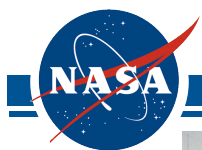




# MSL Technical and Replan Status

Richard Cook



# Integrated Spacecraft

PSS—Mars Science Laboratory







# Cruise Stage

PSS—Mars Science Laboratory





# Cruise Stage Status

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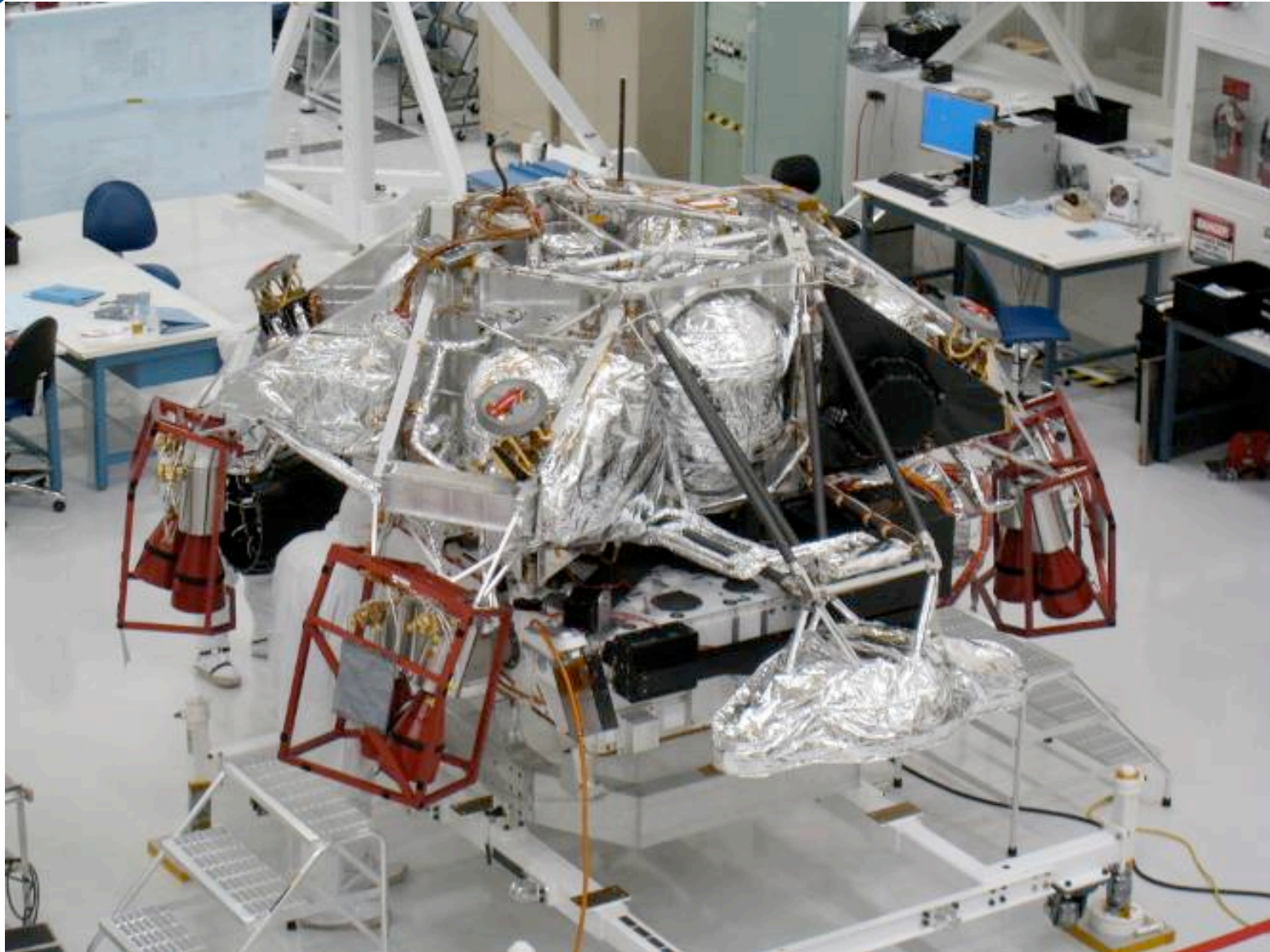
- Completed Deliveries
  - Primary structure
  - Attitude Control Sensors (Star scanner, sun sensor, etc)
  - Propulsion System
  - Cruise Flight Software
  - Cruise Telecom antennas and interconnects
  - Cruise Heat Rejection System
- Open Issues
  - Solar array
    - Known rework required on solar cells to fix CTE issues
  - Avionics & Power Distribution Electronics
    - See avionics discussion





# Descent Stage

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# Descent Stage Status

PSS—Mars Science Laboratory

- Completed Deliveries
  - Primary Structure
  - X-band Telecom Subsystem
  - IMU
  - Bridle/Umbilical & Separation Devices
  - Heat Rejection System
- Issues/Remaining Work
  - Descent Stage Prop System
    - Prop system fully integrated & tested
    - Transition tube qual issue understood, rework plan in development
  - Avionics
    - See following charts
  - Radar
    - EM unit completed, FM in final assembly & env test
    - Field tests scheduled for FY10
  - EDL Flight Software
    - Initial delivery complete, full capability in work
  - Final Skycrane V&V
    - Descent Stage/Rover Separation & Deployment Tests



# Backshell

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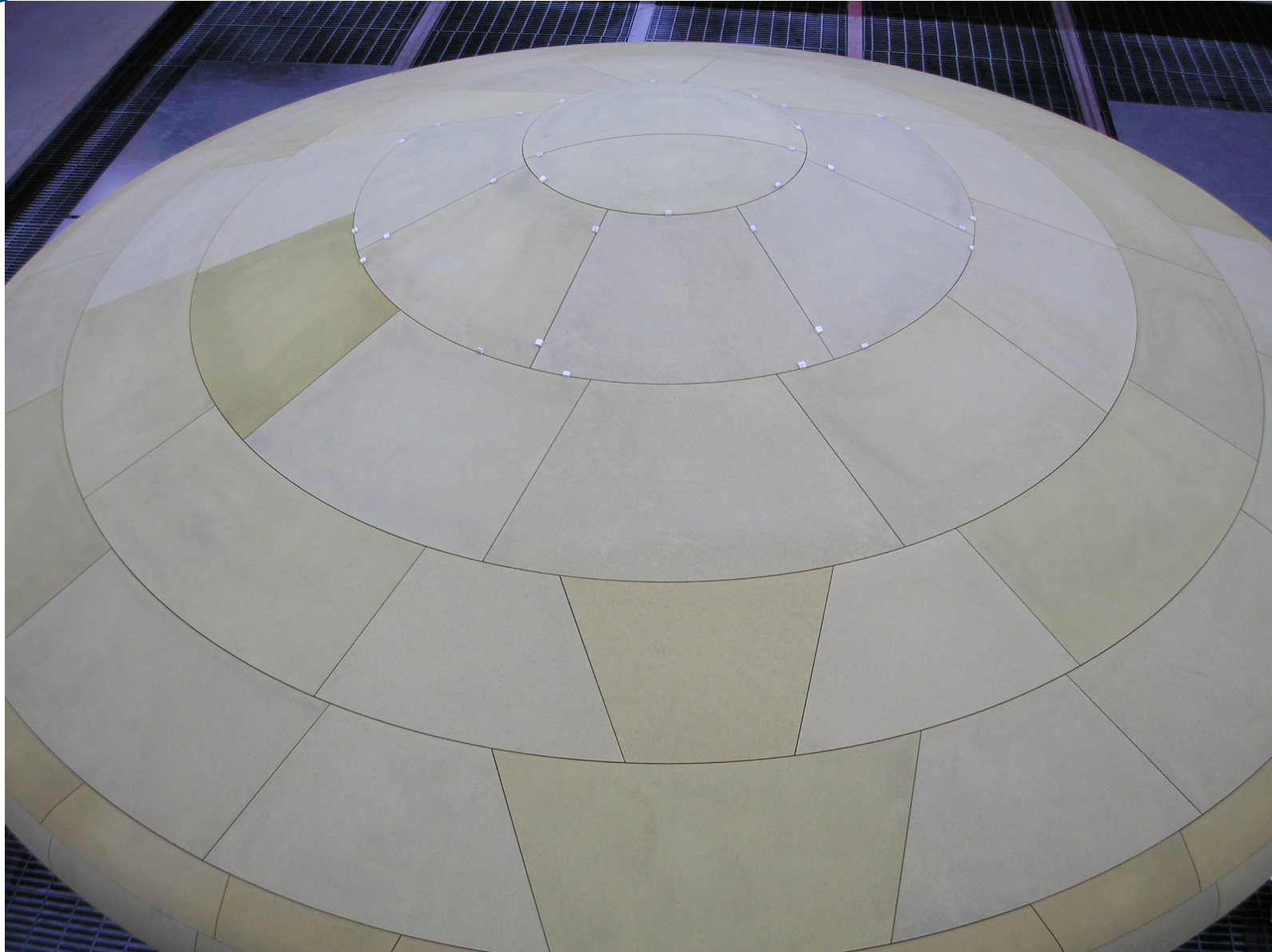






# PICA Heatshield

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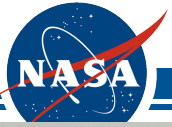


# Aeroshell Status

PSS—Mars Science Laboratory

- Completed Deliveries
  - Backshell Structure & Thermal Protection System
  - Parachute Closeout Cone/BIP & EDL Telecom Antennas
- Open Issues/Remaining Work
  - PICA Heatshield
    - Assembly on-going, will complete Feb '09
  - Flight Parachute
    - FM build on-going, qual tests in Feb'09

# Rover Chassis



PSS—Mars Science Laboratory





# Rover Status

PSS—Mars Science Laboratory

- Completed Deliveries
  - Rover structure
  - Rover Heat Rejection System
  - Rover X-band & UHF telecom system
- Open Issues/On-going Work
  - Avionics - see following charts
  - RTG - see following charts
  - Payload - see following charts
  - Rover Mechanisms/Sample Processing System - see following charts
  - Surface Flight Software
    - Development effort planned for FY09 & 10





# Avionics Status

PSS—Mars Science Laboratory

- MSL developing a new generation avionics & power electronics subsystem
  - Fully redundant Command & Data Handling Subsystem based on PCI/PowerPC architecture
    - Most functionality implemented in a set of high density FPGAs
  - Centralized motor control system for rover mechanisms & EDL thrusters
  - Power system capable of handling RTG, batteries & solar arrays
- Substantial hardware development activities have been completed
  - All Engineering Model boxes (~20) completed and delivered to testbed
  - All FM boxes except Rover Motor Controller have been delivered to ATLO
    - ~180 Flight electronics boards assembled & tested
  - Two iterations of Flight FPGAs completed
- Issues
  - Hardware design maturity is less than desired because design cycle extended longer than planned and subsystem & box testing activities were curtailed to meet delivery needs
    - Immaturity primarily manifested as high rate of problem/failure reports
  - Key technical issues: Environmental test issues on Rover Compute Element, Grounding architecture problems, Motor Controller fuse & temperature problems

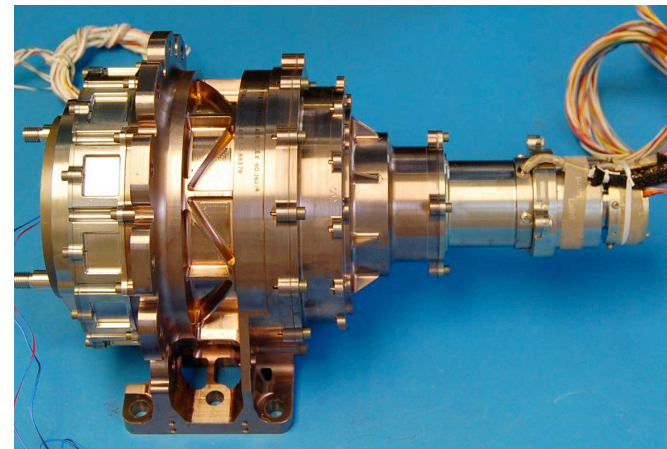


# Actuator Status

PSS—Mars Science Laboratory

- Actuators used throughout rover
  - 51 actuators & 54 stand-alone motors (including Engineering Models, spares, etc.)
    - High and Medium Torque Actuators for Mobility, Robotic Arm, Mast
    - Motors for Drill/CHIMRA (Space Dev gearboxes)
  - Built by Aeroflex Corp - Long Island
- Status
  - Redesign from Titanium to Stainless steel set back actuator development by ~9 months
  - Significant effort undertaken by both Aeroflex & JPL to complete deliveries for '09 launch
    - Multiple shift staffing, schedule incentives, back-up vendor procurements
    - Strong JPL management oversight and technical support
  - All Engineering Model actuators built & delivered to mechanisms (arm, drill, etc.)
  - Late technical problems found in flight model testing at low temperature
    - Brake issues, insufficient torque, etc.
  - Delivery delays in FM actuators pushed mechanism deliveries past ATLO need date

**Robotic Arm Shoulder/  
Elbow Actuator**





# Sample Processing System Status

PSS—Mars Science Laboratory

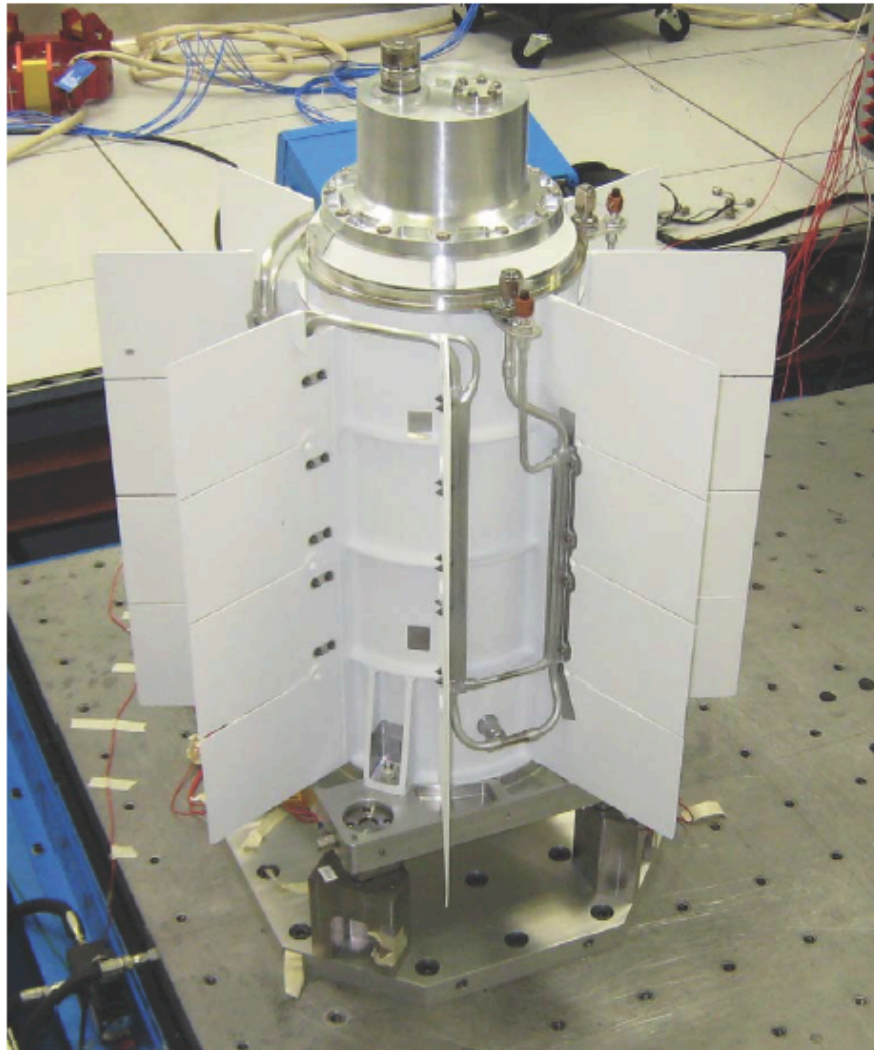
- Robot Arm
  - Engineering Model in final assembly, will complete delivery to Testbed in March '09
  - FM components complete except actuators, will build FM arm in early FY10
- Drill / CHIMRA
  - Engineering Models in final assembly, will complete delivery to Testbed in March '09
  - Life Test & Flight builds deferred to FY'10
    - Space Dev actuator builds in FY'09 after motor delivery
- Sample Chain Validation
  - Near term focus in on electromechanical (motor control, mechanisms) system validation
  - Continuing Phoenix Lessons learned activities & Science Team interactions (started in FY08)
  - Will start sample transfer testing using EM mechanisms in Testbed





# MMRTG

PSS—Mars Science Laboratory



**Electrically Heated MMRTG Qualification Unit**

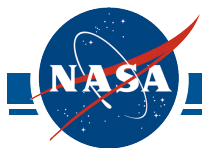


# MMRTG Status

PSS—Mars Science Laboratory

- MSL MMRTG Flight Unit
  - Fully fueled at Idaho National Lab (INL)
  - Currently undergoing environmental qualifications testing at INL
  - Stored at INL until deliver to Cape in 2011
- MMRTG Qual Unit
  - Currently integrated with MSL to support environmental tests at JPL
  - Then be stored at JPL for further testing (pyro shock)
- Open Issues
  - Transient performance issues observed on Engineering Model during pyro shock & vibe tests
    - No issues observed during FM vibe
    - Will conduct higher fidelity pyro shock test on Qual Model

# Payload



PSS—Mars Science Laboratory

**Images of p/l elements here**





# Payload Status

PSS—Mars Science Laboratory

- Delivered
  - MARDI, MAHLI, DAN, APXS
- Mastcam
  - Mastcam filterwheels in rework
  - Env test & cal in Jan'09, Delivery in mid-Feb'09
- RAD
  - Mechanical integration completed, instrument returned to SwRI
- CheMin
  - FPGA installed, to be followed by Penalty vibe and T/V Calibration;
  - Delivery in mid-January '09
- SAM
  - Thermal/Vac on-going; Mars Ambient tests complete; CPT#1 pending.
  - Delivery in Place in early March with integration deferred to Nov/Dec 09.
- ChemCam
  - Digital anomalies resolved; working CCD linearity issue
  - Delivery in mid-February
- REMS
  - Delivery in place in February with sensors as-is, replacement units later in FY'09



# System V&V Status

PSS—Mars Science Laboratory

- Launch/Cruise stack activities have gone well
  - Full complement of hardware is not available for L/C testing, but adequate mitigation plan exists for missing elements
    - Rover stand-alone environmental test
    - Descent stage stand-alone vibe test
- Functional performance & technical margins are acceptable
- Major elements of mission functionality still need to be verified in Rover System Test Program
  - Payload interface & operations
  - Sample acquisition & handling
  - Mobility & RSM operations
  - Radar field test
  - Skycrane mechanical V&V



# ATLO Status

PSS—Mars Science Laboratory



**Stacked Spacecraft Bagged  
& Awaiting Transportation**



**Stacked Spacecraft Transportation**



**Stacked Spacecraft in Acoustic Chamber**





# 2009 Schedule Assessment

PSS—Mars Science Laboratory

- Project concluded in early December 2008 that 2009 launch was not viable
  - Delivery delays in critical rover hardware, particularly actuators
  - Continuing concerns about avionics maturity
  - Quantity of remaining test activities that need to be completed successfully
- ITA, Center, Directorate & NASA Administrator concurred
  - Slip announced December 4



# 2011 LRD Implementation Plan

PSS—Mars Science Laboratory

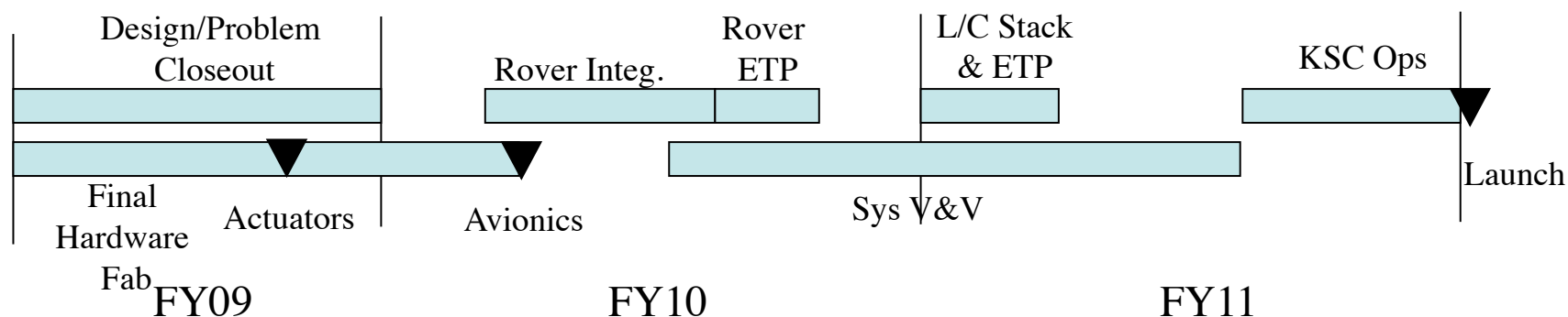
- Project is developing a revised implementation plan for 2011 launch
  - Developed top-level schedule with significant margin ( $>2\times$  JPL Design Principles)
    - Launch between October & December 2011
  - Conducting a systematic reassessment of design, implementation approach & residual risks
  - Generating a new cost estimate
- Will complete critical risk retirement activities in FY'09
  - Actuator life test and Flight Model deliveries
  - Resolve Avionics PFRs and mature FPGA/box designs
  - Complete development/test of EM SA/SPaH
  - Conduct a design scrub and resolve open issues
  - Complete delivery of payload, radar, and RTG



# Top-Level Schedule Strategy

PSS—Mars Science Laboratory

- FY09 - Risk Reduction
  - Retire high risk development issues
  - Finish hardware builds where feasible
- FY10 - Delivery & Test
  - Complete remaining hardware builds
  - Conduct Rover System Environmental Test Program
- FY11 - Test & Margin
  - Complete Launch/Cruise ETP & KSC Operations
  - Maintain > 4 months margin for additional testing





# Juno/MSL Launch Period Assessment

PSS—Mars Science Laboratory

- MSL & Juno both launch on Atlas V vehicles
  - Juno launch period is August 2011
  - KSC/ULA require nominal 90 day separation before MSL launch
  - No open slots exist in Atlas manifest in late 2011
    - KSC investigating option to accelerate Atlas launch rate with AF & ULA
- MSL launch period options
  - Type 2 - October 2011
    - Satisfies all MSL requirements including mass capability, EDL communication coverage & entry speed
    - Insufficient separation from Juno without significant launch rate acceleration
  - Type 1 - December 2011
    - Requires use of Atlas V 551 (additional cost)
    - Increased entry velocity - appears to be within PICA capability
    - Partial Direct to Earth EDL comm. - maintains orbiter coverage
- Project(s) working with MEP & PSD to resolve issue
  - May have cost implications on MSL replan





# Replan Summary

PSS—Mars Science Laboratory

- Much of MSL hardware and software are complete
  - Schedule erosion, therefore inadequate test time, was the major driver in the launch delay decision
  - Initial Launch/Cruise environmental test is currently underway
- Go-forward risks are manageable
  - Many elements are low risk since development is essentially complete
  - Additional schedule provides sufficient time for thorough V&V program
  - Schedule margin is fully funded
  - High risk developments will be retired in FY09
  - Cost reserves are fully unencumbered, and will be used to cover unknown unknown technical issues
- Launch conflict with JUNO will not be finalized for a few months
  - Cost and technical risk (EDL, comm, PICA) being determined
- Project is completing a revised cost estimate for 2011 launch
  - FY09 plan fits within existing MSL budget, with reserve
  - Additional funding required for 2010 and 2011 under development