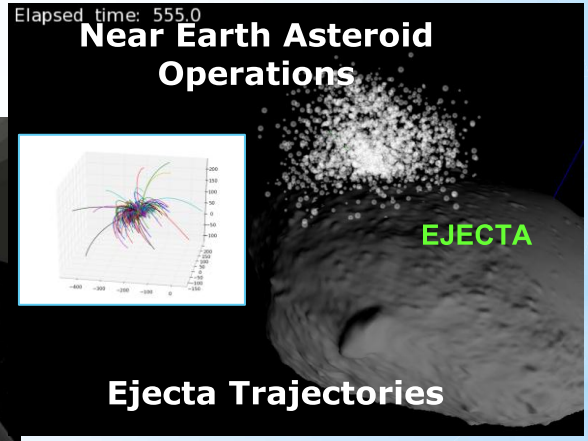
Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged











Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

JSC/COMPASS Collaboration

- Johnson Space Center Missions Operations Directorate (MOD)
  - Shifting from Shuttle work to other missions
  - Needed flexible, powerful simulation tool
  - Evaluated a variety of options
  - Chose DSENDS

- During initial adoption of DSENDS, several areas were identified for enhancements
- Formed a joint JPL-JSC collaborative development team to refactor and improve DSENDS to meet the needs of both centers (January 2011 – Present)
- Collaborative work refactored DSENDS core modules in new DshellCommon module
- JSC MOD Developed COMPASS (Core Operations, Mission-Planning, and Analysis Spacecraft Simulation) on top of the new DSENDS

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

DSENDS JPL-JSC Variations

JPL DSENDS		JSC MOD COMPASS
User code and run scripts		User code and run scripts
DshellCommon	↔	DshellCommon
DSENDS Models		COMPASS Components
Dartslab Models	↔	Dartslab Models
Dshell	↔	Dshell
Darts multibody code	↔	Darts multibody code
Dartslab core SW, Libraries	↔	Dartslab core SW, Libraries

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

Sample Run Script (Python)

- Setup
- Create simulation executive

```
sim = SimulationExecutive()
```

- Configure the environment

```
config = {

  'Mars' : {
     'class': 'TargetAssembly',
     'params' : { 'Target' : targets['Mars'],
                  'Bodies' : bodies['Target']['Bodies'],
                }
     },
```

Definitions for target planet (Mars)

parameters

An “Assembly” is a combination of low-level models or sub-assemblies with proper inter-connections.

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

Sample Run Script (Python)

```
 'SC1' : {
    'class' : 'VehicleAssembly',
    'basename' : 'CapsuleBase',
    'params` : { 'Bodies' : bodies['SC1']['Bodies']},
    'assemblies' : {
        'grav' : {
                'class': 'GeneralGravityActuatorAssembly',
                'context' : { 'body' : 'CapsuleBase' }
                }
        }
    }
}
```

Definition for spacecraft ‘SC1’

Nested assemblies, Gravity model

- Create the simulation objects

```
sim.createAssemblies(config)
sim.bindState()
sim.resetState(0.0)
```

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

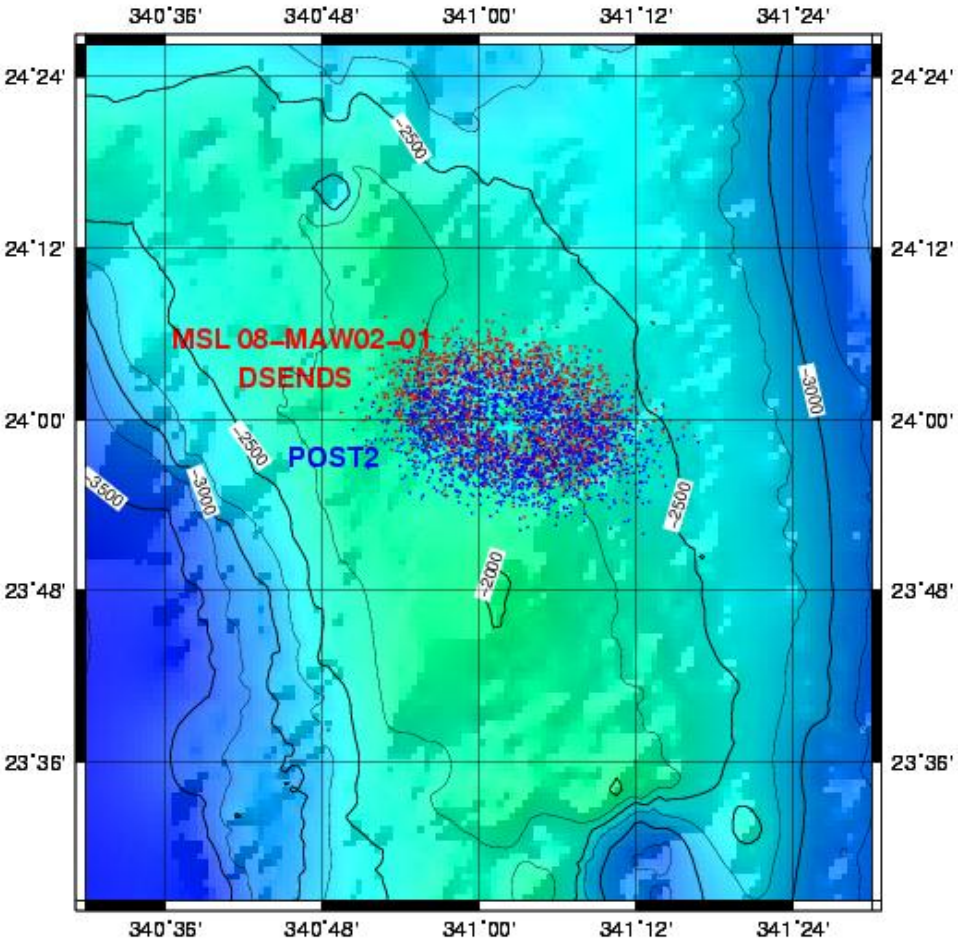
Sample Run Script (Python)

- Configure Finite State Machines to sequence simulation
- Other initializations
- Execute simulation

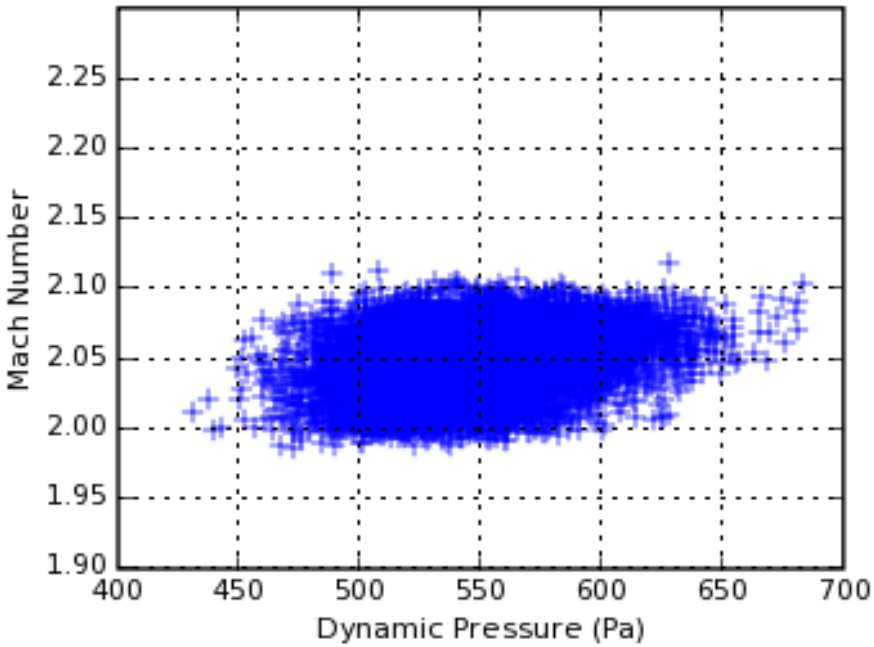
```
sim.step()
```

MSL Entry Guidance Analysis

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged



Landing dispersions at Mawrth

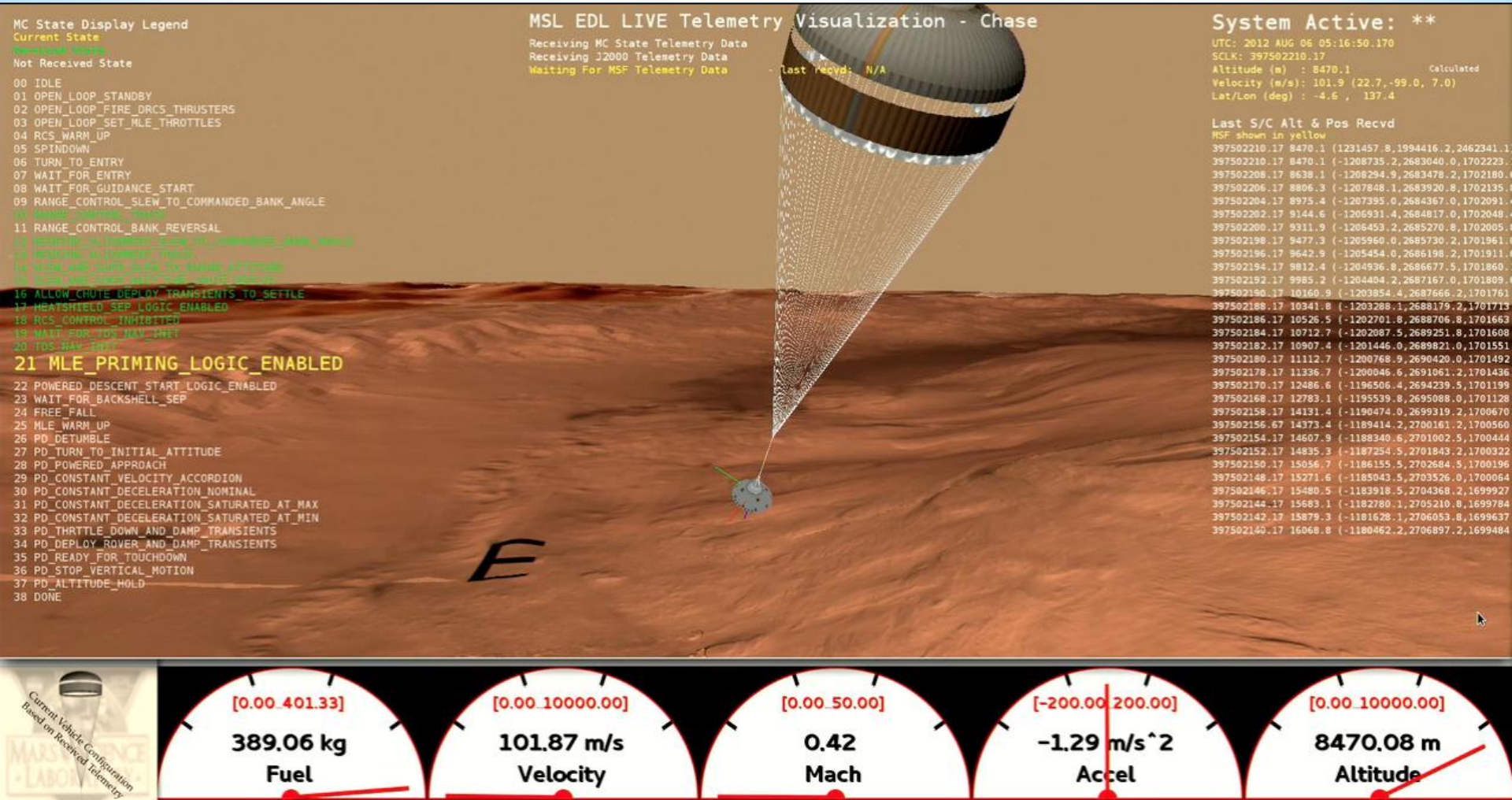


Chute deployment Mach-Q Box dispersions

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

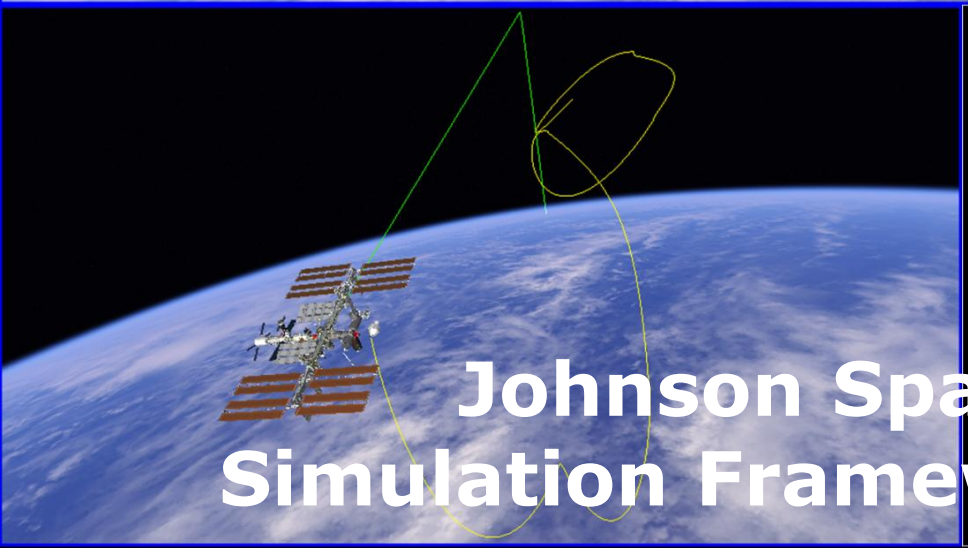
MSL EDL Telemetry Visualization

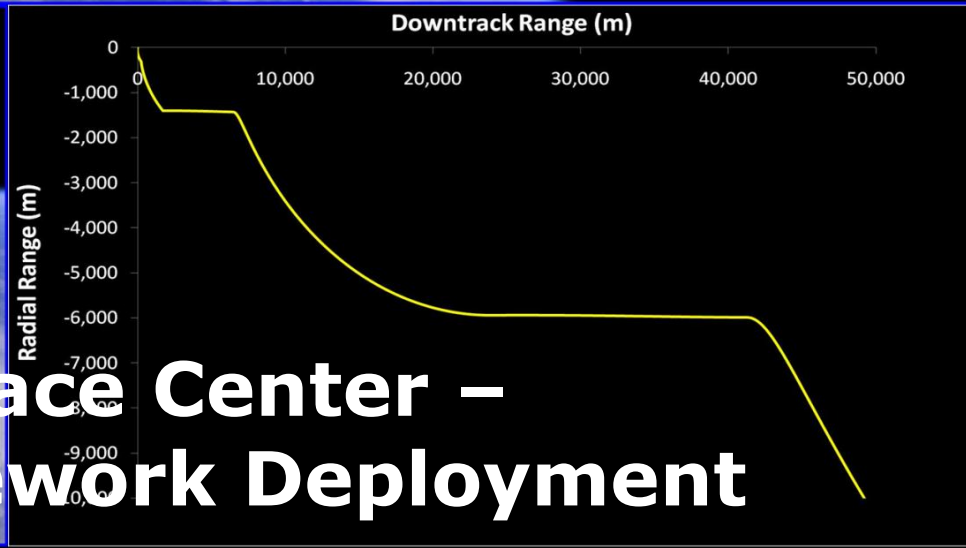
- Used during recent MSL landing for GNC Ops



Space Station Rendezvous

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged



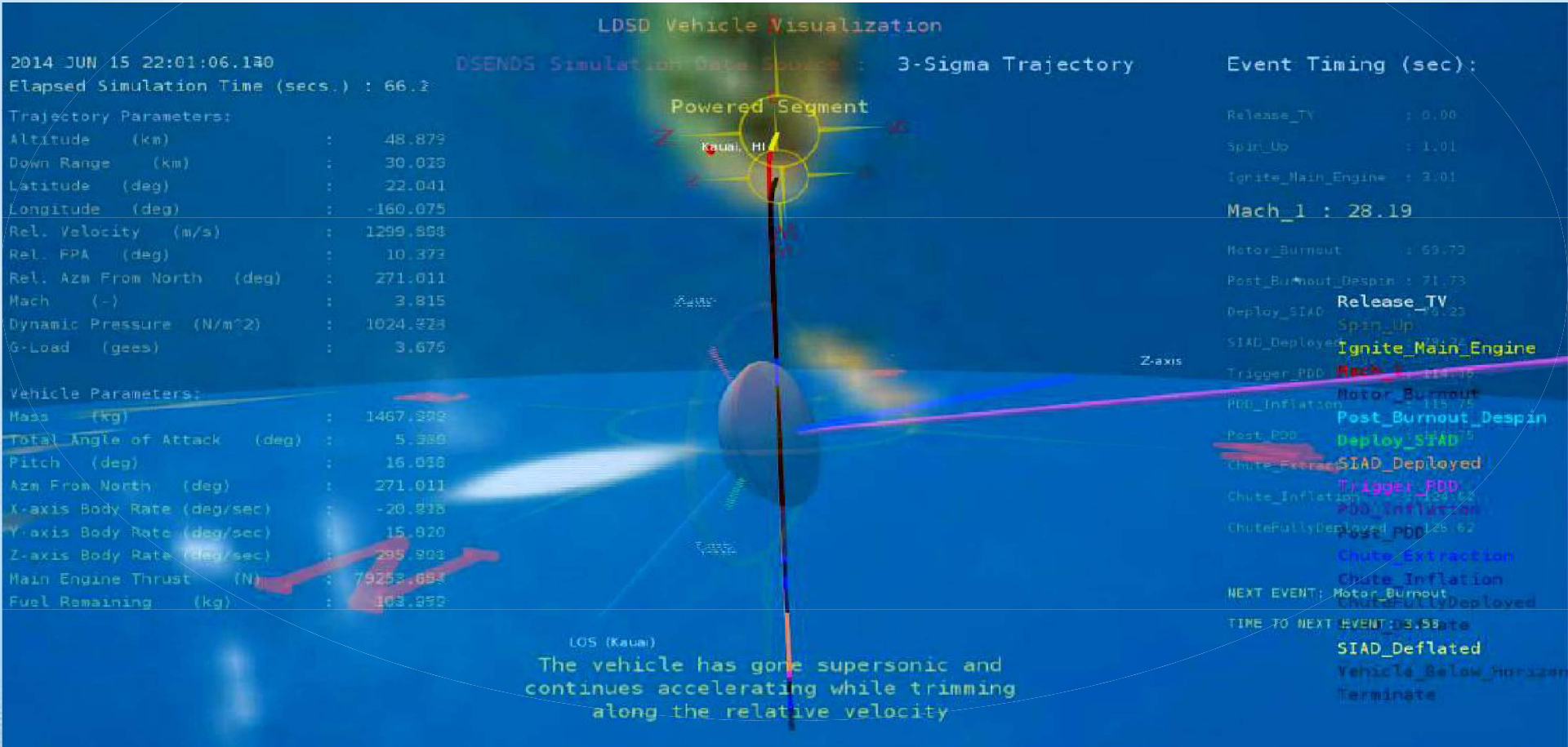


Johnson Space Center – Simulation Framework Deployment

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

LDSD Experiment Visualization

- Low Density Supersonic Decelerator Experiment Visualization



Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

SEAS Lunar Mission Analysis

- NASA Inter-center visualization and analysis of lunar sample return mission concept including descent from orbit, landing, rover surface driving, and return to orbit

Copyright 2012 California Institute of Technology. Government Sponsorship Acknowledged

Conclusions

- DSENDS is a powerful simulation and analysis tool
- Currently creating a version of DSENDS for University/STEM
  - Aerospace department, Georgia Institute of Technology
  - Senior/Graduate student use in lab courses

- Thanks to our JSC MOD Partners:
  Scott Nemeth, Carl Merry (who now works for Sierra Nevada Corporation), and Ronald Frye, as well as Marc Abadie, Darren Baird, Bryan Evans, Robin Friedrich, Christopher Glenn, John Gouveia, John Hallstrom, Michael Harvey, Daniel Ramirez, and Marius Zaczek

http://dartslab.jpl.nasa.gov