Overview

Dr. David J. Atkinson, Division Manager (Acting)

Mr. David A. Nichols, Assistant Division Manager for Flight Projects

Development of mission information systems and supporting infrastructure, spanning the product lifecycle from fundamental computer science research through development, deployment and operations of complex software systems, including space platform, ground, and enterprise applications.
Division Strengths

- Market for products/services: healthy
  - Growing demand for networking/EIS applications
  - Growing demand for expertise in GSW/FSW
  - Stable (relative) demand for DSMS products
    - Shifting from "big bang" system development to "evolutionary"
  - Many emerging opportunities for new products
    - Interplanetary Network
    - Autonomous/automated systems (finally mature enough for infusion)
    - Supercomputing (Science, Instrument GSE, Engineering)
    - Systems for Reimbursable customers
  - Satisfied customers with more at the door: NASA, AGA

- Products: healthy now and robust for the future
  - Current products meet current customer needs - no major mismatch
  - Many opportunities to add value for the customer (existing products)
  - Solid basis for continued creation of breakthrough and disruptive technologies -- Opportunities for significant technology infusion
  - Good ideas on how to improve quality, productivity, innovation
Personnel: Best of the best

- Among world leaders in automated control system architectures/applications (MDS), artificial intelligence, data mining and analysis, high-performance computing, quantum technologies
- Among NASA leaders in networking, IT security, collaboration environments, applications of artificial intelligence, and more.
- Top of the line software engineers and architects; an increasing cadre of software system development managers. We have multiple, very hot teams.
- Outstanding and improving skills in proposals and new business development
- Top people are heavily recruited - a sign they are good!
- Development staff dedicated to working in “project” environment - knowledgeable, participative, and dedicated to s/w engineering quality improvement
- High level of pride in the Division justified by a proven record of success
- Loyal when challenged with a vision & opportunity to make a difference
- Technically excellent in virtually all disciplines/skills needed for our products; leaders are at the state of the practice (products), state of the art (R&TD)
- Culture of getting to, staying at, and pushing the leading edge
- Hungry for greater challenges
Division 36
Demographics

JPL Employees by Job Families

- Engineer's: 72%
- Science: 2%
- Technology: 1%
- ED&O: 10%
- Admin: 13%
- Support Services: 2%
- IS&CS: 2%

Division Total Population:
- JPL Accountable: 451
- Contractor Cat "A": 217
- Contractor Cat "X": 120
- Division Total: 788
Strengths (cont.)

- Partners and relationships: capability value-added for customers
  - NASA
    - ARC: Long-time partners in IT R&TD, albeit with occasional sibling rivalry. Stronger relationship today than every before. Major technology source.
    - GSFC: Active partnership and communication on improving software quality and engineering practices.
    - Dryden: NASA, DoD, and interfaces to industry (UAV,X-33, ...)
  - Nat'l Labs
    - APL (autonomy), LLNL, Los Alamos (high perf. computing; quantum)
  - DoD
    - Army, USN/Marines, DARPA, DISA, AFRL, NRO, NIMA, AGA
  - Industry
    - Sun Microsystems, Cray Research/SGI, Boeing, Lockheed, Princeton Satellite Systems, Northrup Grumman, CSC, Raytheon, Draper Labs
  - Academia
    - MIT, CMU, UCI, UCLA, UCSB, UCB, USC, Vanderbilt, ASU, UA, Univ. Colorado (Boulder), Univ. Michigan, Wesleyan, Stanford, U.Wisconsin, SUNY (Rochester), ...rich set of relationships.
Major Products of the Division

- **Multi-Mission Data Systems (9x)**
  - DSMS (AMMOS)
    - TTC&DM (Tracking, Telemetry, Cmd and Data Mgmt)
    - TLP (Telemetry Processor)
    - TDDS (Tracking Data Delivery Subsystem)
    - DTT (Downlink Telemetry and Tracking)
    - NMC (Network Monitor and Control)
    - MCIS (Monitor and Control Infrastructure Service)
    - DSCC Connection Automation Framework
    - CS (Complex Supervisor)
    - SPPA (Support Products Provider Assembly)
    - SPS (Service Preparation Subsystem)
    - SOE Automation
  - DSN
    - CCSDS SLE Frame Delivery Services
    - DSN Command Subsystem
    - DSN Uplink System (command, exciter transmitter controller, uplink ranging functions)
    - DSN Resource Scheduling tools / Broker conflict-free
    - DSN Tracking
    - Beacon-based communications architectures
    - Network Simplification Project (Uplink)
  - MDS
    - Data Management and Delivery Frameworks
    - Data Transport Domain
    - Visualization and Automation Tools
    - Advanced Planning and Scheduling applications

- **Project Specific Products**
  - TTCS (Telemetry Command and Control System):
    - recent: JASON
  - Mission Data Management systems/services
  - Software Development Environments
  - Flight System Software Architectures and Flight
    - Project Software Element Mgmt (new)
  - Customize and Adapt DSMS and related software for Flight Projects
  - Operations and Testbed System Integration
  - Mission Support Area Facilities
  - Ground Data Systems Tools and Flight Team Training
    - Curriculum
  - Flight Operations Engineering
  - Flight Control Team Operations
  - Project/DSN Documentation Systems and content
  - Fault Protection Algorithms and Architecture
  - Automated Test-case generation systems

- **Institutional Software Systems Leadership**
  - Software process standards deployment
  - Software Quality Improvement (SQI)
  - Software engineering tools, environments
  - Laboratory for Reliable Computing
Major Products of the Division

- Institutional Computing and Info Systems
  - Enterprise Networks and Engineering
  - Voice and Video Telecommunications
  - Facilities, Hardware Engineering, Maintenance and Operations
  - Network Technology Development
  - Network and Computer Systems Administration
  - Supercomputing, Visualization, and High Definition Systems
  - IT and Network Security, Surveillance and Access Control
  - Enterprise Information Systems (e.g., email)
  - Wide-area Collaboration systems
  - NASA-wide Video Conferencing and connectivity
  - Network interoperability and connectivity with Mission, Industry & Contracting Partners, University, & other Centers
  - Knowledge Management Systems
  - Advanced Web Systems (Portal) applications

- Reimbursable Non-NASA
  - (IMMACS) Integrated Marine Multi-Agent Command & Control System (SharedNet)
  - DII COE (Distributed Information Infrastructure Common Operating Environment)
  - Corp Battle Simulation (CBS); WARSIM support
  - IVHM/UAV (Dryden/Boeing/Lockheed)
  - IVHM/SLI (JSC/Boeing/Lockheed)
  - Sub-surface data analysis (Army COE; others)
  - Geospatial Intelligence Advancement Testbed (NIMA)

Research Products (partial list)
- Collaborative Engineering Tools
- Advanced supercomputing architectures
- Quantum Computing Technologies
- Parallel computing research applications for scientific data processing, visualization, simulation, and modeling.
- Data mining research applications
- Data analysis and fusion methods
- Planning, Scheduling, and autonomous commanding research
- Closed-loop autonomous systems; architectures
- Massively parallel algorithms
- Verification and validation of autonomous systems
- Automated fault monitoring, diagnosis, identification and recovery systems
L. BERGMAN, MANAGER
A. MARTIN, DEP. MGR.

NETWORK & COMPUTER SYSTEMS ADMINISTRATION
C. BURGESS

- Workstation and network deployment for IND DSMS and flight projects
- Administration of local and remote user accounts
- Support Remedy, Oracle, and other JPL developed application services
- UNIX and LINUX system administration

ENTERPRISE NETWORKS & TELECOMMUNICATIONS
D. WILCOX

- Enterprise network engineering and deployment
- Enterprise network operations
- Telephone services
- Video distribution network
- Wireless network
- Conference room A/V upgrades

FACILITIES, HARDWARE ENGINEERING, & M&O
K. ZAMORA

- Sun and SGI workstation maintenance
- IT bundling
- UNISYS mainframe maintenance and SA support
- IT facilities infrastructure engineering
- Computer center and control room design
- Multi-media hardware

WEB SYSTEMS APPLICATION
L. CHING

- Web site development
- Systems implementation including custom database applications, human factors and usability, and applications of unique products

ADVANCED CONCEPTS ENGINEERING
D. CHENEY

- Knowledge management engineering and deployment
- DocuShare support
- JPL portal engineering and implementation
- Contracted web and multi-media services
GOALS AND OBJECTIVES

- Enable practical and effective Petaflops scale computing within a decade.
- Dramatically improve efficiency, generality, and programmability over today's supercomputers

INNOVATIVE TECHNOLOGIES

- Low power high speed (200GHz) RSFQ superconductor logic
- Smart processor-in-memories (PIM)
- Holographic intermediate (3/2) storage between disk and DRAM
- Advanced optical communications

ARCHITECTURE APPROACH

- Very high speed processors for reduced concurrency
- Merges diverse technologies to leverage complementing strengths
- PIM memory architecture for reduced communications bandwidth
- Multithreaded execution model for latency management & high efficiency
Objective:
- Make spacecraft cheap enough to fly and smart enough to survive.
- Develop new class of scalable spaceborne PIM-based computers for 21st Century
  ) 10-100X power reduction  ) 1-10 GFLOPS/chip
  ) 4X-8X latency reduction  ) 100Gbps on chip I/O
- Support autonomous mission & MDS model
- Single architecture for varied mission profiles: orbiters, landers, rovers, flyers, sensor webs

Strategy
- Exploit recent advances in CMOS technology and PIM architecture
- Highly replicated fine-grain processor hardware for power management, fault tolerance, and real-time response.
- Extend memory and task to virtual model for dynamic adaptive resource management.
- Employ message-driven active messages fine-grain object oriented execution.
- Adapt advanced multithreading for simple unified resource management.
Interplanetary Internet, 2020
JPL

EXPLORATION SYSTEMS AUTONOMY SECTION (367)
FUNCTIONAL ORGANIZATION CHART

EXPLORATION SYSTEMS AUTONOMY
A. TAVORMINA, MANAGER
T. Yunke, DEP. MGR.

367

TECHNICAL STAFF
M. JUDD
K. REINHOLTZ
B. SMITH

3670

ARTIFICIAL INTELLIGENCE
S. CHIEN
3672
• Automated mission activity planning & scheduling systems
• Integration of planning systems with onboard science analysis

ULTRA COMPUTING TECHNOLOGIES
A. FJIANY
3673
• Vehicle and ground-based health maintenance systems
• Model-based diagnosis technologies
• Novel computational paradigms
• Quantum algorithms

MACHINE LEARNING SYSTEMS
R.CASTA'NO
3674
• Statistical pattern recognition
• Data mining (spatial and temporal)
• Fast, automated feature identification
• Onboard science analysis systems
• Autonomous science discovery in large data sets
• Computational systems biology
• Scientific inference systems
• Integration of science analysis with onboard planning systems

DATA UNDERSTANDING SYSTEMS
K. HURST
3675
• Computational modeling and analysis methods for large spatio-temporal natural systems
• 3-Dimensional finite element modeling
• Algorithm-based fault tolerance research
• Image data fusion for scientific understanding
• Distributed sensor systems - information architectures and modeling

QUANTUM COMPUTING TECHNOLOGIES
J. DOWLING
3676
• Quantum theory and applications
• Quantum gravity
• Quantum magnetometry
• Quantum clock synchronization
• Quantum lithography
• Quantum information theory
• Quantum internet testbed
• Quantum communications
• Quantum interferometry

PARALLEL APPLICATION TECHNOLOGIES
D. KATZ
3677
• Advanced parallel computing applications
• On-the-fly visualization of massive datasets (solid earth, astronomy, ocean)
• Data fusion and change detection in large datasets
• Rendering and serving of large datasets to distributed users
• Advanced mission simulation and risk assessment technologies
• Common component architecture
• Grid computing methods and technologies

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Autonomy Program
APM: Ben Smith

Onboard Planning & Execution

Pattern Recognition & Data Understanding

Quantum Computing

Health Monitoring & Diagnosis

Safe and Precise Landing
Opportunistic Science & Onboard Data Processing

Code-S Relevance
- Titan Organics Explorer
- Europa Orbiter
- Europa Lander
- CNSR
- Neptune Orbiter
- NGST
- TPF
- Mars
Quantum Technologies at JPL

Quantum Micro Devices:
Ultra-Fast Superconductor Single Photon Detectors and Quantum Gates

Quantum Interferometry and Gravity Gradiometry

Quantum Internet Testbed:
Quantum Lithography and New EPR sources

Quantum Clock Synchronization
Ultra-Secure Quantum Communications

$\Delta \Phi = 2k (g_g g_v) T^2$
SOFTWARE SYSTEMS AND OPERATIONS ENGINEERING SECTION (368)
FUNCTIONAL ORGANIZATION CHART

SOFTWARE SYSTEMS AND OPERATIONS ENGINEERING
R. VARGO, MGR
B. KAHR, DEPUTY MGR.

TECHNICAL STAFF
B. ARROYO
G. CHIN
A. ELSON
D. ERICKSON
E. GAT
C. HIDALGO

FLIGHT SOFTWARE DEVELOPMENT & TECHNOLOGY
R. SHERWOOD
3682
- Planning and scheduling systems
- Beacon based communications architectures
- Advanced execution systems
- Generation of model-based code
- Fault Protection algorithms and architecture
- Next generation mission software architectures
- Automated test case generation

MISSION SOFTWARE TEST & INTEGRATION
J. COHEN
3683
- Test and verify flight and ground software
- Support earth science payload operations
- Support payload ground integration
- Develop software environments

MISSION DATA SYSTEMS ADAPTATION
Y. LEE
3684
- Customize and adapt mission unique software
- Operations and Integration of testbeds
- Web-based mission operations systems
- Visualization tools for mission operations
- Develop software environments
- Manage mission data
- Data accountability
- Database administration
- Time correlation services
- Engineer mission data management systems
- Sustain mission data management processes

MISSION INFORMATION MANAGEMENT SERVICES
S. SPHON
3685
- Operate, monitor, and control spacecraft and instruments in real time
- Process, stage, radiate, and verify spacecraft commands
- Evaluate system level spacecraft and instrument performance
- Evaluate and monitor GDS performance
- Coordinate DSN tracking
- Flight operations engineering
- Design, implement and manage mission support area

MISSION CONTROL & OPERATIONS ENGINEERING
R. SMITH
3686
- Conflict free DSN scheduling commitments
- GDS tools and flight team training and readiness
- Flight Team performance validation
- GDS performance assessment
- ITAR security
- Mission documentation systems
- Educational outreach
- Project software scheduling
- Project software management
- Software systems architecture
- ATLO systems integration management
- Process/standards SE
- Test and training SE
- Resource allocation & planning SE
- ITSE
- GDS SE

CUSTOMER INTEGRATION SERVICES
N. TOY
3687

MISSION SOFTWARE SYSTEMS ENGINEERING
L. HALL
3688
JPL Deep Space
Mission Control Centers
Mission Data System

**Vision**
A systems engineering process and matching software frameworks for developing unified flight, ground & test system architectures for space missions

**Objectives**
- Unified flight, ground & test architecture
- Reusable software components & simpler interfaces
- Earlier collaboration of mission, system & software design
- More effective use of software engineering resources
- Safety by design, in every aspect
- Operations based on intent (goals), not commands
  - Embraces autonomy architecturally
- Evolvable to in situ exploration & other autonomous applications
- Customer-controlled complexity:
  - Simple to sophisticated, depending on mission requirements
  - Easy to exercise options

**Key Architectural Themes**
- Construct subsystems from architectural elements
- Migrate capability from ground to flight to simplify ops
- System state and models form the foundation for info processing
- Express domain knowledge explicitly as models
- Operate missions using constraints on desired state
- Design for real-time reactions to changes in state
- Make fault protection integral to the system
- Authorize and monitor all resource usage
- Separate state determination from state control
- Determine state honestly from the evidence
- Separate data management from data transport
- Use a common mathematical base for Navigation and ACS
- Design interfaces for change

**Applicability**
- Entry, descent, and landing (EDL):
  - Needed by eleven NASA Space Science missions
  - Requires accurate state information and closed-loop control
- Formation flying:
  - Needed by six NASA Space Science missions
  - Requires distributed control with s/c-to-s/c communication
  - Requires coordinated navigation and attitude control
- In situ / Remote operations:
  - Needed by eleven NASA Space Science missions
  - Requires autonomous operation and fault recovery
- Cross-links / Proximity links:
  - Needed by twelve NASA Space Science missions
  - Requires data transport among multiple spacecraft
Advanced Mission Software Technology

Responsible for the refinement and infusion of advanced software technologies for current and future flight missions.

- Migrate advanced software technologies from research groups to flight projects including planning and scheduling systems, Beacon-based communications architectures, advanced execution systems, etc.

- Perform near-term mission software research and development including:
  - Code-generation
  - Advanced fault protection software
  - Next generation mission software architectures
  - Automated test case generation

- Develop advanced reusable mission software (flight, ground, test) for use in mission operations of autonomous spacecraft, constellation spacecraft, and advanced surface missions.

Accomplishments:
- Established collaborative partnership with USC in software architecture
- Established partnership with University of Colorado Space Grant College to fly on-board planning software on upcoming 3 Corner Sat constellation
- Infusion of automated test case generation into Mission Data Systems (MDS) Project
- Developed an innovative software architecture technology and component-based engineering methodology for MDS
- Co-Investigator in New Millennium ST-6 Phase 1 Technology Development task
Autonomous Sciencecraft Constellation
New Millennium ST6 Experiment

Thinking Systems technologies developed at JPL enabled this winning proposal

• Onboard data processing
  (Knowledge Discovery: DiamondEye)

• Fast onboard planning & execution
  (Self Commanding Spacecraft: CASPER)

Capabilities to be Demonstrated

Autonomous Retargeting:
• Detect surface-change events on 1st pass and autonomously reconfigure constellation for higher resolution observation on repeat pass.

Intelligent Downlink Selection:
• Onboard feature recognition algorithms summarize & prioritize observations to maximize science return for fixed bandwidth.

Mission Relevance

• Enable observation of short-lived surface-change science opportunities
  • Earth: lava flow, floods, iceberg calving
  • Mars: dune motion, ice cap adv./retreat
  • Io: observe volcano eruptions
  • Europa: surface change from tidal stress.

• Maximize science return for fixed downlink bandwidth.
MISSION SOFTWARE SYSTEMS SECTION (369)
FUNCTIONAL ORGANIZATION CHART

MISSION SOFTWARE SYSTEMS
A. LARSON, MGR
N. DEHGANI, DEPUTY MGR.
369

TECHNICAL STAFF
E. CORDUAN
M. DEGYURKY
J. KAHR
M. LAVIN
T. MCVITTIE

SOFTWARE SYSTEMS ENGINEERING
M. LEVESQUE
3692
- Tracking, telemetry, command & data management (TTC&DM) software engineering for DSMS
- International space communications standards
- Future mission planning for ground data system (GDS) design and costing

MISSION S/W INTEGRATION & TEST
S. MARKHAM
3693
- Assembly & subsystem testing and integration testing of all DSMS TTC&DM products
- Simulated and end-to-end data flow testing
- Tailor DSMS TTC&DM products to flight project requirements
- Flight project acceptance testing and MVTs
- Operations procedures and training
- Subsystem/system testing and integration for the Network Simplification Project (NSP)

MULTISSION DATA SYSTEMS
J. LOUIE
3694
- Design, implementation, and test of TTC&DM data systems
- Telemetry frame, packet, and channel data processing
- Core data communications and data transport
- Spacecraft and instrument GSE Test T&C (TTACS)
- DSMS Network Simplification Project
- Tracking Data Delivery System (TDDS)
- Telemetry Processor (TLP)
- CCSDS Frame Delivery Service

MISSION DATA MGMT & DELIVERY
A. GUERERO.
3695
- Design and build new Uplink Subsystem for DSN
- Define, design, and implement file data management applications
- Mission Data System (MDS) data management and delivery frameworks

MISSION SERVICE MANAGEMENT
E. LAW
3696
- Design and implement new Network Monitor and Control (NMC) subsystem as part of Network Simplification Project
- DSMS Service Preparation Subsystem (SPS)

DISTRIBUTED SYSTEMS TECHNOLOGIES
L. DE FORREST
3697
- SW architectural direction and software systems engineering to DII COE
- Integrated Marine Multi-agent Command and control Subsystem (IMMACS)

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Deep Space Mission System

- Telemetry, Command, Communications and Data Management systems for IPN-ISD Telecom Services, covering both AMMOS and DSN.

- Network Monitor and Control (NMC) and Service Preparation System (SPS) for IPN-ISD Monitor and Control Services
Collaborative Communities of Agents, Sensors, & People

Common Goals:
- In-situ collaboration with instruments, systems, and people from other organizations and nations.
- Efficient use of very narrow communications links to exchange priority information.
- Command & Control supporting multiple simultaneous missions.
- Generic computer services protecting systems: security, fault tolerance, integrity, replication.
- Agent-based reasoning supporting autonomous operations & fault detection/correction.

Common Approach:
- Based on a rich information-centric model of the “world” - objects & relationships
- Information distribution based on priorities and subscriptions.
- Store and forward architecture supporting distributed servers on a variety of air, orbital, and ground platforms.
- Information-centric approach and open architecture provides excellent support for agents & opportunistic collaboration.

Collaborators: JPL/NASA, Cal Poly SLO, Penn State, NRL-Stennis & DC, SPAWAR-SSC/SD, FGM Inc.
Sponsors: ONR, DSS FNC, USMC