RIACS

# 25 Years of Innovation

USRA 40 YEARS 1969-2009

*RIACS is a division of the Universities Space Research Association,*
*Celebrating 40 years of service to the space science and technology community*

The Research Institute for Advanced Computer Science (RIACS), a division of the Universities Space Research Association (USRA), recently celebrated 25 years of scientific research supporting the NASA Ames Research Center in California's Silicon Valley.

Since its inception in June 1983, RIACS has conducted basic and applied research in computer science for the nation's aeronautics and space-related missions and programs, and a goal of the institute's research has been to enable a high degree of automation for every aspect of scientific research and engineering. RIACS was recently nominated by NASA for the 2008 National Medal of Technology and Innovation – the highest honor for technological achievement bestowed by the President of the United States – for twenty-five years of pioneering innovation in computer science, intelligent systems, and software that have been instrumental in advancing our nation's civil space and aeronautics programs.

RIACS's achievements include numerous published research results that have had lasting effects in their disciplines; seminal firsts related to the application of artificial intelligence to civil space and aeronautics programs; and the infusion and operational sustainment of technological innovations for routine use within NASA. In addition, patented and open source systems pioneered by RIACS have also had impact beyond NASA, including impact on the process of software testing, aerodynamic simulations, autonomous vehicles, and collaborative enterprise applications. During its twenty-five year history, RIACS has collaborated with NASA to lead the development of a number of pioneering technologies, including: *Sparse Distributed Memory* – an associative memory that mimics human long-term memory, *Adaptive Grid Computations* – a set of methods that dramatically improved performance by optimizing mappings from computational grids to parallel machines, *AutoClass* – the first artificial intelligence software to make a published astronomical discovery, *RemoteAgent* – the first artificial intelligence system to fly onboard a spacecraft and control it in deep space, *MAPGEN* – the first artificial intelligence software to plan the work of robots on another planet, *Clarissa* – the first spoken-dialog system used in space, *Java Pathfinder* – the first model checker for software testing

**1983**

**RIACS founded as a joint collaboration between USRA and the NASA Ames Research Center, after two years of planning under the auspices of the NASA Office of Aeronautics and Space Technology. Initial research focused on concurrent programming, artificial intelligence, and computational physics**

**Peter Denning joins as first director of RIACS**

**1984**

**Working with Herny Lum, RIACS helps establish an Artifical Intelligence Plan for NASA Ames**

**Development work begins on a simulation of the local area network for the International Space Station (LANES)**

**Dr. Eugene Levin works with NASA on Numerical Aerodynamic System (NAS) Technical Studies for Advanced NAS**

directly on code, and *Cart 3D* – a critical invention for computational fluid dynamics that enabled accurate simulation of tumbling debris for NASA's Return to Flight of the Space Shuttle program.

These achievements were made possible through the capability of RIACS to support multi-disciplinary and cross-organizational teams of world-class scientists and engineers from the NASA Advanced Supercomputing (NAS) and Intelligent Systems Divisions of the NASA Ames Research Center, as well as organizations such as Boeing, Xerox, Purdue University, Stanford University, and MIT. RIACS has also worked on projects funded by the National Science Foundation, NASA Jet Propulsion Laboratory, NASA Goddard Space Flight Center, Department of Defense, and other organizations. The environment conducive to this cross-organizational teamwork is directly linked to USRA's non-profit chartered purpose, enhanced by its capability of hiring the best talent from around the world with fast turn-around due to USRA's exemption from the H1B visa cap.

Specific areas of current focus include: Autonomous Systems and Robotics (e.g., agent-based architectures), Collaborative and Assistant Systems (e.g., collaborative mission control technologies, geospatial information systems, and program management systems), Discovery and Systems Health (e.g., statistical data mining techniques), Robust Software Engineering (e.g., automated software testing), Small Spacecraft (e.g., modular architectures), and Science Instruments (e.g., statistical data analysis).

## High Performance Computing Research

Part of supporting NASA's high performance computing goals

Since its founding in 1969, the Universities Space Research Association has been an integral part of the nation's space program, and RIACS has played an important role in the association's forty-year history of service to the aeronautics and space research community. During this time, USRA has been led by five presidents:

| | |
|---|---|
| A. Robert Kuhlthau | (1969 - 1976) |
| Alexander Dessler | (1976 - 1981) |
| Paul Coleman | (1981 - 2000) |
| David Black | (2000 - 2006) |
| Frederick Tarantino | (2006 - present) |

Since its inception, eight directors have led RIACS as it pioneered advanced technologies in supercomputing and intelligent systems.

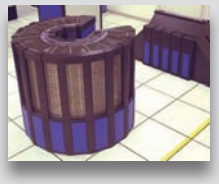
| | |
|---|---|
| Peter Denning | (1983 - 1990) |
| Richard Sincovec (acting) | (1990 - 1991) |
| Joseph Oliger | (1991 - 1998) |
| Bob Moore | (1998 - 1998) |
| Mike Raugh (acting) | (1998 - 1999) |
| Barry Leiner | (1999 - 2003) |
| Serdar Uckun (acting) | (2003 - 2004) |
| David Bell | (2004 - present) |

The institute has also been a prolific contributor to the academic community, publishing more than 1,330 papers and technical reports during its twenty-five year history. In addition, RIACS has hosted more than 230 visiting scientists, received more than 20 awards, and has more than 80 patents and invention disclosures.

**Parallel algorithms research expands with the acquisition of an Intel iPSC Hypercube and Sequent Computing supercomputers**

**NAS Technical Studies continue in support of the definition, design, implementation, integration, and test activities of the Advanced NAS program, especially the Extended Operating Configuration (EOC) and Graphical Subsystem. Many recommendations adopted by NAS Projects Office**

**1985**



**CRAY-2 Algorithm and Performance Studies begun to examine the interaction between slow massive main memory and fast machine cycle times**

**Work begun to improve High Reynolds Number Incompressible Flow around a circular cylinder**

**"Numerical Aerodynamic Simulation Program NPSN System Specification for the Extended Operation Configuration (EOC)" published and approved for Advanced NAS**

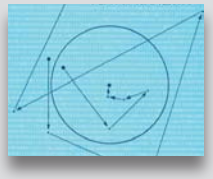
**1986**

involved expanding the agency's networking and data transport efforts. It is easy in today's Internet age to take connectivity for granted, but there was a time – not so long ago – when determining how users would access computational resources was a fundamental issue. One of the first challenges addressed by RIACS staff was to study the issues pertinent to developing a local area network (LAN) for the International Space Station. In this effort, requirements for the LAN system were identified and a variety of media access protocols were evaluated. Subsequently, the draft information systems request for proposals was reviewed to aid in the space station's development process.

Simultaneous to the International Space Station's LAN development, RIACS scientists were working to connect a number of Federal scientific networks within the research community. By the early 1990s, the Defense Advanced Research Projects Agency (DARPA) was funding part of RIACS' work on the NASA High Performance Computing and Communications Program's (HPCCP) effort to link five gigabit testbed networks throughout the United States. In 1993, RIACS staff guided the establishment of the sixth, known as the Bay Area Gigabit Network Testbed (BAGNet). NASA Ames and Xerox Palo Alto Research Center were the first two BAGNet testbed sites. By 1995, the commercial Internet was firmly established, and BAGNet led to research in improving the quality of service for data transfer. Subsequently, the space agency became involved in the Next-Generation Internet initiative, and its research efforts evolved under the NREN (NASA Research and Education Network) banner. RIACS staff supported NASA's NREN and its use as a platform for prototyping and demonstrating new applications for achieving NASA's science, engineering, and educational objectives – use that continues at the agency to this day.

In order to take advantage of Moore's Law, part of the NAS's mission is a research component that constantly evaluates the next generation of computer processors, determines which will fit into the NAS environment, and makes recommendations for NASA's future production supercomputers. In the late 1980s, the NAS's research component needed a measurable standard by which to gauge new processors, but one did not exist. From this need grew the NAS Parallel Benchmarks (NPB), developed to objectively study the performance of parallel supercomputers.

Supporting a NAS–led team, RIACS staff were among the co-authors of the NPB, consisting of five kernels and three simulated CFD applications derived from important classes of aerophysics applications. The depth of these benchmarks and the fact that they capture the essence of typical large-scale CFD applications have made NPB popular, not only for the purpose of evaluating parallel supercomputing



**1987**

***Sparse Distributed Memory*** **is authored by RIACS scientist Pentti Kanerva and published by MIT Press, Cambridge**

**"Automatic discovery of Optimal Classes" published by RIACS scientist Peter Cheeseman, exploring efficient methods of automatic machine learning**

**1988**

**The Bayesian Learning Project develops automated technology, based on Bayesian statistical techniques, for discovering general patterns in data**

**RIACS Networked Systems, Parallel Systems, and Learning Systems Divisions formed to facilitate network-based control of complex experiments; push supercomputer performance; and work on artificial intelligence problems, respectively**

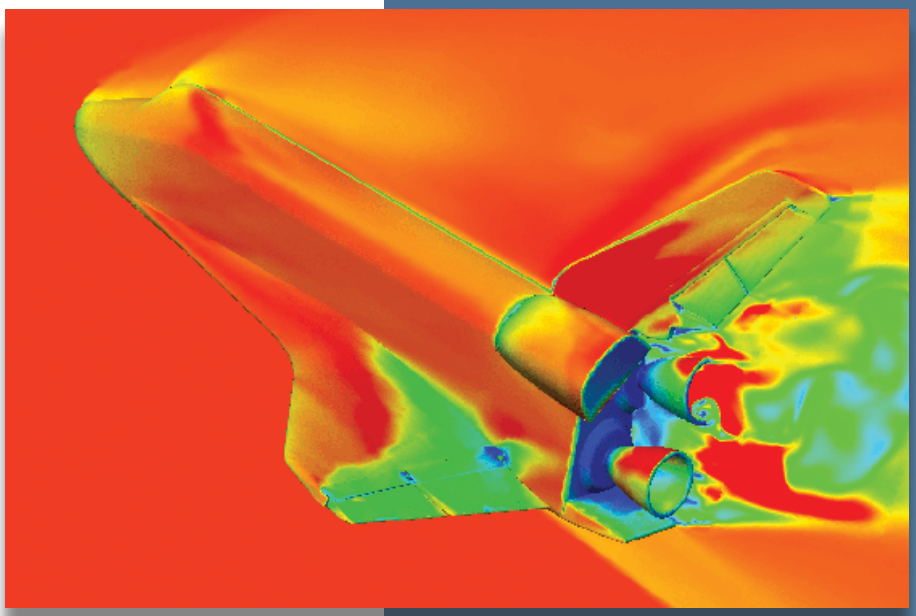
systems but also in demonstrating the viability of novel software and architectural concepts. In the 1990s, the NAS Parallel Benchmarks suite set the standard that the majority of supercomputers were measured by, and subsequently became one of the most widely used benchmarks in many areas of high-performance parallel computing.

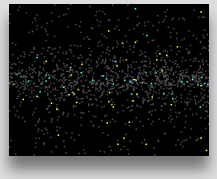
In 1996, RIACS staff began collaborating with NASA researchers to develop algorithms to simulate steady state flows in three dimensions using Cartesian grid representations. This work was released to the scientific and academic communities as CART3D, a high-fidelity inviscid analysis package for conceptual and preliminary aerodynamic design that allows users to perform automated CFD on complex vehicle shapes – whether they are aircraft, space vehicles, ships, submarines, race cars, or big rig trucks. Cart3D automates grid generation to a remarkable degree, enabling even the most complex geometries to be modeled 100 times faster than previously possible. Simulations generated by Cart3D help identify and fix problems in a variety of aircraft and spacecraft from the Space Shuttle to military transports and helicopters. In addition, Cart3D allows the simulation of complex geometries in fields other than aerospace, ranging from astrophysics to computer science to electromagnetics.

In 2002, Cart3D was named co-winner of NASA's Software of the Year Award, and

*Cart3D played a critical role in resolving the main physical cause of the Space Shuttle Columbia disaster – foam debris that struck the orbiter on ascent – by generating simulations that predicted the trajectory of tumbling debris from foam and other sources. RIACS visiting scientist Professor Marsha Berger, of the Courant Institute, New York University, was co-inventor of Cart3D.*

*Below: Cart3D Image of Space Shuttle Courtesy of NASA*

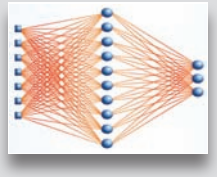




**AutoClass becomes the first artificial intelligence software to make a published astronomical discovery**

**RIACS Director Peter Denning receives the Computer Research Board's award for Service to Computing Research and the ACM Distinguished Service Award**

## 1989



**NASA Technical Report "Distributed Memory Approaches for Robotic Neural Controllers" is published, examining the suitability of two distributed memory neural networks as trainable controllers for a simulated robotics task**

**RIACS' Roland Freund receives the Heinz-Meier-Leibniz award in applied mathematics from the German Secretary of Education**

## 1990

a U.S. patent for the Cart3D methods was issued a month later. Cart3D was subsequently commercialized by ANSYS Inc. of Cannonsburg, Penn., for private and industry use.

### Space Shuttle Return-to-Flight

Following its list of successes, Cart3D then played a critical role in resolving the main physical cause of the Space Shuttle *Columbia* disaster – foam debris that struck the orbiter on ascent – by generating simulations that predicted the trajectory of tumbling debris from foam and other sources. Cart3D's computational six-degree-of-freedom CFD process for simulating ascent debris was then validated through a variety of physical tests before the Space Shuttle was cleared to fly again. The return-to-flight simulations

**1991**

- The NAS Parallel Benchmarks, with RIACS scientists Paul Frederickson and Robert Schreiber among the co-authors, is released and becomes the standard for performance evaluation of parallel computer systems
- Joseph Oliger serves as RIACS director

**1992**

- RIACS National Software Exchange Project initiated to support High Performance Computing and Communications Program Software Exchange (funded by DARPA, Department of Energy, National Science Foundation, and NASA)
- AutoClass recognized by NASA, receiving the 1992 Space Act Award

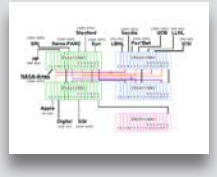
of unsteady aerodynamic data for complex trajectories was possible because of the nearly decade-long research on generating Cartesian grids for complex geometries.

In further return-to-flight operations, RIACS staff member Dr. Walt Brooks, on assignment to the government throught the Intergovernmental Personnel Act (IPA), initiated the Columbia Supercomputer project. In October 2004, NASA's 10,240-processor supercomputer Columbia reached a sustained performance of 42.7 teraflops (trillion calculations per second) – using only 80 percent of the computer's capacity – making it the fastest production supercomputer in the world at the time. The Columbia system subsequently reached a sustained performance of 51.9 teraflops and was immediately put to use to support the agency's Space Shuttle Return-to-Flight effort including running CFD models to help NASA characterize debris flow patterns and understand the conditions the Space Shuttle's thermal protection system experiences during re-entry.

Since its inception, the Columbia supercomputer system has been used to model climate and sea ice interactions, study the formation and evolution of the dark matter halo that has enveloped the Milky Way

*Dr. Walt Brooks, a RIACS staff member on IPA assignment as the NAS Division Chief, led the Project Columbia team, which included Silicon Graphics Inc. (SGI) and Intel, as well as NASA and its contractors. This represented the most recent major contribution by a RIACS staff member for supercomputing at NASA, after decades of high-performance computing advancements. Founded just a few months after the NASA Advanced Supercomputing Division, RIACS was set up to act as a bridge between NASA Ames Research Center, the academic community, and the computer industry.*

*Left: Columbia Supercomputer*
*Courtesy of NASA Ames*



**RIACS' Marjory Johnson is one of the coordinators in the establishment of the Bay Area Gigabit Network Testbed (BAGNet). NASA Ames and Xerox Palo Alto Research Center are first two testbed sites**

**1993**

**Model-Based learning tools used to automatically analyze spectral data from the Space Shuttle Main Engine (SSME) become the main tools used for this purpose at Marshall Space Flight Center**

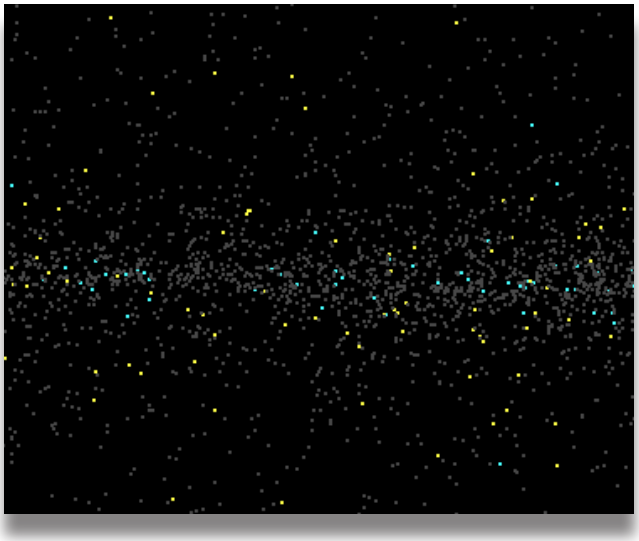
**1994**

galaxy for the last 13.7 billion years, help scientists understand the evolutionary history of our galaxy, evaluate proposed changes to the Space Shuttle's External Tank, improve the safety and reliability of space flight operations, and provide a complete CFD simulation of the Space Shuttle's ascent from launch to orbit.

## Intelligent Systems Research – Enabling NASA Space Mission Success

Since its inception, the development of innovative intelligent systems using Artificial Intelligence (AI) software has been one of the main research agendas of RIACS. As early as 1984, RIACS supported NASA civil servant Dr. Henry Lum to establish an artificial intelligence plan for the NASA Ames Research Center. In 1985, after Dr. Lum led the creation of what is now NASA's Intelligent Systems Division, RIACS made its first and second AI hires to support the new division – Dr. Peter Cheeseman who led research on Bayesian statistics for aerospace applications and Dr. Pentti Kanerva who led research on Sparse Distributed Memory.

Sparse Distributed Memory (SDM) research used an associative memory approach for neural networks storing very long patterns (up to thousands of bits long) that represent encoded sensory data and associated actions, and was capable of retrieving patterns when presented with partial cues. In 1988,



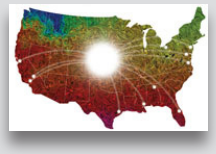
Dr. Kanerva published his ground-breaking work Sparse Distributed Memory through MIT Press, which served as an inspiration for many in cognitive science and artificial intelligence. A recent search has shown Sparse Distributed Memory being referenced in nearly 1,000 articles, 50 books, and 15 patents. SDM has been applied to automatic speech and vision recognition, as well as to smooth motor control of robots. Current research focuses on supporting neural networks as used in NASA's Intelligent Flight Control Systems project.

Bayesian statistics has been and continues to be a major research focus of RIACS, starting with the development of the AutoClass software suite.

**1995**

**Autonomous System Architectures facilitates the integration of autonomous components for planning, anomaly detection, diagnosis, resource allocation, and robust execution in spacecraft architectures**

**1996**



**RIACS staff begins supporting the NASA Research and Education Network (NREN), chairing and co-chairing annual workshops and technical planning committees, as well as interfaicing with the university community.**

AutoClass finds natural classes in real and discrete valued data, without needing to be told how many classes are present or what they look like, and automatically produces a report of its probabilistic findings at the end of its search. AutoClass is notable as being the first AI software to make a published astronomical discovery – on July 27, 1989 – when statistical patterns detected by the AutoClass software indicating new classes of infrared stars in the low resolution spectral catalogue from the NASA IRAS mission were accepted for publication in the *Astronomy and Astrophysics Journal*. Many journal papers have since been published by astronomers and astrophysicists who used AutoClass to enable additional discoveries, and AutoClass has been used to discover new classes in other domains such as the discovery of classes of proteins, introns and other patterns in DNA/protein sequence data.

AutoClass research was awarded the 2007 Association for the Advancement of Artificial Intelligence (AAAI) Classic Paper Award, being deemed the "most influential" from the 1988 conference year, and has been cited in numerous patents, including 18 patents issued to Microsoft Corp. alone.

### Space Operations: RIACS Research Takes Flight

RIACS scientists were also instrumental in developing the first artificial intelligence system to fly onboard a spacecraft and control it in deep space. On May 17, 1999, the Remote Agent Software was given primary command of NASA's Deep Space One spacecraft and its futuristic ion engines, controlling the spacecraft without human supervision. The event also represented the first onboard artificial intelligence planning/scheduling and model-based diagnostics system in deep space.

*RIACS scientist Dr. Peter Cheeseman was the lead inventor and principal investigator of AutoClass, and of the classification project resulting in the first astronomical discovery made by a computer system. This research was later recognized by AAAI, which in 2007, presented the "Classic Paper" award for a paper written on Bayesian Classification, deemed most influential from the 1988 conference year. AutoClass has since been described as being "an inspiration and touchstone reference for the first generation of Bayesian machine learning researchers."*

*Left: AutoClass Classification of Astronomical Objects*
*Courtesy of NASA Ames*

**1997**

**RIACS staff begin using the Brahms multi-agent language to model team work practices within NASA missions to improve operational efficiency**

**1998**

**RIACS staff receives Best Paper Award, IEEE Automated Software Engineering Conference for "Assumption Generation for Software Component Verification"**

**Bob Moore and later Mike Raugh serve as RIACS director**

For two days, Remote Agent successfully operated within the on-board computer of Deep Space One, more than 60 million miles from Earth. A second Remote Agent experiment, conducted four days later, demonstrated the ability to plan onboard activities and diagnose and respond to simulated faults. RIACS scientists were co-inventors of the Remote Agent's three main artificial intelligence technologies: the Smart Executive, the Mode-Identification and Recovery (Livingstone) fault-diagnosis system, and the mission planner/scheduler.

By demonstrating that an artificial intelligence system could fly onboard and control a spacecraft, the Remote Agent Experiment laid a foundation for autonomy in future robotic spaceflight. This enables more complex missions in the presence of machine failures, and more scientific investigation without human intervention. Remote Agent led to multiple executive, diagnostic and planning systems used for NASA missions and beyond, including systems flown on Earth Observing 1, an F/A-18, and the Mars Exploration Rovers mission. RIACS scientists led collaborative efforts among scientists from the NASA Ames Research Center's Intelligent Systems Division, the Jet Propulsion Laboratory, and their collaborators to develop Remote Agent.

In collaboration with NASA, RIACS scientists led the development of MAPGEN, a ground-based, mixed-initiative, human-in-the-loop control system used to generate activity plans for the rovers. A few days after landing on Mars on January 3, 2004, command sequences created from the output of the MAPGEN tactical activity planning software brought NASA's Mars Exploration Rover (MER) *Spirit* to life in the Gusev Crater on Mars. As a result, MAPGEN became the first artificial intelligence software to plan the work of robots on another planet. Twenty-one days later, output from MAPGEN brought the second MER rover *Opportunity* to life on the opposite side of Mars.

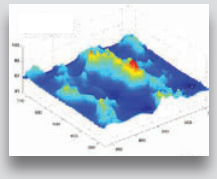
**Remote Agent becomes the first artificial intelligence system to fly onboard a spacecraft and control it in deep space**

**The Remote Agent team is honored with the NASA Software of the Year Award**

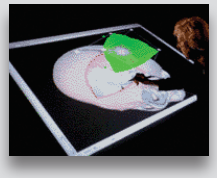
**Collaborative Virtual Environments for Medical and Scientific Imaging is selected as runner up for NASA Software of the Year**

**Barry Leiner serves as RIACS director**

## 1999



**Bayesian Inference and Image Analysis used to integrate information from multiple sensors such as Earth observation and planetary data**



**Collaborative Virtual Environments for Medical and Scientific Imaging demonstrated between NASA Ames, Stanford University Hospital, Salinas Valley Memorial Hospital, Cleveland Heart Clinic, and the Navajo Nation health clinic**

## 2000

*RIACS researchers played a prominent role in the collaborative efforts among scientists from NASA Ames Research Center's Intelligent Systems Division and the Jet Propulsion Laboratory to develop Remote Agent. Staff members included Dr. Barney Pell, Dr. Pandu Nayak, Mr. Kanna Rajan, and Dr. Ari Jonsson.*

*Left: NASA Deep Space One 3D Rendering. Courtesy of NASA*

Each rover then returned beautiful panoramic images and searched for evidence of past water activity on Mars with MAPGEN used every Martian day (sol) to plan the work for both rovers; presently more than 1,500 sols each. MAPGEN is credited with increasing scientific yield between 20- to 30-percent by enabling more activities to be planned each day. The Europa software suite is the core artificial intelligence planning software built into MAPGEN, and Europa will be used in NASA's upcoming Phoenix Mars Lander and Mars Science Laboratory (MSL) missions, as well as for the International Space Station Solar Array Constraint Engine (SACE). Europa was released as open-source

**RIACS begins support of NASA Astrobiology Institute and assisting the Astrobiology Integration Office**

**RIACS supports Human Centered Computing in the development of computational modeling tools for simulating how people collaborate, communicate, and work within their environment**

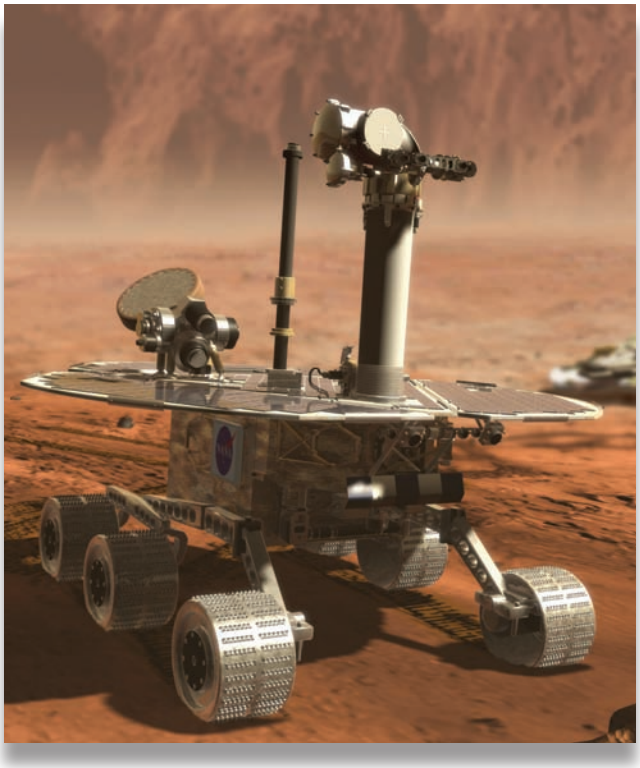
## 2001

**CART3D named co-winner of NASA Software of the Year Award**

**USRA-RIACS and NASA Ames co-chair first community-wide Bio-Info-Nano workshop**

**NASA Public Service Medal awarded to Kathleen Connell for outstanding leadership in the development of broad community, state, and national support of NASA's life science and astrobiology program**

## 2002



software in 2008, and has subsequently been used to support autonomous submersible research at the Monterey Bay Aquarium Research Institute.

RIACS Scientists worked in close collaboration with researchers of the NASA Ames Research Center's Intelligent Systems Division, the Xerox Research Centre Europe, NASA Johnson Space Center, and other collaborators to develop Clarissa – the first spoken-dialogue system used in space. On June 27, 2005, the Clarissa voice-enabled procedure browser held a conversation with Astronaut John Phillips on the International Space Station for Expedition 11.

In collaboration with Clarissa, Astronaut Phillips completed training procedures for testing onboard water supplies, and exercised all the main system's functionality including speech recognition and dialogue management. Clarissa queried Phillips about the details of what he needed to accomplish in a particular procedure, then read through step-by-step instructions and responded to voice commands. This allowed the astronaut to control the system while keeping his eyes and hands focused on the task rather than the laptop computer where the software was running. Clarissa listened to everything the astronaut said, determining what to do based on a "command grammar" of 75 commands, drawing upon a vocabulary of 260 words, and accurately interpreting commands 94 percent of the time.

Clarissa was built upon the REGULUS and ALTERF open source projects, and the effort was led by the RIACS Research in Advanced Language Interfaces and Speech Technology (RIALIST) group. RIACS scientists and engineers were lead innovators of the REGULUS and ALTERF open source software, and principal investigators for the Clarissa project. REGULUS was released as open source in April 2003.

**RIACS supports the agency's verification and validation (V&V) efforts to improve the reliability of software developed at NASA, which in turn will reduce the risk of mission failure**

**Serdar Uckun serves as RIACS director**

**2003**

**MAPGEN is the first artificial intelligence software to plan the work of robots on another planet.**

**Project Columbia Supercomputer reaches a sustained 51.9 teraflops making it the fastest production supercomputer in the world**

**David Bell serves as RIACS director**

**2004**

## Management Software, Data Understanding, and Beyond

RIACS scientists worked in partnership with NASA researchers to develop the NX Knowledge Network to aid in the collaborative management of the space agency. NX Knowledge Network has been used for all three of the agency-wide NASA Management Council Meetings, improving the collaborative performance of NASA's senior leadership in managing the agency. In addition, NX has been used for every subsequent quarterly management council meeting, as well as for study groups led by NASA's Program Analysis and Evaluation group. Key users include the NASA Administrator, NASA Center Directors, and other members of NASA's Strategic Management, Program Management, and Operations Management Councils. NX was subsequently integrated with the InsideNASA portal as part of the NASA Engineering Network with agency-wide use by NASA's approximately 46,000 engineers, contractors, and civil servants.

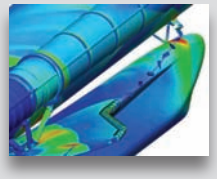
The NX Knowledge Network was the result of a Space Act Agreement between NASA Ames Research Center and Xerox Corp. under the leadership of RIACS staff, which included NASA licensing to Xerox technology co-invented by RIACS staff. The invention was titled, "Extensible database framework for management of unstructured and semi-structured documents," and was subsequently issued U.S. Patent 6,968,338. On March 20, 2006, Xerox announced a new product called "DocuShare CPX" that included a commercialized version of the invention.

To support the management of NASA's missions and programs, RIACS staff co-invented the NASA Program Management Tool (PMT), which uses the underlying principles of the NX Knowledge Network. A major success of PMT occurred on April 15, 2008, when reports analyzing

*During the Mars Exploration Rover mission, MAPGEN was credited with improving scientific return on investment between 20- to 30-percent by automating the process of generating daily task plans for the* Spirit *and* Opportunity *rovers. RIACS scientist Dr. Ari Jonsson was the lead inventor of EUROPA, a constraint-based planning and scheduling engine that lies at the heart of the MAPGEN application. RIACS scientist Mr. Kanna Rajan was Principal Investigator and Project Manager.*

*Left: Mars Exploration Rover 3D Rendering Courtesy of NASA*

**The voice-enabled procedure browser Clarissa becomes the first spoken-dialogue system to hold a conversation with an astronaut in space**



**Project Columbia Supercomputer and CART3D used in NASA's Return to Flight efforts**

**Java Pathfinder, the first model checker for software testing, was released as open source**

**RIACS staff receives NASA Space Act Award for Advanced XML Database Integration Technique for Managing Unstructured Documents (NETMARK)**

**2005** **2006**

the entire NASA budget were produced automatically integrating data from multiple sources and presenting it in the natural language of financial managers – spreadsheets. Two days later, these reports were, for the first time, used as part of NASA's agency-wide Budget Review Process. PMT enabled NASA for the first time to collect and report financial performance data across all Mission Directorates, themes, programs, projects, and centers on a consistent and timely basis.

Previous case studies of PMT have demonstrated elimination of discrepancy rates of as much as 40 percent in one aeronautics program, and freeing people from the manual labor of integrating data and producing reports by as much as 85 percent for one NASA center (e.g., the same group of people could complete one set of reports in 1.5 days rather than 1.5 weeks for one NASA center). The system is now being used agency-wide for both institutional and programmatic financial management – NASA Agency and Center CFOs, NASA Office of Program and Institutional Integration, Mission Directorates, and assorted program and project managers, having become an integral part of the agency's monthly financial management processes. A patent application for PMT has been submitted by NASA. RIACS staff currently lead and contribute to the infusion and sustained operations of the software for agency-wide use and for its eventual commercialization.

## Recognition of Excellence

RIACS scientists and researchers have received many prestigious national and international awards in recognition of their pioneering technological achievements.

Highlights among these awards include six NASA Space Act Awards for developing technology that has helped NASA achieve its aeronautical, commercialization, and space goals; two NASA Software of the Year awards, the highest award bestowed by the agency for software innovation; six NASA Turning Goals into Reality awards; *Computerworld's* "Best Practicies in Storage" award; and the 2007 AAAI "Classic Paper" award for a paper deemed "most influential" in the Artificial Intelligence community from the 1988 conference year.

In addition, RIACS was nominated in 2008 for the United States National Medal of Technology and Innovation for 25 years of pioneering innovation in computer science, intelligent systems, and software that have been instrumental in advancing our nation's civil space and aeronautics programs.

## The Next 25 Years

The first 25 years of technological achievements at RIACS have laid a foundation for the next 25 years of mission-driven research, development, and operational sustainment of innovative software intensive

**RIACS staff receives AAAI "Classic Paper" Award as paper deemed most influential 20 years later – Bayesian Classification**

**RIACS launches Space Science and Technology video series in partnership with San Francisco Bay Area PBS affiliate KCSM-TV, winning three Telly Awards**

**Orbital Communications Adapter Monitoring System (OCAMS) deployed at International Space Station Mission Control, Johnson Space Center**

**Program Management Tool adopted for agency-wide use by the NASA CFO**

**EUROPA, the artificial intelligence planning software used for the Mars Exploration Rover mission, is released as open source**

**2007** **2008**

systems. Innovative technologies and collaboration among government, academia, and industry creates the possibility for breakthroughs in mission capabilities, reduced risk, and increased productivity.

"The foundation of RIACS's success is the talented researchers who have made tremendous contributions to the achievements of NASA and the accomplishment of its mission goals," said Dr. David Bell, director of RIACS. "The coming advances in intelligent systems are poised to revolutionize the way NASA and other federal agencies achieve their missions. We look forward to the next 25 years of achievements, with RIACS continuing as a valued partner supporting NASA's Ames Research Center and beyond."

## The RIACS Logo

The original RIACS logo (left), designed shortly after the institute began operations in 1984, was derived from NASA's "worm" logo. The original logo served the Institute for the better part of its first decade, until a new logo was placed into service in the early 1990s. The institute's second logo was retired in 2004, when the current RIACS logo (right) was placed into service.

## RIACS Science Council Chairs (1983 - Present)

| | |
|---|---|
| C. William Gear, University of Illinois | 1983 - 1984 |
| Bruce Arden, Princeton University | 1985 - 1988 |
| Joseph Oliger, Stanford University | 1989 - 1990 |
| John Hopcroft, Cornell University | 1991 - 1992 |
| Dennis Gannon, Indiana University | 1992 - 1994 |
| Robert Schnabel, University of Colorado | 1995 - 1998 |
| Jeffrey Bradshaw, Boeing Corporation | 1999 - 2002 |
| David Bailey, Lawrence Berkeley National Labs | 2002 - 2006 |
| Daniel Cooke, Texas Tech University | 2006 - present |

## NASA Ames Center Directors (1958 - Present)

| | |
|---|---|
| Smith J. DeFrance | 1958–1965 |
| H. Julian Allen | 1965–1968 |
| Hans Mark | 1969–1977 |
| Clarence Syvertson | 1977–1984 |
| William F. Ballhaus Jr. | 1984–1989 |
| Dale Compton | 1989–1994 |
| Kenneth K. Munechika | 1994–1996 |
| Henry McDonald | 1996–2002 |
| G. Scott Hubbard | 2002–2006 |
| S. Pete Worden | 2006 - present |

## Exploration & Technology Directorate Directors (1994 - Present)

| | |
|---|---|
| David Cooper | 1994 - 1997 |
| Steven Zornetzer | 1997 - 2001 |
| Jan Aikins (acting) | 2001 - 2003 |
| Daniel Clancy | 2003 - 2005 |
| Eugene Tu | 2005 - present |

## NAS Division Chiefs (1983 - Present)

| | |
|---|---|
| F. Ron Bailey | 1983 - 1990 |
| Ron Deiss (acting) | 1990 - 1991 |
| David Cooper | 1991 - 1994 |
| Walt Brooks | 1995 - 1996 |
| Marisa Chancellor (acting) | 1996 - 1997 |
| Paul Kutler (acting) | 1997 - 1998 |
| William J. Feiereisen | 1998 - 2002 |
| John Ziebarth (acting) | 2002 - 2003 |
| Walt Brooks | 2003 - 2005 |
| Rupak Biswas (acting) | 2005 - present |

## Intelligent Systems Division Chiefs (1984 - Present)

| | |
|---|---|
| Henry Lum | 1984 - 1994 |
| Ron Deiss | 1994 - 1995 |
| Max Reid (acting) | 1995 - 1995 |
| David Thompson (acting) | 1995 - 1995 |
| Gregg Swietek (acting) | 1995 - 1996 |
| Man Mohan Rai (acting) | 1996 - 1996 |
| Sonie Lau (acting) | 1996 - 1996 |
| Keith Swanson (acting) | 1996 - 1997 |
| Dennis Koga (acting) | 1997 - 1998 |
| Peter Norvig | 1998 - 2001 |
| Daniel Clancy | 2001 - 2003 |
| David Korsmeyer | 2003 - present |

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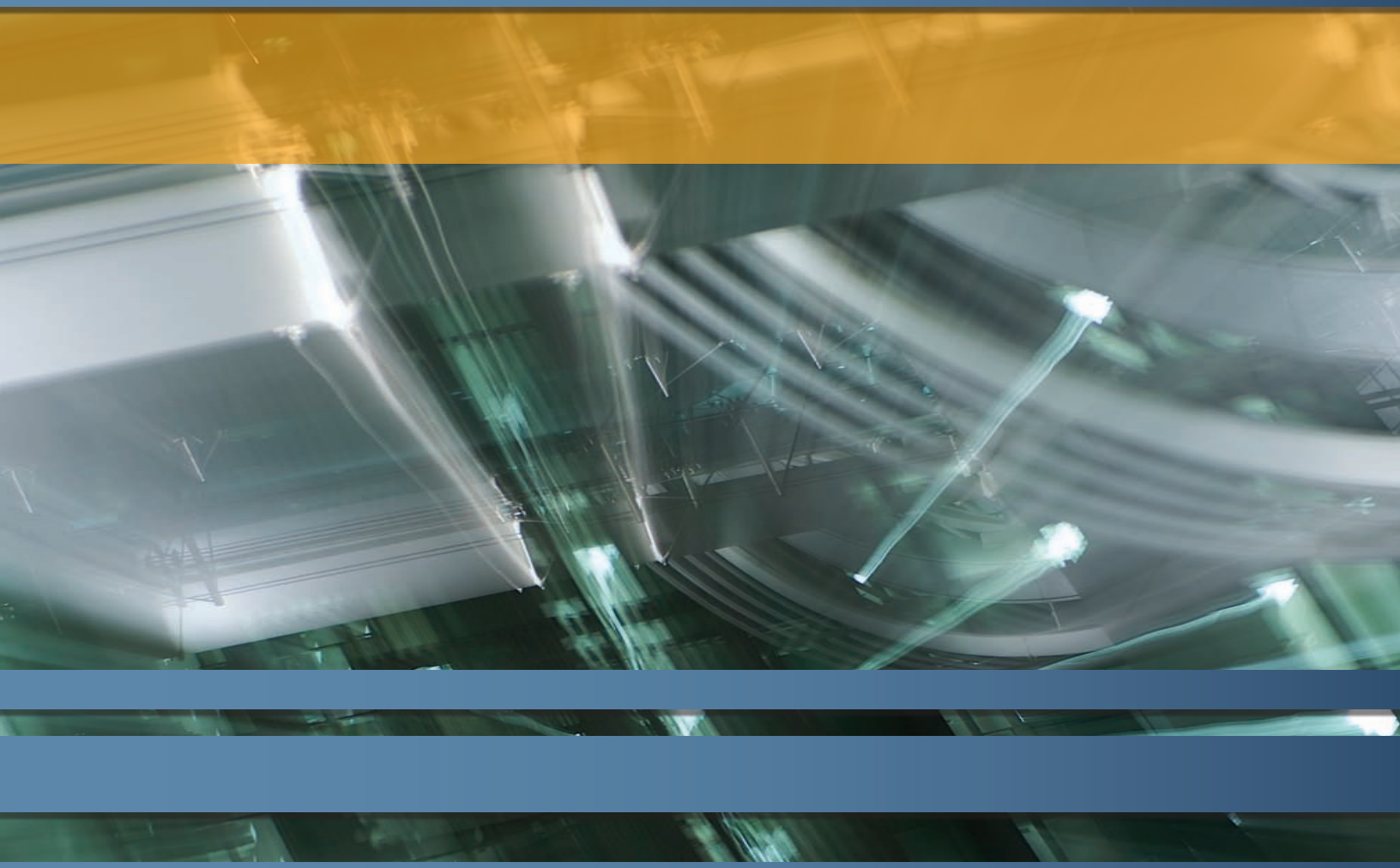

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