# The MPCS Multimission Telemetry Processing and Display Ground System

## *Its Use in the Mars Science Laboratory Mission and Beyond*

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# A Spacecraft Software's Different Environments

- FSW development
  - Relatively lightweight configuration and performance needs
  - Simulation & Support Equipment (SSE) simulation
- Testbed
  - More integration; subsystem-level testing
    - SSE + Ground Support Equipment (GSE)
  - Automated testing becomes crucial
- Assembly, Test, and Launch Operations (ATLO)
  - Pushes performance limits
  - Highly-controlled, complex configuration
- Mission Operations

# Different Spacecrafts, Different Telemetry & Telecommanding

- Mars Science Laboratory (MSL)
  - Engineering health telemetry (EHA), event verification records (EVR), Data Product files, time correlation packets
  - CCSDS transfer frames
  - Deep Space Network stations via Telemetry Delivery Subsystem (TDS)
  - Support uplink only in FSW workstations, testbeds, ATLO
- Diviner Lunar Radiometer Experiment (DLRE) instrument (on Lunar Reconnaissance Orbiter)
  - EHA only
  - CCSDS packets + GSFC annotation headers
  - No uplink support
- Soil Moisture Active Passive (SMAP)
  - Near Earth Network (NEN) and Space Network (SN)
  - Support uplink in all mission phases

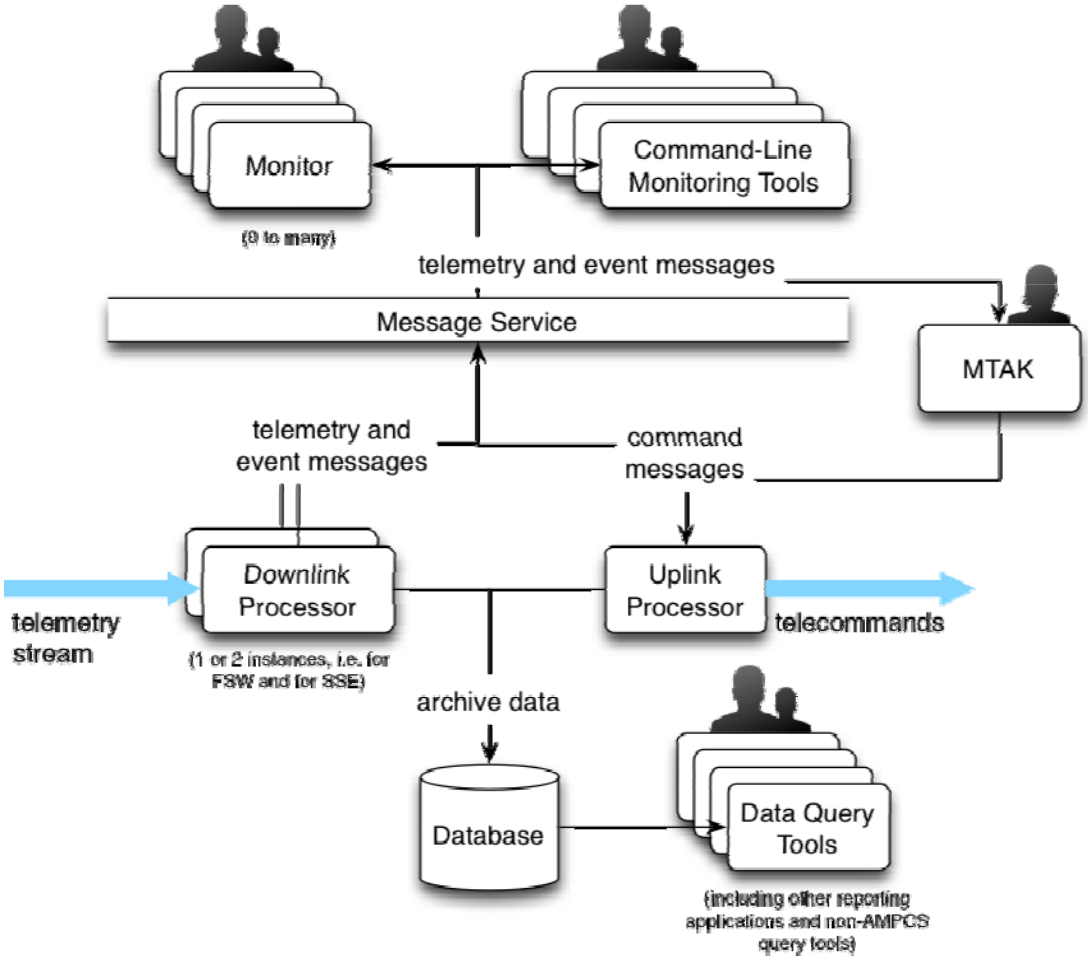
# Why a New Ground Data System?

- Outdated technology
  - Legacy GDS designed in 1980s
  - End-of-life operating system, programming languages, hardware
    - Unable to utilize new technologies (e.g. platform-independence, messaging services, open-source databases, etc.)
  - Limited the missions to old interfaces and paradigms
- Cost
  - Inherit-and-customize
    - Mission-specific tools and system tailoring did not benefit other/future missions
  - Maintenance of legacy software
- No "Test As You Fly, Fly As You Test"
  - Legacy GDS did not support all phases and venues of FSW development, test, and operations
- Other lessons learned
  - Bookkeeping test data based on *time* made it difficult to replicate tests exactly
  - More centralized data management needed

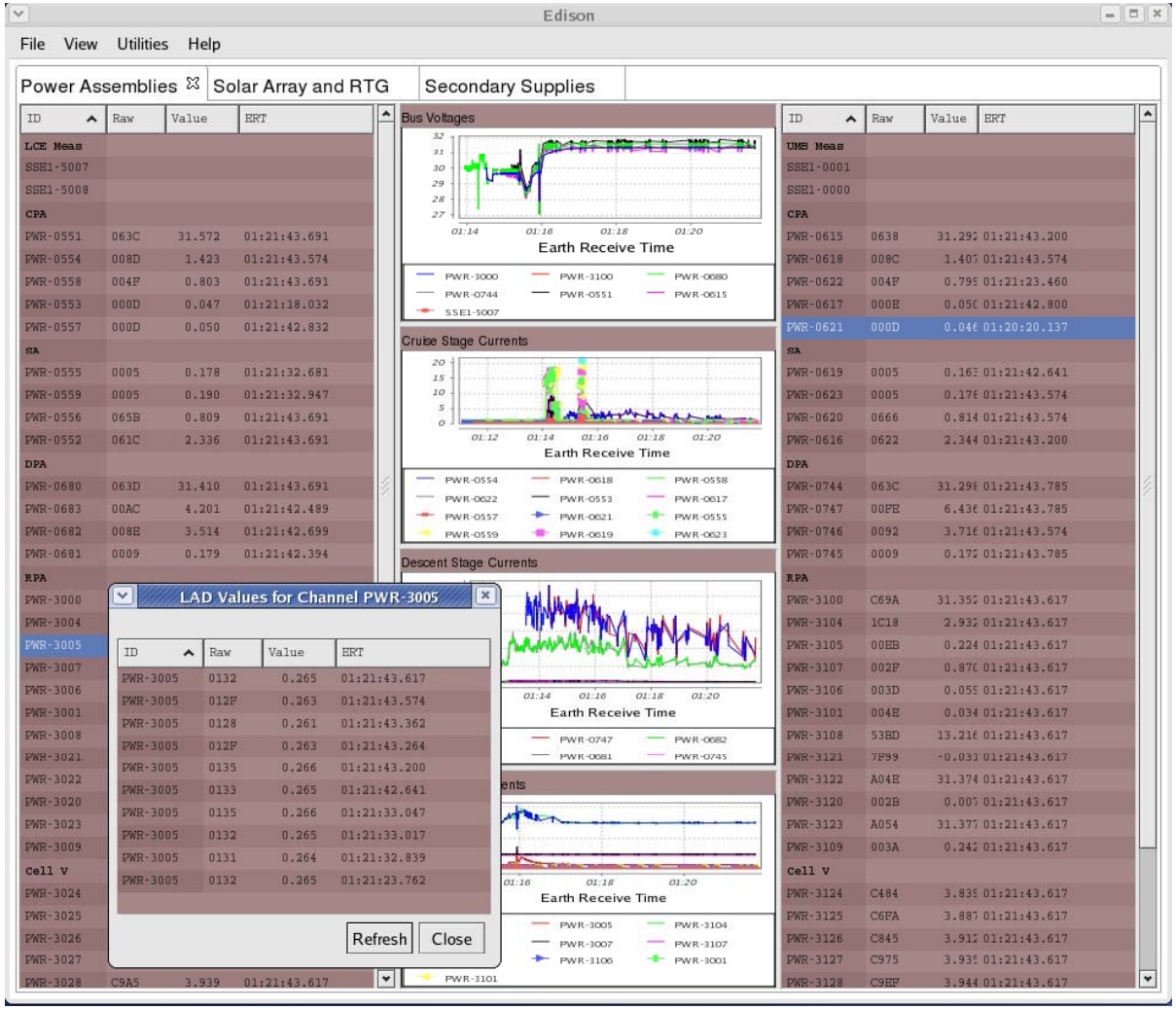
# MPCS

- Mission Data Processing and Control System
  - Part of NASA's Advanced Multimission Operations System (AMMOS) catalog
- Modern architecture and technology
  - Modular and highly-configurable to add/subtract features
    - Downlink processor, uplink processor, independent monitoring tools
    - Message service, database
    - Data query tools
  - Java and Python
    - Officially supported on Linux but runs on Mac OS X, SunOS
  - Extensible real-time displays (e.g. fixed pages)
- Automation
  - UNIX-philosophy command-line tools to enable scripting
  - MPCS Test Automation Toolkit (MTAK) for Python test scripting
  - Event-driven message triggers
- Multimission
  - Core software library and mission-specific software
  - Reference mission that implements CCSDS-based common standards
- Multiphase
  - Configurable to scale

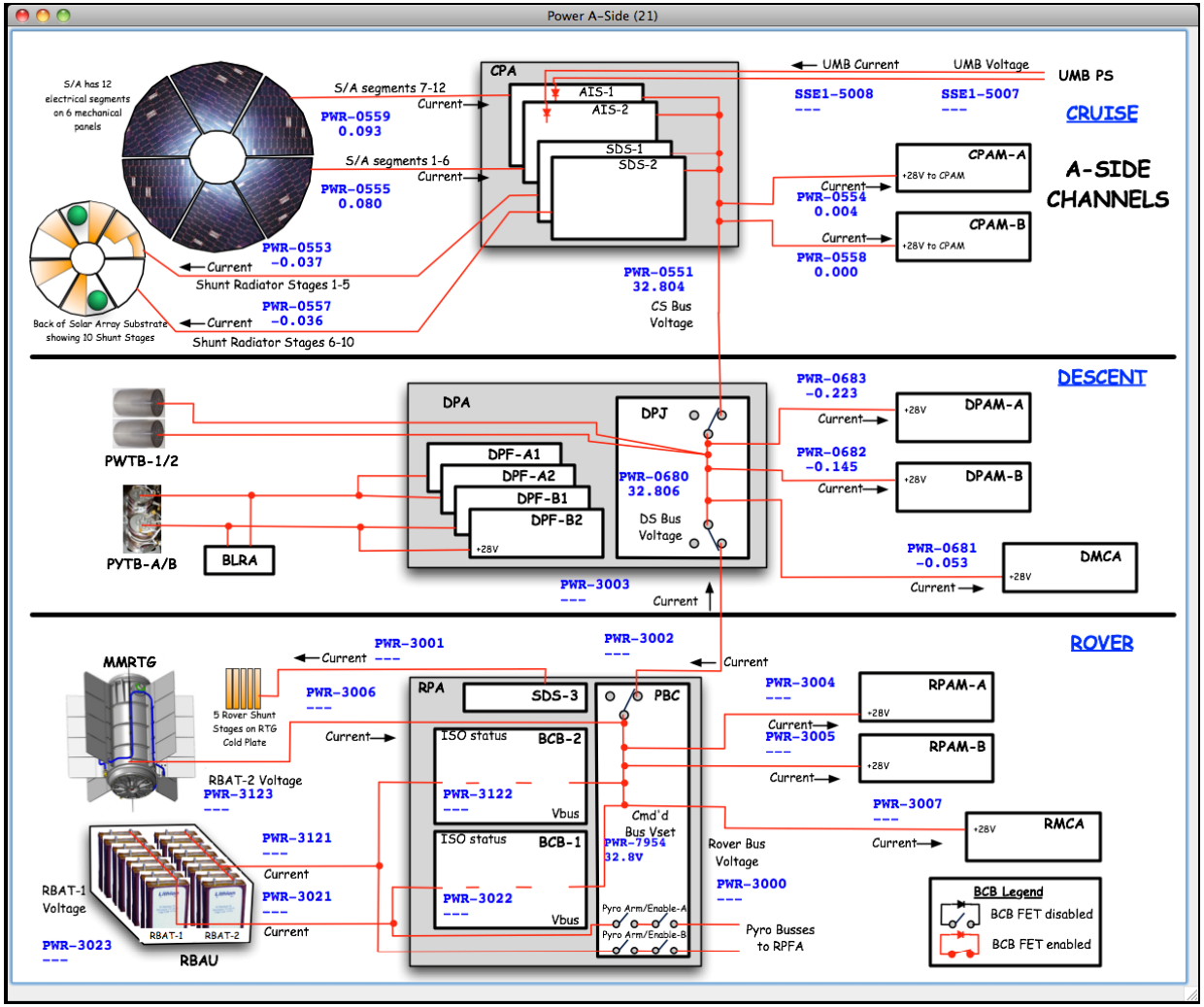
# MPCS Architecture



# Real-Time Monitor Display



# Fixed Pages


Power A-Side (21)
S/A has 12 electrical segments on 6 mechanical panels
S/A segments 7-12
Current
PWR-0559
0.093
S/A segments 1-6
Current
PWR-0555
0.080
CPA
AIS-1
AIS-2
SDS-1
SDS-2
UMB Current
UMB Voltage
UMB PS
SSE1-5008
SSE1-5007
CRUISE
A-SIDE CHANNELS
CPAM-A
+28V to CPAM
CPAM-B
+28V to CPAM
PWR-0554
0.004
PWR-0558
0.000
PWR-0553
-0.037
Current
Shunt Radiator Stages 1-5
PWR-0557
-0.036
Current
Shunt Radiator Stages 6-10
Back of Solar Array Substrate showing 10 Shunt Stages
PWR-0551
32.804
CS Bus Voltage
DESCENT
PWTB-1/2
PYTB-A/B
BLRA
DPA
DPF-A1
DPF-A2
DPF-B1
DPF-B2
+28V
DPJ
PWR-0680
32.806
DS Bus Voltage
PWR-0683
-0.223
DPAM-A
PWR-0682
-0.145
DPAM-B
PWR-0681
-0.053
DMCA
PWR-3003
Current
ROVER
MMRTG
5 Rover Shunt Stages on RTG Cold Plate
PWR-3001
PWR-3002
PWR-3006
RPA
SDS-3
PBC
ISO status
BCB-2
PWR-3122
Vbus
ISO status
BCB-1
PWR-3022
Vbus
Cmd'd Bus Vset
PWR-7954
32.8V
Rover Bus Voltage
PWR-3000
Pyro Arm/Enable-A
Pyro Arm/Enable-B
Pyro Busses to RPFA
PWR-3004
RPAM-A
PWR-3005
RPAM-B
PWR-3007
RMCA
BCB Legend
BCB FET disabled
BCB FET enabled
RBAT-2 Voltage
PWR-3123
PWR-3121
PWR-3021
RBAT-1 Voltage
PWR-3023
RBAT-1
RBAT-2
RBAU

# MSL Cruise, EDL and Surface

- Downlink processors
  - 11 MPCS *chill_down* instances, per station IDs (DSSID) and virtual channels (VC)
- Databases
  - Capture (load) database separate from query database, for optimized performance per usage pattern
  - Creative use of Load Data Infile (LDI) feature to replicate data across network in real-time
- Open message service bus
  - Allowing custom tools to “plug in” and perform various functions off of real-time telemetry and monitor data
- Real-Time Displays
  - Scalable chill_montor instances

# Questions and Answers