Computing, Information, and Communications Technology (CICT) Program Overview

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NASA HQ

COMPUTING
INFORMATION &
COMMUNICATIONS
TECHNOLOGY

Outline

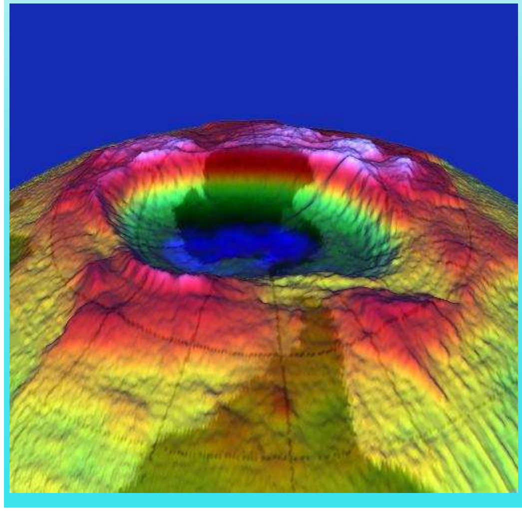
- **Requirements**
  - **Goal**
  - **Technical Objectives**
- **Program Structure**
  - **Organization**
  - **Integrated Capability**
- **Program Processes**
  - **Overall Investment Strategy**
  - **Program Level Customers**
  - **Example Selection Process (CICT IS)**
- **Resources**

CICT Program Goal

Enable NASA's Scientific Research, Space Exploration, and Aerospace Technology Missions

with greater mission assurance, for less cost, with increased science return

through the development and use of advanced computing, information and communications technologies.



NASA CICT Goal

- From Guidance and Requirements to Goal -

GUIDANCE

National Coordination Office for Information Technology Research *and* Development

PITAC Report Research Priorities:

- Software

"…special emphasis should be placed … on managing large amounts of information, making computers easier, to use making software easier to create and maintain, and and improve the ways humans interact with computers"

- Scalable Information Infrastructure

" …research to learn how to build and use large, complex, high-reliable, and secure systems…"

- High-End Computing

"Funding should focus on …. overcoming the limitations of today's systems…"

REQUIREMENTS

NASA Mission:

To understand and protect our home planet
To explore the Universe and search for life
To inspire the next generation of explorers

NASA Enterprises execute missions:

- Earth Science
- Space Science
- Biological and Physical Research
- Human Exploration and Development of Space
- Aerospace Technology

NASA CICT Role:

- Develop computing, information, and communication technologies in support of NASA mission requirements

NASA CICT Goal

Enable NASA's Scientific Research, Space Exploration, and Aerospace Technology Missions with greater mission assurance, for less cost, with increased science return through the development and use of advanced computing, information and communications technologies.

NASA Strategic Plan

Computing, Information and Communications Technologies are critical to NASA Missions

Summary: NASA High Level Roadmap—Contributions to National Priorities

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

Agency Mission	Enterprises	Near-term Plans 2000–2005	Mid-term Plans 2006–2011	Long-term Plans 2012–2025	Contributions to National Priorities
To advance and communicate scientific knowledge and understanding of Earth, the solar system, and the universe	**Space Science** *Addresses Fundamental Questions 1, 2, & 6*	■ Study structure of collapsed objects and star forming nebulae, fine details of microwave background, early formation of galaxies and of stars, dust in other planetary systems, origins of gamma-ray bursts, and the composition of material between stars. ■ Study Saturn, Titan, the composition of comets and asteroids, the orbits of Near-Earth Objects, and the surface and atmosphere of Mars; and return dust and solar wind samples. ■ Study the Sun's atmosphere and interior, the interactions between the solar wind and Earth's magnetosphere, and solar coronal mass ejections. ■ Develop advanced technologies in areas such as avionics, power sources, optics, bioassay technology, and sample return.	■ Measure dark-matter, baryon, vacuum-energy densities, and gravitational waves from black holes; determine origin of cosmic rays and the role of active galactic nuclei in gamma-ray background; observe star birth in nebular cocoons; and spectroscopically survey for nearby Earth-like planets. ■ Learn about formation of the rocky planets, return a sample from a comet, investigate selected sites on Mars in detail, and search for liquid water ocean on Jupiter's moon Europa. ■ Expand understanding of space weather through solar, radiation belt, and ionospheric mappers. Study the detailed physics and structure of our magnetosphere and the outer solar atmosphere, and globally monitor the Sun. ■ Infuse revolutionary technologies into operational missions.	■ Resolve the infrared background and an accretion disk around the Milky Way black hole; measure the chemical composition of supernovas and the gas outside our solar system; and determine the prevalence of life-bearing planets around nearby stars. ■ Fly by Pluto and study Neptune and its satellite Triton. Search for evidence of biological activity on Europa, Titan, and other promising targets. Conduct advanced studies of Mars. ■ Complete our picture of the solar corona and develop an integrated understanding of space weather from a network of spacecraft. ■ Reap benefits of technology investment, including biological, information, and nanotechnology systems, enabling a virtual presence for autonomous scientific discovery.	*Increase the Understanding of Science and Technology*
To advance human exploration, use, and development of space	**Earth Science** *Addresses Fundamental Questions 3 & 6*	■ Measure global rainfall, uptake of atmospheric carbon dioxide (CO_2), atmospheric temperature and humidity, cloud properties, global ocean winds, and topography; and produce 3-D maps of the entire inhabited surface of the Earth. Expand use of commercial systems in collecting data. ■ Employ high-performance computing to address Earth system modeling challenges; validate revolutionary technologies and satellite formation flying; and explore new instrument concepts.	■ Conduct research to achieve 7- to 10-day weather forecasts. Quantify the global fresh water cycle, variation in terrestrial and marine ecosystems, and forest and ocean carbon stocks. Assimilate ocean surface winds, tropospheric winds, and precipitation into climate and weather forecasting models. ■ Employ distributed computing and data mining techniques for Earth system modeling, implement autonomous satellite control and advanced instruments, and demonstrate a new generation of small instruments.	■ Conduct research to achieve 10- to 14-day weather and pollution forecasts, 10-year climate forecasts, 15- to 20-month El Niño forecasts, and 12-month rain rate. Assess sea-level rise and effects and predict regional impacts of decadal climate change. ■ Deploy cooperative satellite constellations, intelligent sensor webs, and advanced instruments for observations from liberation points (L1 and L2).	*Protect the Environment*
	Biological and Physical Research *Addresses Fundamental Questions 4 & 6*	■ Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures. ■ Begin to conduct scientific and engineering research, and enable commercial research activities on the International Space Station (ISS).	■ Understand the effects of long-duration space flight (e.g. radiation, gravity), validate countermeasures and technology, and begin developing countermeasures for long-duration space flight. ■ Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels). ■ Extend our understanding of chemical, biological, and physical systems.	■ Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight. ■ Test and validate technologies for self-sustaining life support systems that can enable humans to live and work in space and on other planets. ■ Achieve a deep understanding of the role of gravity in complex chemical, biological, and physical processes.	*Create Education Excellence*
To research, develop, verify, and transfer advanced aeronautics, space, and related technologies	**Human Exploration and Development of Space** *Addresses Fundamental Questions 4 & 6*	■ Obtain key data for human mission design decisions from robotic science missions and develop technologies, interdisciplinary knowledge, and candidate approaches for human missions beyond Low-Earth Orbit (LEO) with a 5- to 10-fold reduction in costs. ■ Complete ISS development to enable long-duration research. ■ Create new approaches to collaborative partnerships with the private sector for the development of future human space exploration capabilities.	■ Establish robotic/engineering "outposts" at key sites and develop technologies and capabilities for 100-day human missions beyond LEO. Develop approaches to 1000-day missions with 10- to 20-fold cost reductions. ■ Complete research and technology validation (including ISS demos) of competing technologies for 100- to1000-day human missions. ■ Operate the ISS to advance science, exploration, engineering, and commerce. ■ Undertake pilot efforts leading to commercialization of ISS operations.	■ Conduct research and development to enable a further 2- to 4-fold reduction in costs for human exploration and complete development of safe, self-sufficient and self-sustaining capabilities for 1000-day class human-robotic missions beyond LEO. ■ Complete the transition of ISS to a customer-driven and commercial operation. ■ Extend scientific discovery on missions of exploration through the integrated use of human and robotic explorers.	*Peaceful Exploration and Discovery*
Note: This is a high-level summary of 25-year plans toward achievement of Enterprise goals and objectives. For detailed information, see the Enterprise Roadmaps in the Enterprise sections.	**Aerospace Technology** *Addresses Fundamental Questions 5 & 6*	■ Develop and demonstrate technologies to reduce the aviation accident rate, aircraft emissions, and noise. Improve terminal area productivity, support the Federal Aviation Administration's National Airspace System modernization, and develop technologies for general aviation aircraft and infrastructure improvements. ■ Develop processes and technology improvements to support safer crewed launches and reduced cost of launches, and develop advanced space transportation concepts. ■ Develop advanced engineering tools, processes, and design environments, and pioneer basic research in revolutionary technologies such as nanotechnology, information technology, and biotechnology.	■ Reduce the aircraft fatal accident rate by 80%, nitrogen oxide (NO_X) emissions by a factor of 3, carbon dioxide (CO_2) emissions by 25%, and aircraft noise by a factor of 2. Double aviation system throughput and reduce inter-city doorstep-to-destination transportation time by 50% and explore integrated supersonic transport designs. ■ Reduce the risk of launch vehicle crew loss by a factor of 40, payload cost to LEO by a factor of 5, and travel time for planetary missions by a factor of 2. ■ Demonstrate advanced design tools, processes, and virtual environments in critical NASA engineering applications and integrate revolutionary aerospace system technologies.	■ Reduce the aircraft fatal accident rate by a 90%, NO_X emissions by a factor of 5, CO_2 emissions by 50%, and aircraft noise by a factor of 4. Triple aviation system throughput and reduce inter-city doorstep-to-destination transportation time by 67% and long-haul travel time by 50%. ■ Reduce the risk of launch vehicle crew loss by an additional factor of 10, payload cost to LEO by a factor of 10, and travel time for planetary missions by a factor of 10. ■ Demonstrate an integrated, high-confidence engineering environment and demonstrate new aerospace capabilities and new mission concepts in flight.	*Economic Growth and Security*

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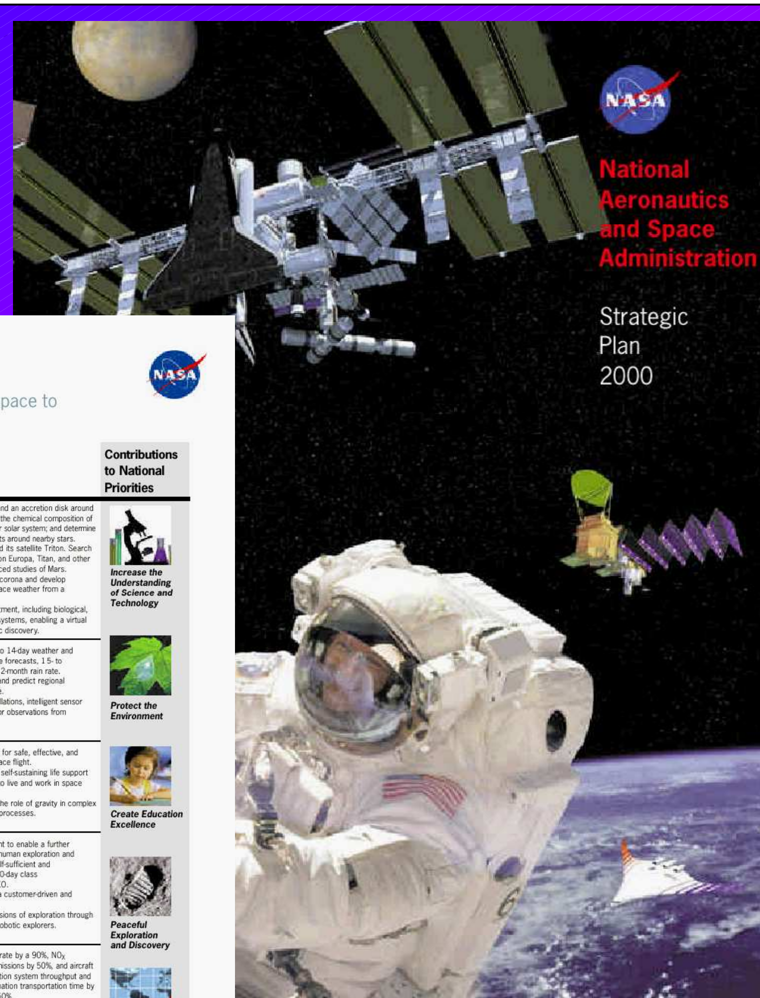
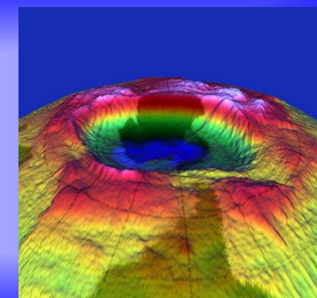


NASA Mission: Scientific Research

Mission:

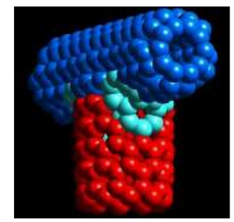
To advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe

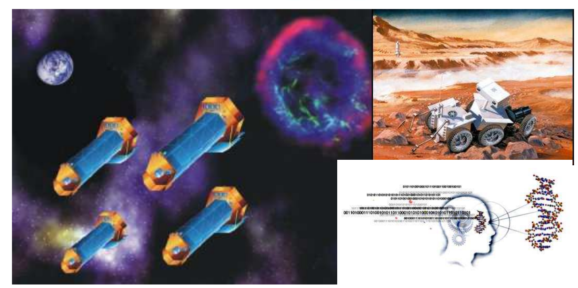


Space Science Enterprise:

"…reap benefits of technology investments, including biological, information, and nanotechnology systems"

"…enable a virtual presence for autonomous scientific discovery"



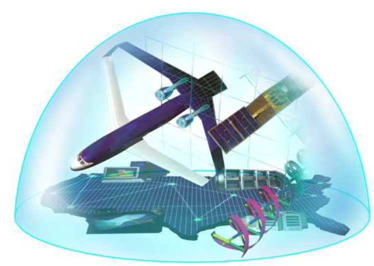


Earth Science Enterprise:

"…implement autonomous satellite control…"

"…deploy cooperative satellite constellations, intelligent sensor webs…"

"…employ distributed computing and data mining techniques for Earth system modeling"



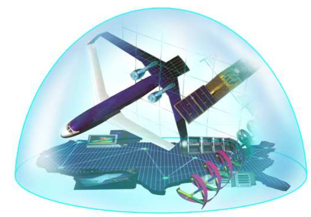
NASA Mission: Space Exploration

Mission:

To advance human exploration, use, and development of space

Biological and Physical Research Enterprise:

"…extend our understanding of chemical, biological, and physical systems"

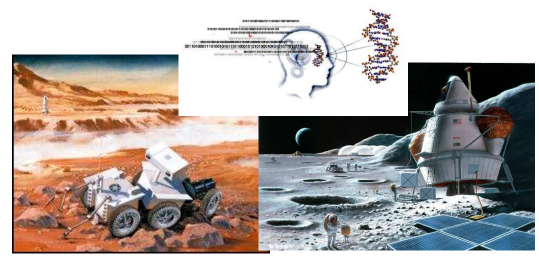


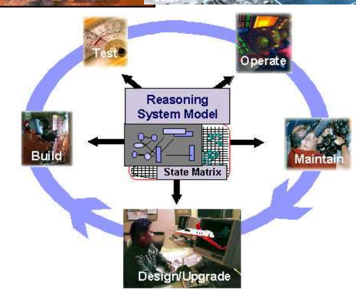
Human Exploration and Development of Space Enterprise:

"…establish robotic/engineering "outposts" at key sites…"

"…extend scientific discovery on missions of exploration through the integrated use of human and robotic explorers"

"Invest in the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration."





NASA Mission:
Aerospace Technology Development

Mission:

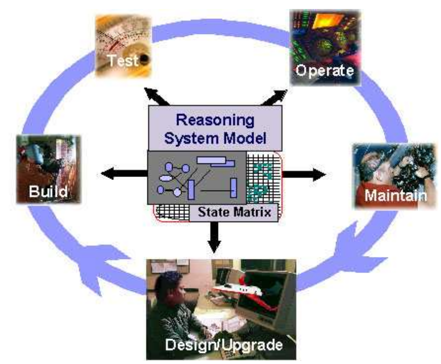
To research, develop, verify, and transfer advanced aeronautics and space technologies

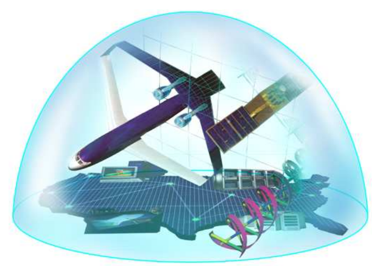
Aerospace Technology Enterprise:

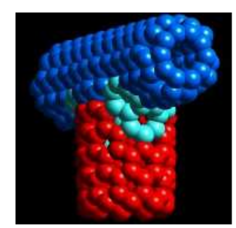
"… develop processes and technology improvements to support safer crewed launches…"

"… develop advanced engineering tools, processes, and design environments…"

"… pioneer basic research in revolutionary technologies such as nanotechnology, information technology, and biotechnology."



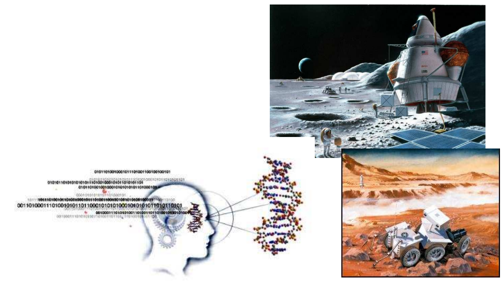




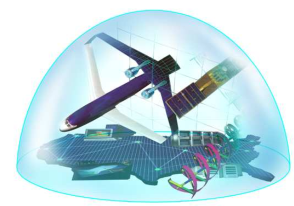
NASA Mission
CICT Technology Requirements

NASA Mid- and Long-Term Mission Plans are reliant on the availability of advanced information technologies:

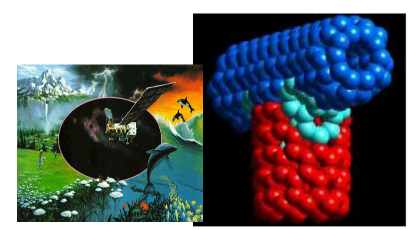
– Smarter more intelligent, collaborative systems including:
  - *Autonomous spacecraft control and scientific discovery*
  - *Intelligent sensorwebs and cooperating constellations*
  - *Integrated human/robotic explorers*



– Advanced computing and communication systems including:
  - *Breakthrough science and engineering simulation capabilities*
  - *Mobile, distributed analysis, data mining, and collaboration capabilities*
  - *Pervasive Earth-to-deep space communications technologies to support robotic and human exploration*



– Revolutionary technologies, including:
  - *Intelligent controls and diagnostics*
  - *Evolvable systems*
  - *Automated software engineering*
  - *Biotechnology and nanotechnology*
  - *Revolutionary computing concepts*



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CICT Program Technical Objectives

Goal-directed human-centered systems

Enable smarter, more adaptive systems and tools that work collaboratively with humans in a goal-directed manner to achieve NASA's twenty-first century mission/science goals.

Seamless access to NASA information technology resources

Enable seamless access to ground-, air-, and space-based distributed hardware, software, and information resources to enable NASA missions in aerospace, Earth science, and space science.

High-rate data delivery

Enable broad, continuous presence and coverage for high-rate data delivery from ground-, air-, and space-based assets directly to the users.

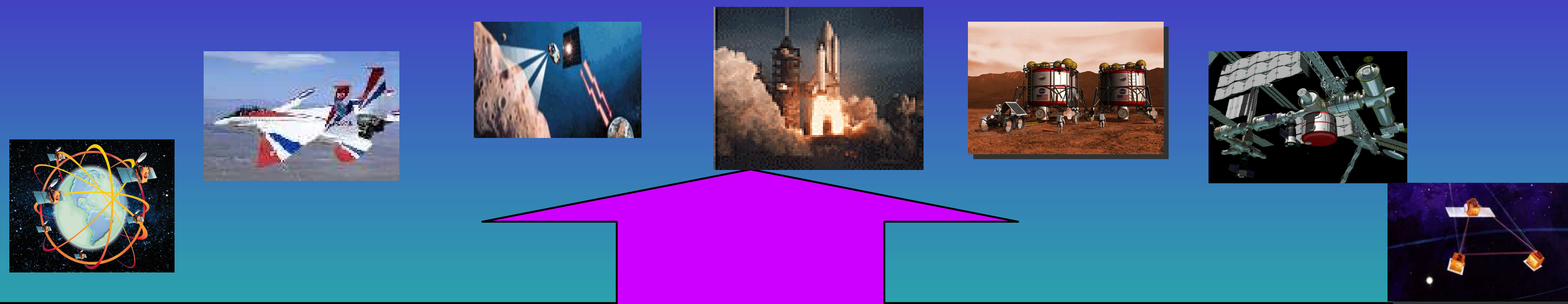
Revolutionary technology infusion

Research, develop, and evaluate a broad portfolio of fundamental information and bio/nano-technologies with the potential to revolutionize future NASA missions.

Outline

- **Requirements**
  - **Goal**
  - **Technical Objectives**
- **Program Structure**
  - **Organization**
  - **Integrated Capability**
- **Program Processes**
  - **Overall Investment Strategy**
  - **Program Level Customers**
  - **Example Selection Process (CICT IS)**
- **Resources**

CICT Program Structure



Intelligent Systems

Enable smarter, more adaptive systems and tools that work collaboratively with humans in a goal-directed manner to achieve the mission/science goals.

Computing, Networking and Information Systems

Provide seamless access to ground-, air- and space-based distributed computing, information, and knowledge to enable NASA missions in aerospace, Earth science and space science.

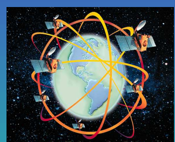
Space Communications

Provide revolutionary space communications technologies

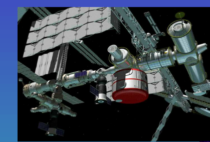
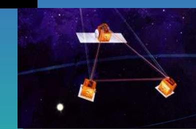
IT Strategic Research

Research, develop and evaluate a broad portfolio of fundamental information and bio/nano technologies for infusion into NASA missions.

CICT Program Structure





Intelligent Systems

- *Automated Reasoning*
- *Human Centered Computing*
- *Intelligent Data Understanding*

Computing, Networking and Information Systems

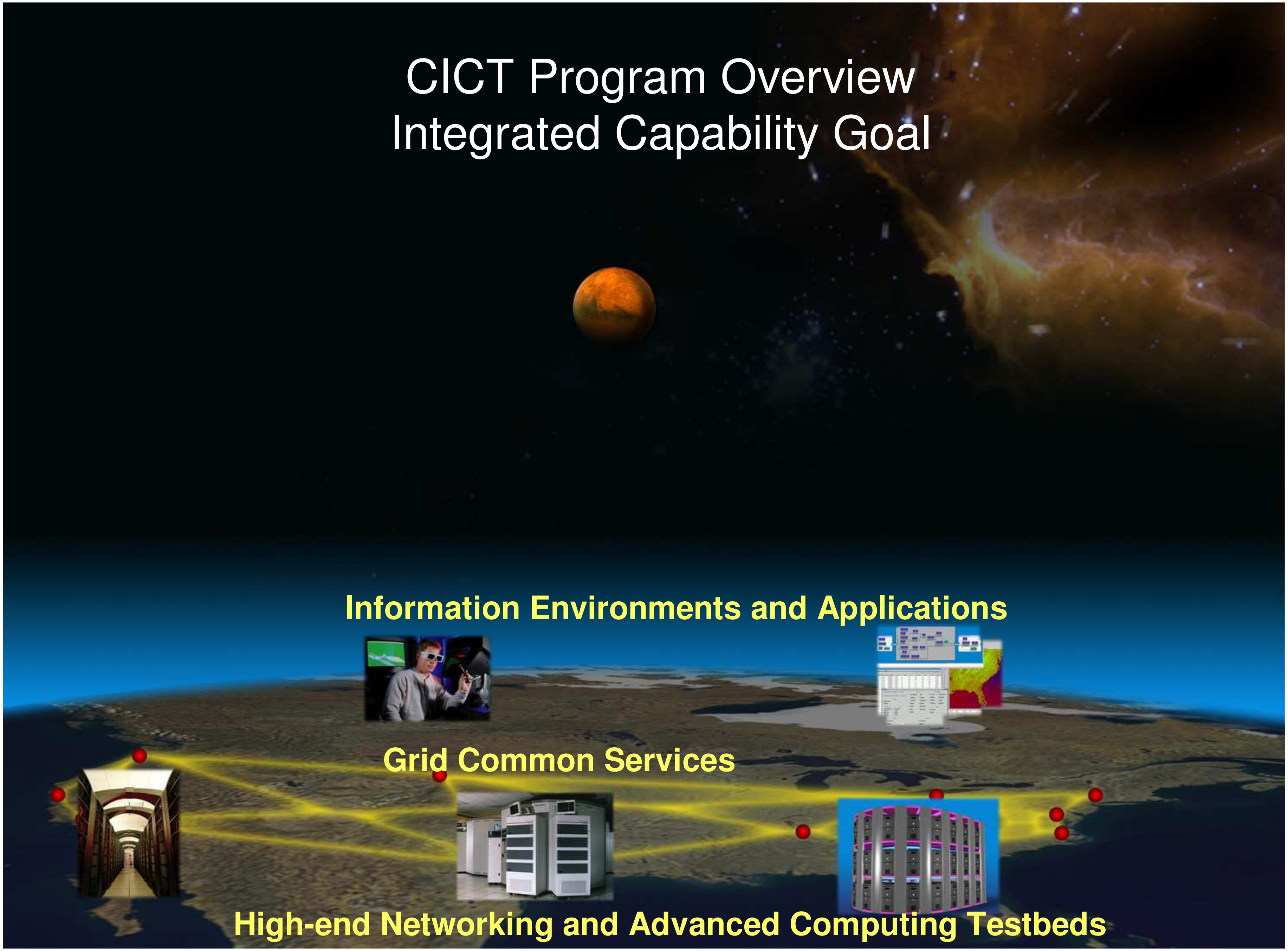
- *Grand Challenge Applications*
- *Information Environments*
- *Grid Common Services*
- *Advanced Computing and Com. Testbeds*

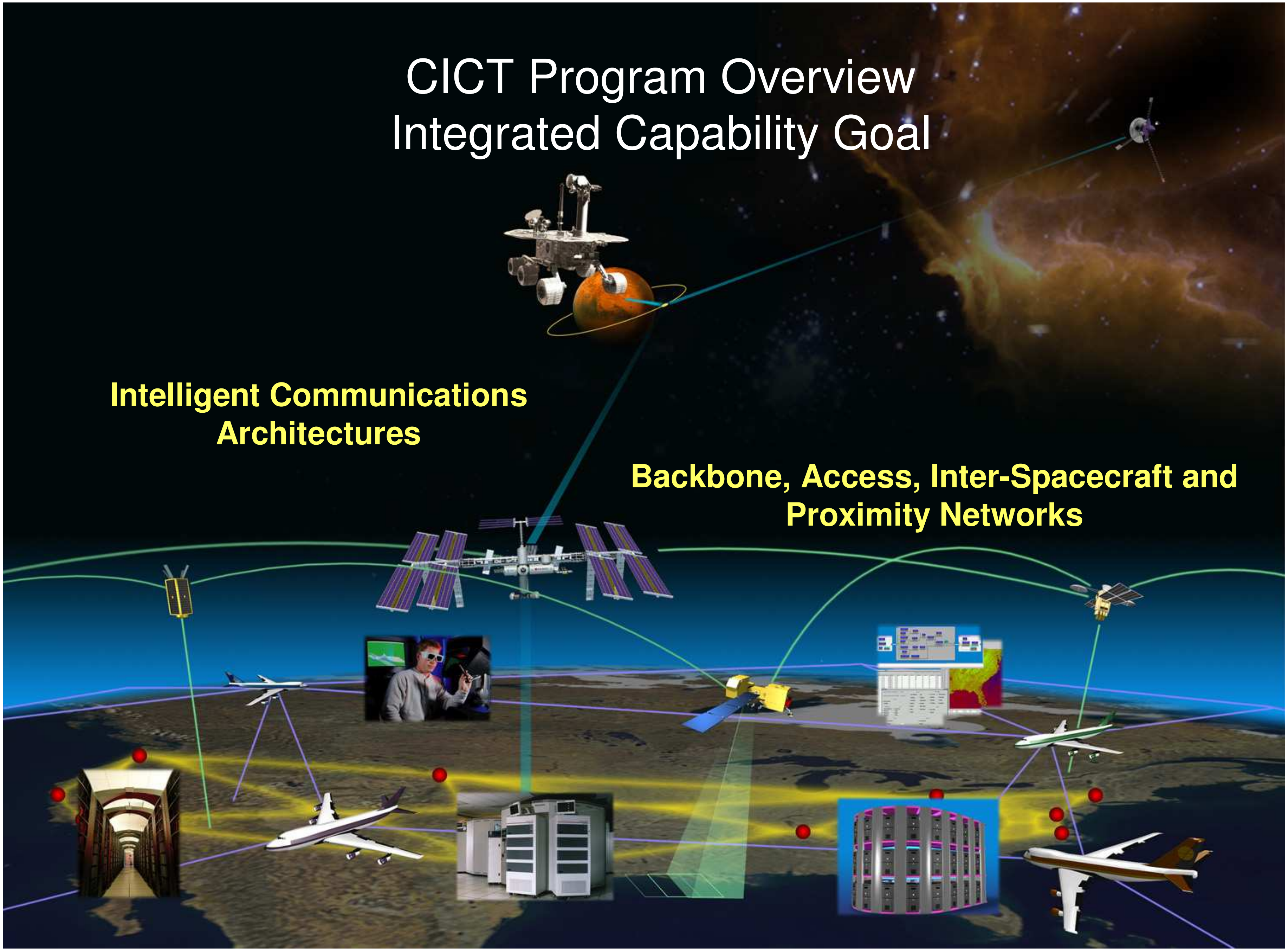
Space Communications

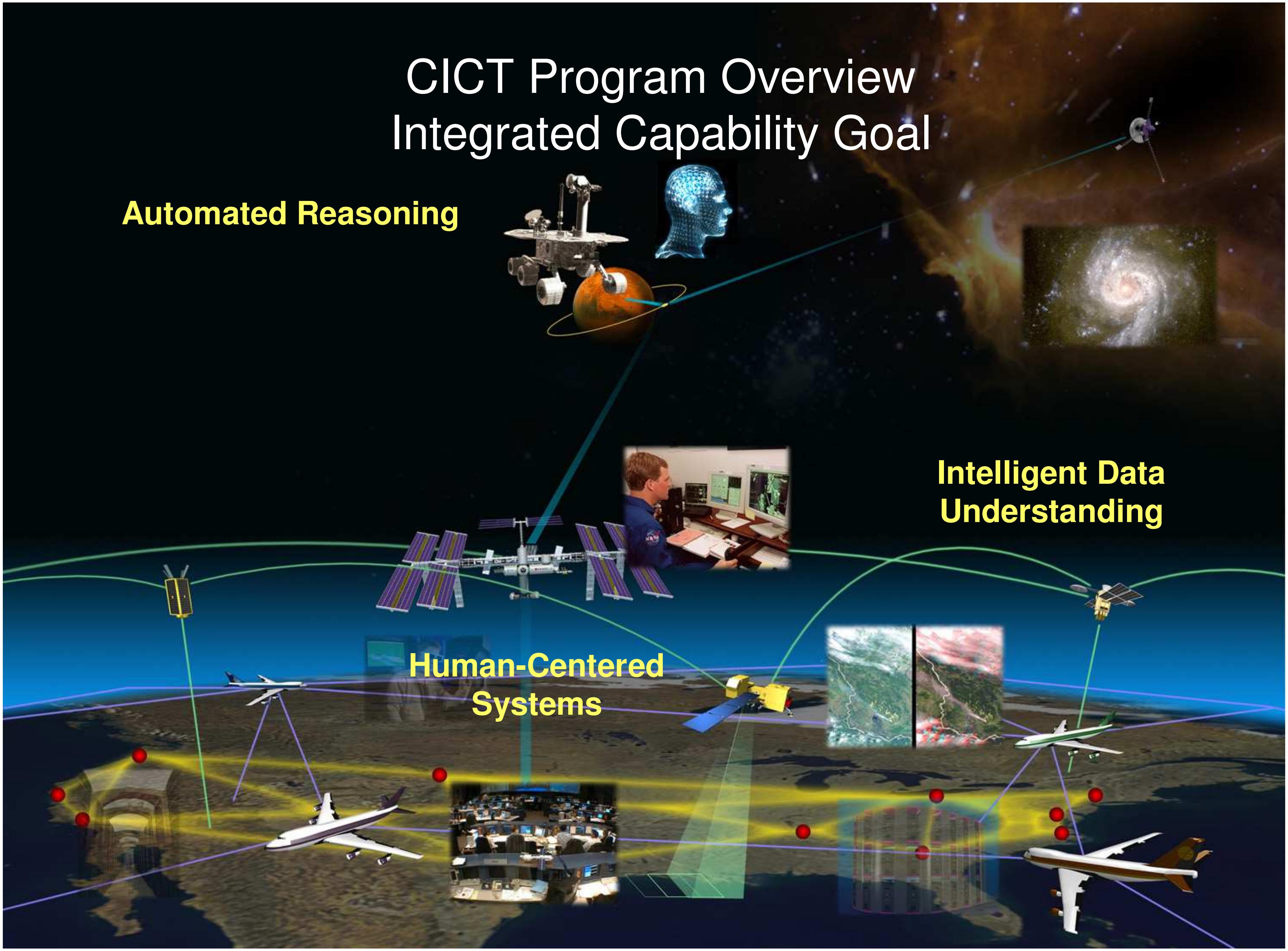
- *Intelligent Com. Arch.*
- *High Rate Backbone*
- *Flexible Access Net.*
- *Inter-spacecraft Net..*
- *Proximity Wireless Net.*

IT Strategic Research

- *Bio/Nano Technologies*
- *Evolvable Systems*
- *Revolutionary Computing*
- *Intelligent Controls & Diagnostics*
- *Automated Software Engineering Technologies*


CICT Program Overview
Integrated Capability Goal
Information Environments and Applications
Grid Common Services
High-end Networking and Advanced Computing Testbeds


CICT Program Overview
Integrated Capability Goal
Intelligent Communications Architectures
Backbone, Access, Inter-Spacecraft and Proximity Networks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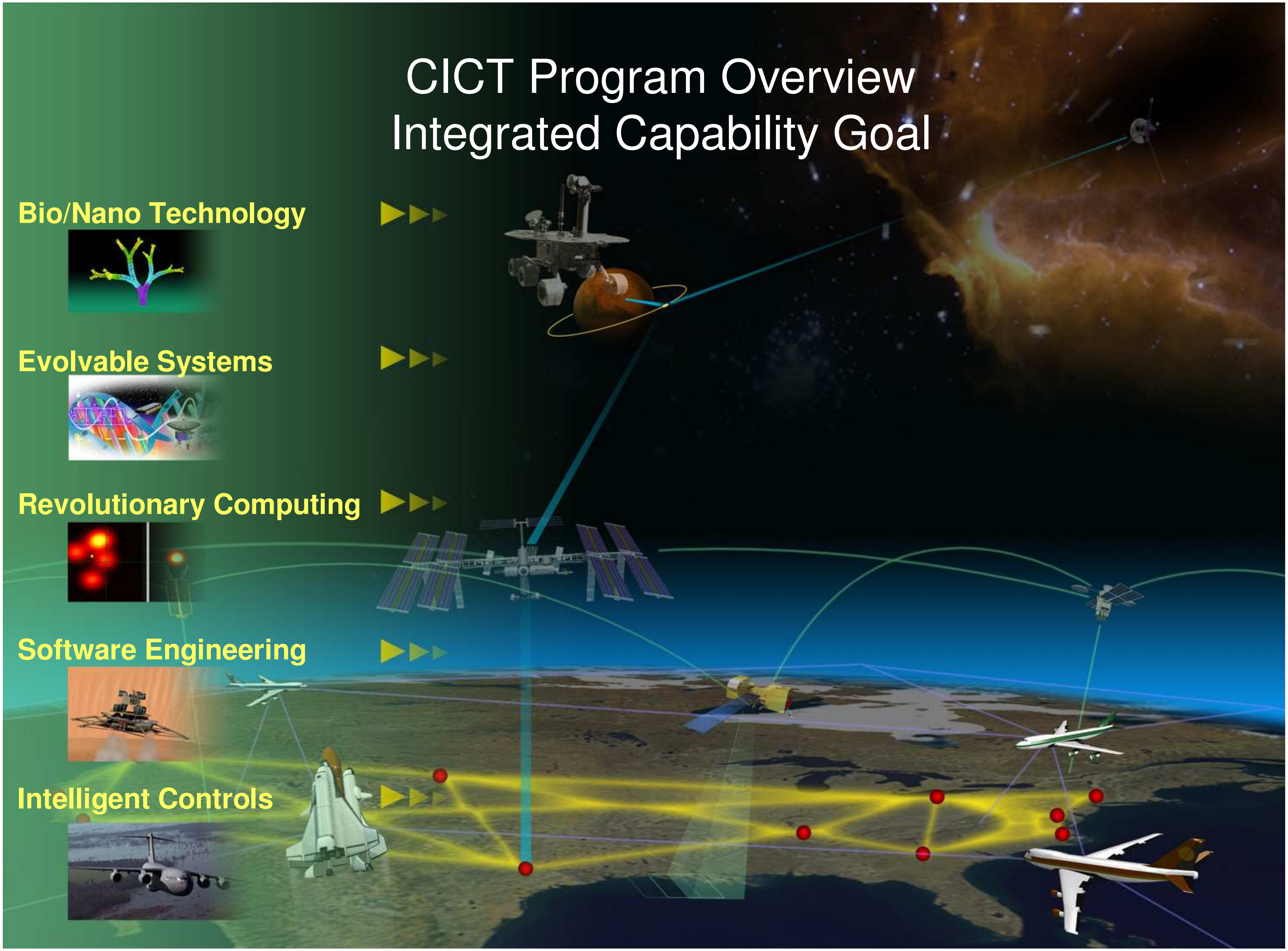
Automated Reasoning
Intelligent Data Understanding
Human-Centered Systems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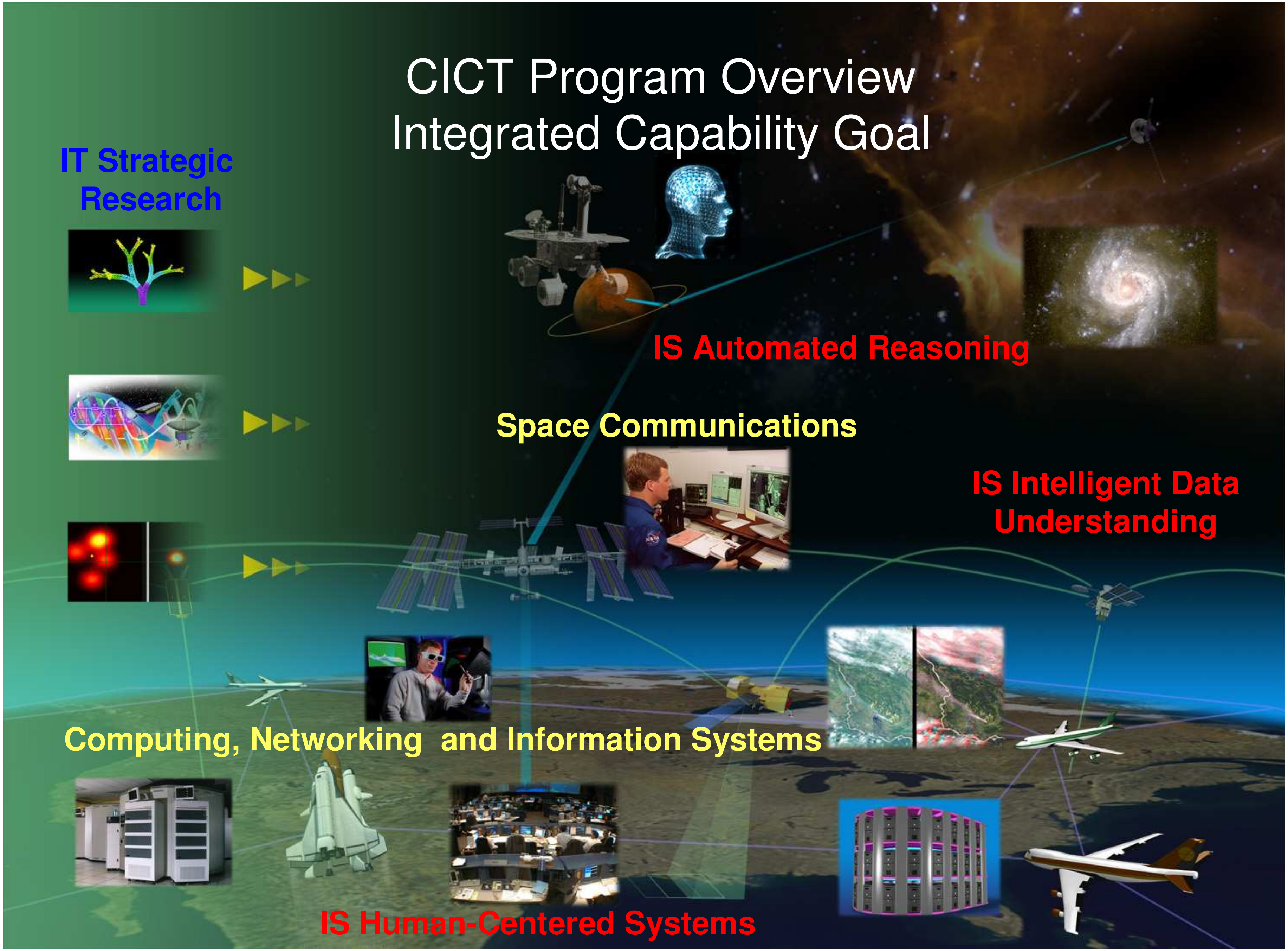
Integrated Capability Goal
Bio/Nano Technology
Evolvable Systems
Revolutionary Computing
Software Engineering
Intelligent Controls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Integrated Capability Goal
IT Strategic Research
IS Automated Reasoning
Space Communications
IS Intelligent Data Understanding
Computing, Networking and Information Systems
IS Human-Centered Systems

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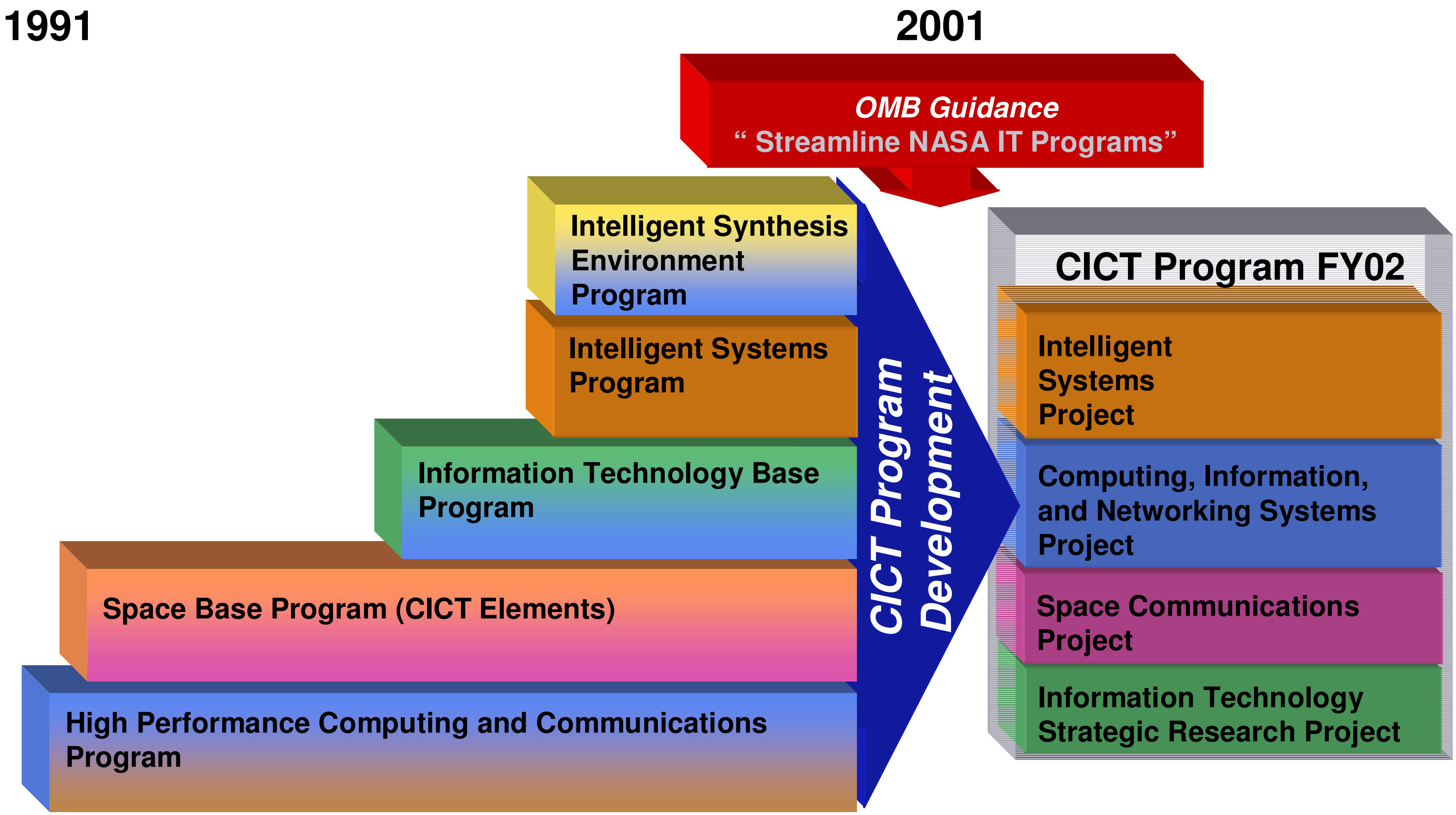
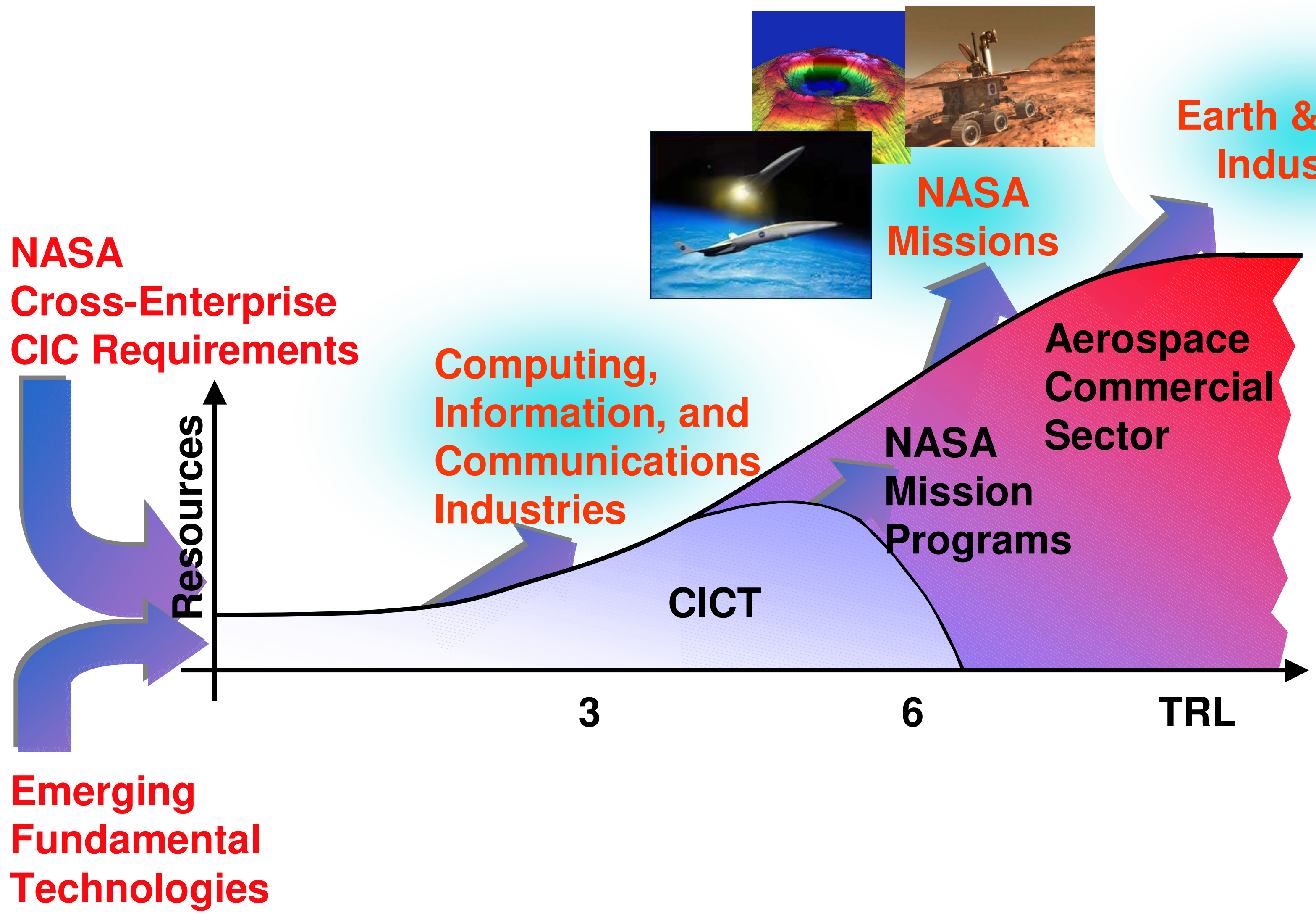
CICT Program
- Historical Perspective -



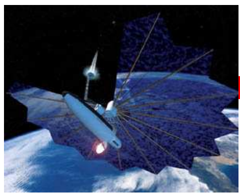
CICT Role In NASA Technology Flow

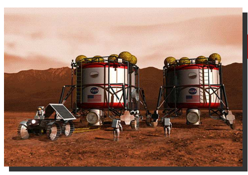


CICT Technology

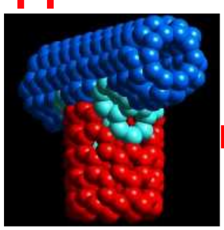
- Requirements to Development to Infusion -

NASA Requirements





Revolutionary Technology Opportunities



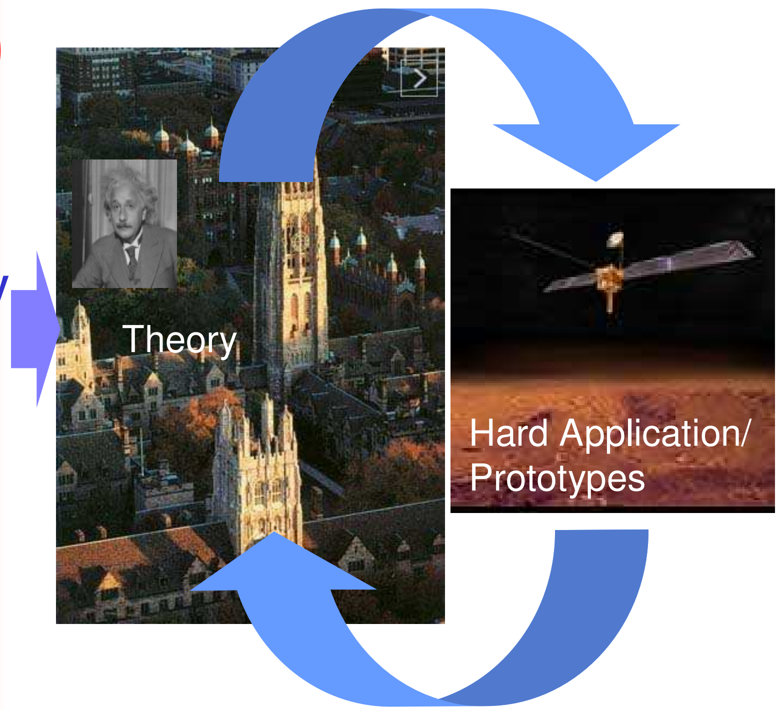
Technology Opportunities & Cross-Enterprise Requirements

CICT Program

Return on Investment

Technology Investment Strategy

Portfolio Balance

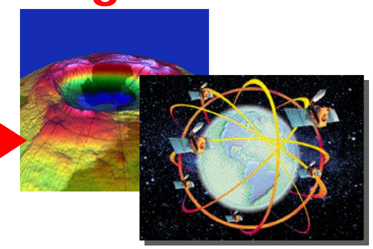


Investment Decisions

Academia/NASA teams bring theory to bear on applications

NASA/Industry teams bring application to NASA missions

NASA Mission Programs

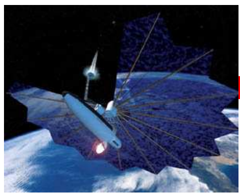


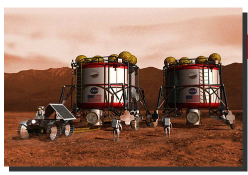
NASA Missions exploit technology, and update NASA requirements

CICT Technology

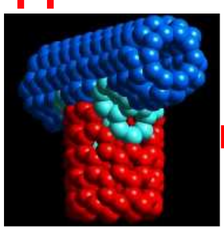
- Requirements to Development to Infusion -

NASA Requirements





Revolutionary Technology Opportunities



Technology Opportunities & Cross-Enterprise Requirements

Requirements Processes

- *Enterprise Strategic Planning*
  - *Enterprise Strategic Plans*
  - *IT Investments Evaluation*
    - *Code S/Y - FY01*
- *Enterprise CIC Requirements Processes*
  - *Mission Needs Council*
  - *Enterprise Workshops*
    - *PRT Dec 01 - Jan 02*
    - *IS/SC Pre-NRA*
- *Enterprise Mission and CICT Joint Planning & Execution*
  - *Mars Missions*
  - *Space Comm. Architectures*

Technology Opportunities

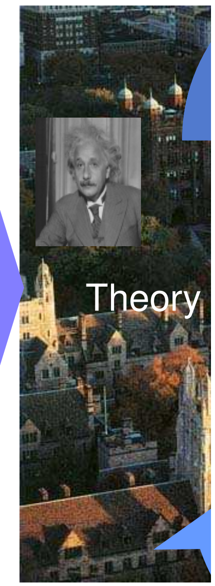
- *Monitor emerging technologies through*
  - *Federal R&D agendas*
  - *Professional organizations*
  - *Literature*
  - *Advisors*
  - *Personal liaisons*

CICT

Return on Investment

Technology Investment Strategy

Portfolio Balance

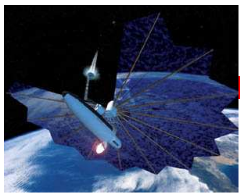


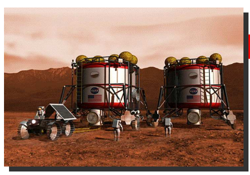
Investment Decisions → *Academia/NAS/ teams bring the/ bear on applica/*

CICT Technology

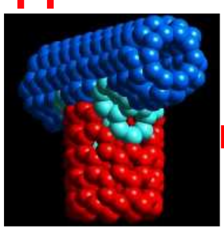
- Requirements to Development to Infusion -

NASA Requirements





Revolutionary Technology Opportunities



Technology Opportunities & Cross-Enterprise Requirements

CICT Program

Return on Investment

- **Mission IT requirement**
- **Gap analysis**
- **Return on investment**

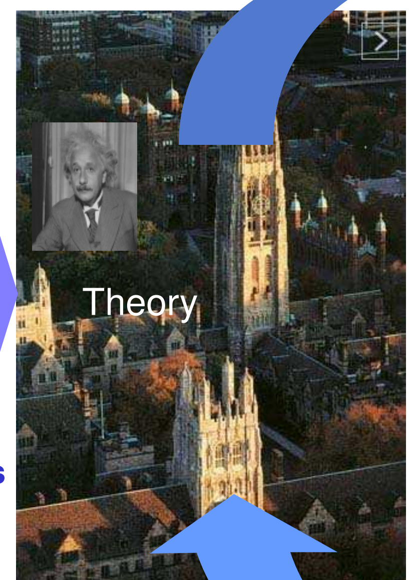
Technology Investment Strategy

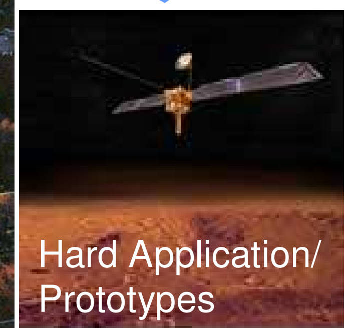
Portfolio Balance

- **Technology opportunities**
- **Balance**
  - **Missions**
  - **Time Horizon**
  - **Risk**

Investment Decisions

Investments





Academia/NASA teams bring theory to bear on applications

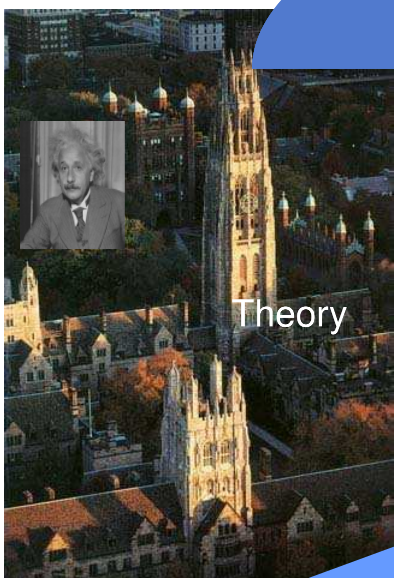
NASA/Industry teams bring application to NASA missions

CICT Technology

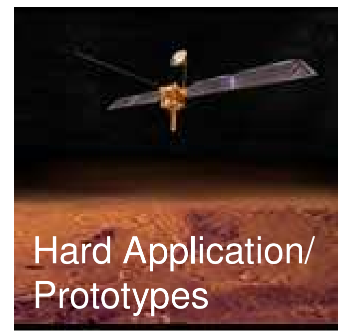
- Technology Development Processes -

CICT Program

Primary
Technology Development Processes



- **Academia/NASA teams develop theory to prototype technologies level.**
  - **Exploratory NRAs**
  - **IT Strategic Research**
    - **Bio/Nanotechnology**
    - **Evolvable Systems concepts**
- **NASA/Industry teams mature and integrate prototype technologies with target initial NASA missions.**



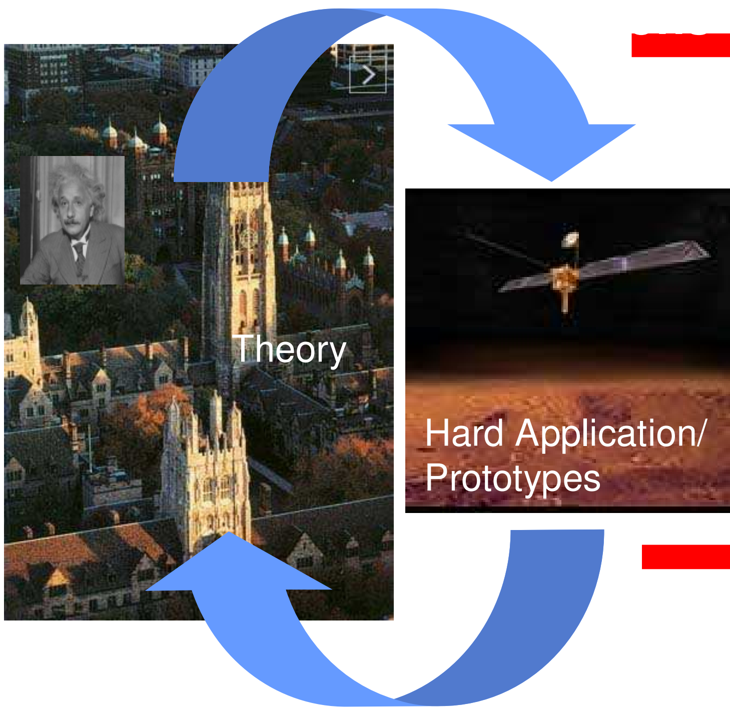
Academia/NASA teams bring theory to bear on applications

NASA/Industry teams bring application to NASA missions

CICT Technology

- Technology Infusion Processes -

CICT Program

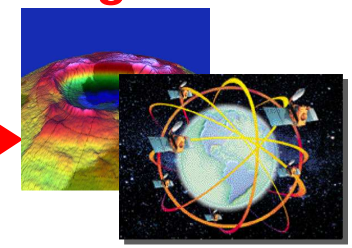


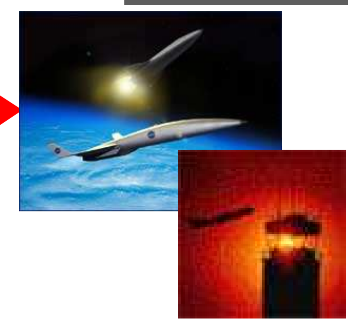
Academia/NASA teams bring theory to bear on applications ⇄ *NASA/Industry teams bring application to NASA missions* →

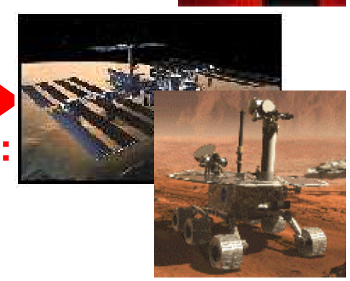
Primary Technology Infusion Processes

- Target initial mission applications early in technology development process & work jointly with target Enterprise mission towards technology infusion:
  - IS
    - Mars ‘03 and ‘09 Missions
    - Earth Modeling Teams
    - Shuttle Operations
  - CNIS
    - Climate Modeling Teams
    - ISS and Shuttle Operations
- Once technology has been tested in a mission application, migrate to operational/commercial elements:
  - NASA operational elements
    - COSMO and SOMO
    - Mission Ops (Codes M & S)
  - Industry Sectors
    - Network & Space Comm.
    - High-Performance Computing

NASA Mission Programs



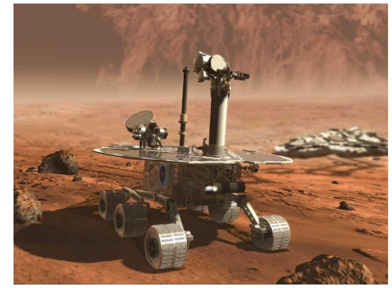




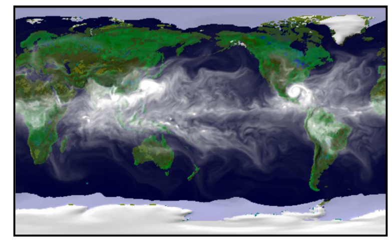
→ *NASA Missions exploit technology, and update NASA requirements*

CICT Technology Infusion Activities Examples

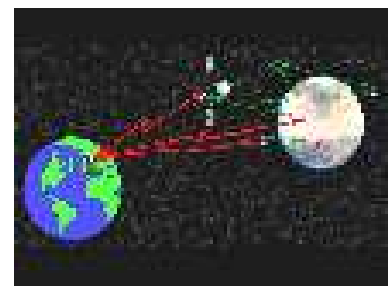
- **Mars Exploration Rover (MER-Mars 03 Mission)**
  - *Supports the Office of Space Science (Code S)*
  - *MER Operations Study*
  - *MER Board*
  - *MER Planning & Scheduling*



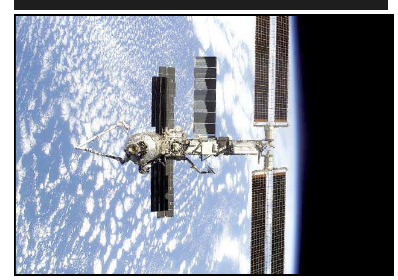
- **Multi-Level Parallelism**
  - *Supports the Office of Aerospace Technology (Code R) and the Office of Earth Science (Code Y)*
  - *Increases performance and usability of large-processor-count computing systems*
  - *40X improvement on FVCCM3 climate code*



- **Advanced Space Communications Capability**
  - *Supports the Office of Space Science (Code S)*
  - *100 Watt Traveling Wave Tube Microwave Sources for Mars missions*
  - *Transceiver Chip for Mars 05 Mission for Electra Communication Payload Package for Baseband Signal Processing*



- **Advanced Space Operations Capability**
  - *Supports the Office of Space Flight (Code M)*
  - *Real-time automated reasoning and trouble shooting for software embedded systems (e.g. Diagnostics on Space Station)*
  - *Intelligent diagnostic software for enhanced caution and warning*
  - *Sensor fusion techniques for anomaly detection*



CICT
Customers & Partners

	NASA Mission Customers	National Commercial Sector	National Research Community
Intelligent Systems	OES, OSS OAT, OSF	Aerospace & IT Industries and other NASA providers	Comp. Sci., Earth, and Space Science communities
Computing, Networking, and Information Systems	OAT, OES, OSS, OSF, NASA IT Ops. Orgs.	Aerospace & IT Industries and other NASA providers	Earth and Space Science communities
Space Communication	OSS, OES, OSF, OAT	Aerospace, satellite, and wireless comm. Industries	DOD, Comm and networking communities
Information Technology Strategic Research	OAT, OES, OSS, OSF	Aerospace & IT Industries and other NASA providers	Comp. Sci., Biological, and Nanotechnology communities

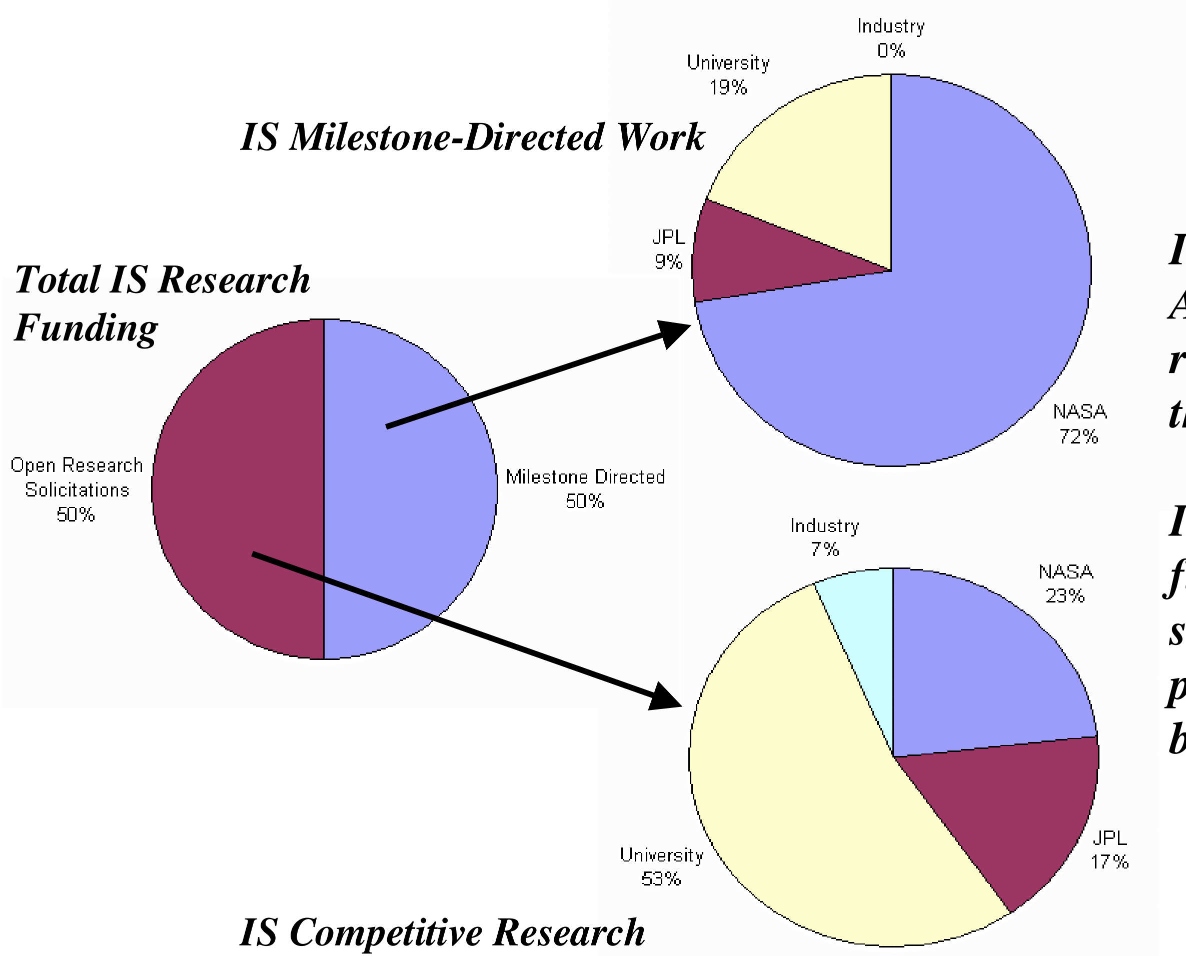
OAT - Aerospace Technology Enterprise
OES - Earth Space Enterprise
OSS - Space Science Enterprise
OSF - Human Exploration and Development of Space

Red - Primary Technology Customer (Driving Requirements)
Blue - Technology Customer
Black - Technology Beneficiary and/or Partner

CICT IS Funding Strategy

IS Milestone-Directed Work

Total IS Research Funding



IS Competitive Research is Applied to NASA relevant problems through the Milestone-Directed work.

It is the interaction between fundamental computational science theory and hard NASA problems which produces breakthrough results.

IS Competitive Research
Awards to the Computational Science Community
(98% of the peer reviewers for this work are outside NASA)

Process for the Competitive Research Work

Step One (White Paper)
Proposals > 500

Down-select

Internal Peer Review – IS Project Office
Criteria: Quality & NASA Relevance

Step Two (Full) Proposals > 250

Down-select

External Peer Review – 98% External to NASA
Criteria: Quality

Technically Excellent Proposals > 100

Down-select

Mission Relevancy – Enterprise Representatives
Criteria: Enterprise Relevance

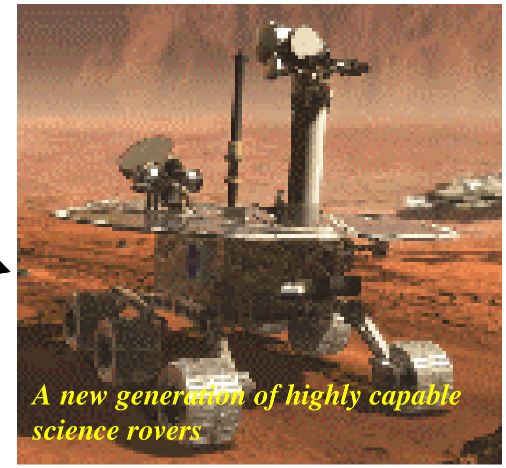
52 Funded Projects - Awarded

Final Selections made with active concurrence of the Enterprises

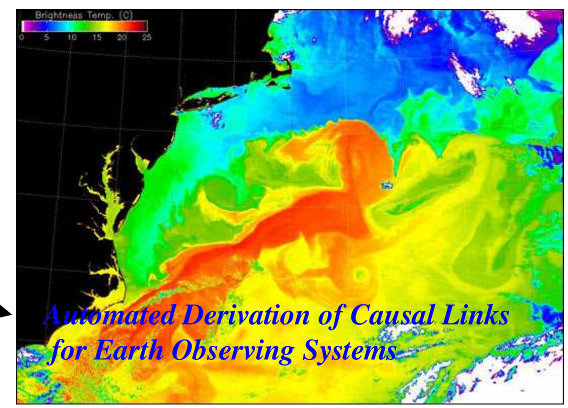
Initial IS Research Solicitation

52 Research Awards to the Computational Science Community:
$8.5M in FY01, $17.2M in FY02

Organization	PI Name Last, First	Title	
Harvard University	Pfeffer, Avrom J.	Probabilistic Reasoning for Complex Dynamic Systems	
Massachusetts Institute of Technology	Kaelbling, Leslie	Multi-Resolution Planning in Large Uncertain Environments	AR
Carnegie Mellon University	Simmons, Reid	Heterogenous Multi-rover Coordination for Planetary Exploration	
Massachusetts Institute of Technology	Williams, Brian C.	A Hybrid Discrete/Continuous System for Health Management and Control	
NASA/Ames Research Center	Smith, David E.	Limited Contingency Planning for Concurrent Activities	
NASA/Ames Research Center	Lowry, Michael	Program Synthesis of Verifiably Correct State Estimation Programs	
Arizona State University	Kambhampati, Subbarao	Heuristic Control of Planning and Execution in Metric/Temporal Domains	
Vanderbilt University	Biswas, Gautam	Robust Methods for Autonomous Fault Adaptive Control of Complex Systems	
University of Minnesota	Heimdahl, Mats P. E.	Intelligent Specification-Centered Test-Case Generation Review Identifier	
USRA-RIACS	Cheeseman, Peter	Super-Revolved 3D Surface Models from Rover Images	
Jet Propulsion Laboratory	Barrett, Anthony	Continual Coherent Team Planning	
Jet Propulsion Laboratory	Estlin, Tara	An Onboard Scientist for Multi-Rover Scientific Exploration	
Jet Propulsion Laboratory	Matthies, Larry H.	Autonomous Vision Guided Safe and Precise Landing	
Jet Propulsion Laboratory	Smith, Benjamin D.	Using Combinatorial Optimization Algorithms to Improve Automated Planning and Scheduling	
Yale University	Hudak, Paul	Domain-Specific Self-Adaptive Software	
University of Illinois, Urbana-Champaign	Wah, Benjamin W.	Stochastic Anytime Search With Applications in Autonomous Planning and Scheduling	
Carnegie Mellon University	Wing, Jeanette	Formal Verification Tools and Techniques for Autonomous Systems	
Arizona State University	Baral, Chitta	Agent Development and Control Verification Using Dual Characterization	
NASA/Ames Research Center	Clancey, William J.	Work Practice Simulation Environment for Habitat Design and Scheduling	
Carnegie Mellon University	Anderson, John R.	Simulating Learning of Complex, Dynamic Tasks	HCC
Institute for Study of Learning & Expertise (ISLE)	Gervasio, Melinda	Filtering Information in Complex Temporal Domains	
Massachusetts Institute of Technology	Leveson, Nancy G.	Approaches to Human Centered Software Development	
Brown University	Sloman, Steven	Causal Reasoning	
SRI International	Shriberg, Elizabeth E.	Harnessing Speech Prosody for Robust Human-Computer Interaction	
Indiana University	Leake, David B.	Integrated Intelligent Support for Knowledge Capture, Refinement and Sharing	
University of Southern California	Berger, Theodore W.	Robust Speech Recognition Using Dynamic Synapse Neural Networks	
University of Texas, Houston	Zhang, Jiajie	Human Centered Intelligent Flight Surgeon Console	
NASA/Johnson Space Center	Schreckenghost, Debra	Distributed Crew Interaction with Advanced Life Support Control Systems	
Jet Propulsion Laboratory	Kohen, Hamid	Multi-Media Human Computer Interfaces for Mission-Critical Systems	
University of West Florida	Bradshaw, Jeffrey M.	Teamwork in Practive: Design for Collaboration in Mixed Human-Robotic Teams	
NASA/Ames Research Center	Keller, Richard M.	A Testbed for Agent-assisted Collaborative Scientific Experimentation	
NASA/Ames Research Center	Lowry, Michael	Formal Analysis of Human-Automation Interaction	
Boston University	Myneni, Ranga B.	A Benchmark Dataset of Multidimensional Earth Science Satellite Data for Testing of Learning Algorithms	
NASA/Goddard Space Flight Center	Tilton, James C.	Knowledge Discovery and Data Miining Based on Hierarchical Segmentation of Image Data	IDU
SRI International	Waldinger, Richard	Deductive Compostion of Multiple Data Sources	
Oregon Graduate Institute of Science & Technology	Pavel, Misha	Robust Intelligent Systems Based on Information Fusion	
NASA/Ames Research Center	Stutz, John	Disparae Image Registration	
University of Minnesota	Kumar, Vipin	Discovery of Changes from the Global Carbon Cycle and Climate System Using Data Mining	
Washington State University	Kargupta, Hillol	Distributed Data Mining for Large NASA Databases	
Purdue Research Foundation	Brodley, Carla	Machine Learning & Data Mining for Improved Intelligent Data Understanding of High Dimensional Earth Sensed Data	
NASA/Ames Research Center	Kao, David	Feature Extraction 7 Visualization From Distributed Data Sources with Uncertainty	
Carnegie Mellon University	Glymour, Clark	Automated Discovery Procedures for Gene Expression & Regulation for Microarray & Serial Analysis of Gene Experssion Data	
Jet Propulsion Laboratory	DeCoste, Dennis	Intelligent Engineering Time-Series Pattern Matching	
Western Michigan University	Emerson, Charles W.	Fractal & Geostatistial Metadata for Monitoring Global Change Using Remote Sensing Imagery	
University of West Florida	Teng, Choh Man	Polishing: Enhancing Data Quality by Repairing Imperfections	
Jet Propulsion Laboratory	Burl, Michael C,	Automated Knowledge Discovery from Simulators	
NASA/Goddard Space Flight Center	LeMoigne, Jacqueline	Image Registration and Fusion for Future Formation Flying Systems	



A new generation of highly capable science rovers



Automated Derivation of Causal Links for Earth Observing Systems

High Potential Research Breakthroughs

Examples: Migration of Breakthrough Research into NASA Missions

IS Research Award

Multi-Resolution Planning in Uncertain Environments
L. Kaelbling/MIT

IS Milestone-Directed Work

Automated Rover Science
NASA/JPL

Space Science Mars Mission Requirements
NASA/JPL

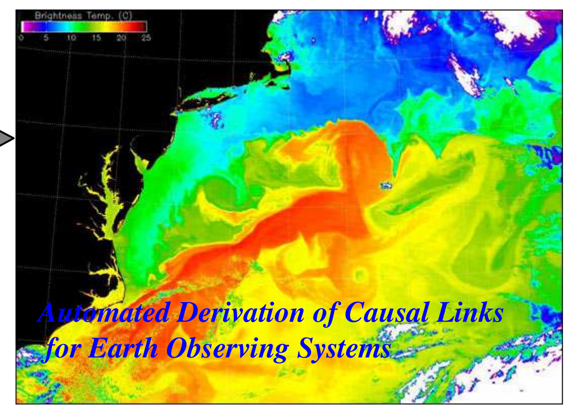
IS Research Award

Automated Discovery Procedures for Gene Expression
C. Glymour/Carnegie Mellon University

IS Milestone-Directed Work

Extensions of Serial Analysis into Causal Links
Univ. of West Florida

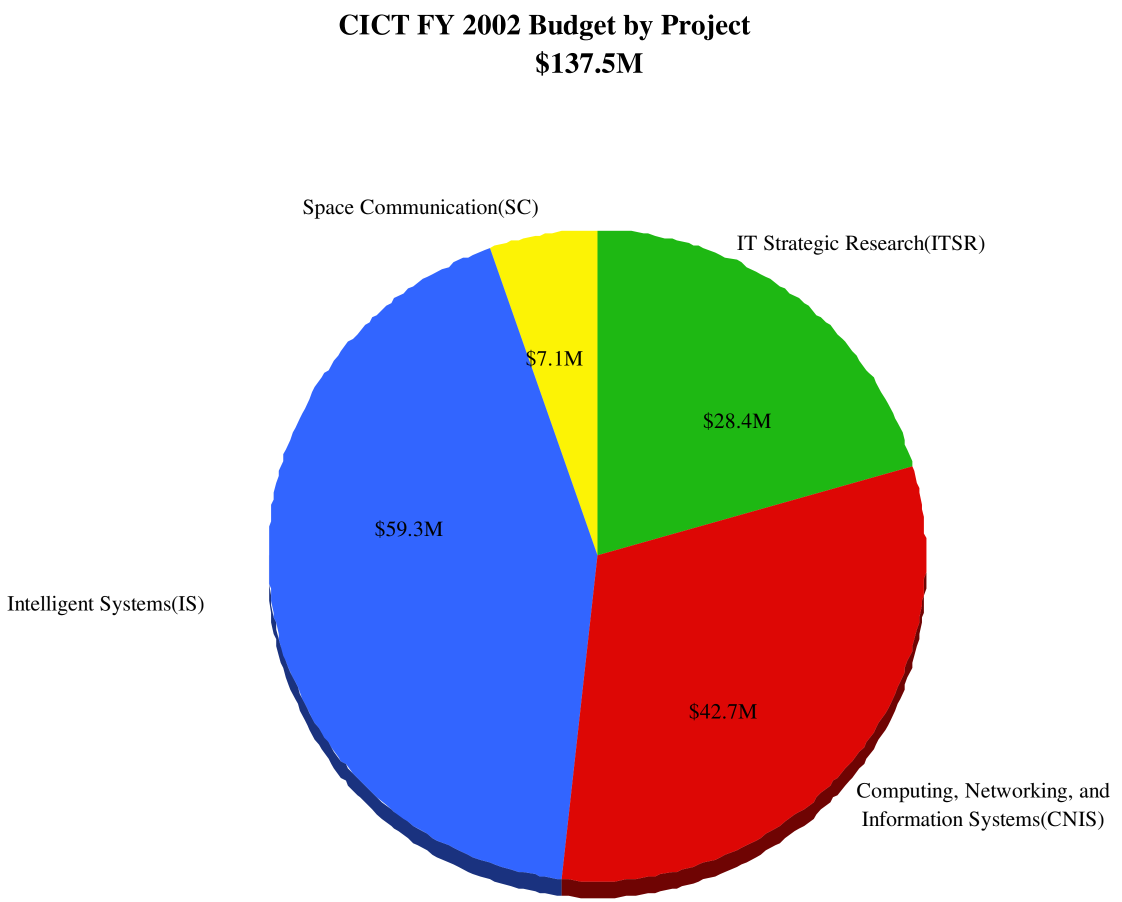
Earth Science Exemplar Data Sets
NASA/GSFC



Outline

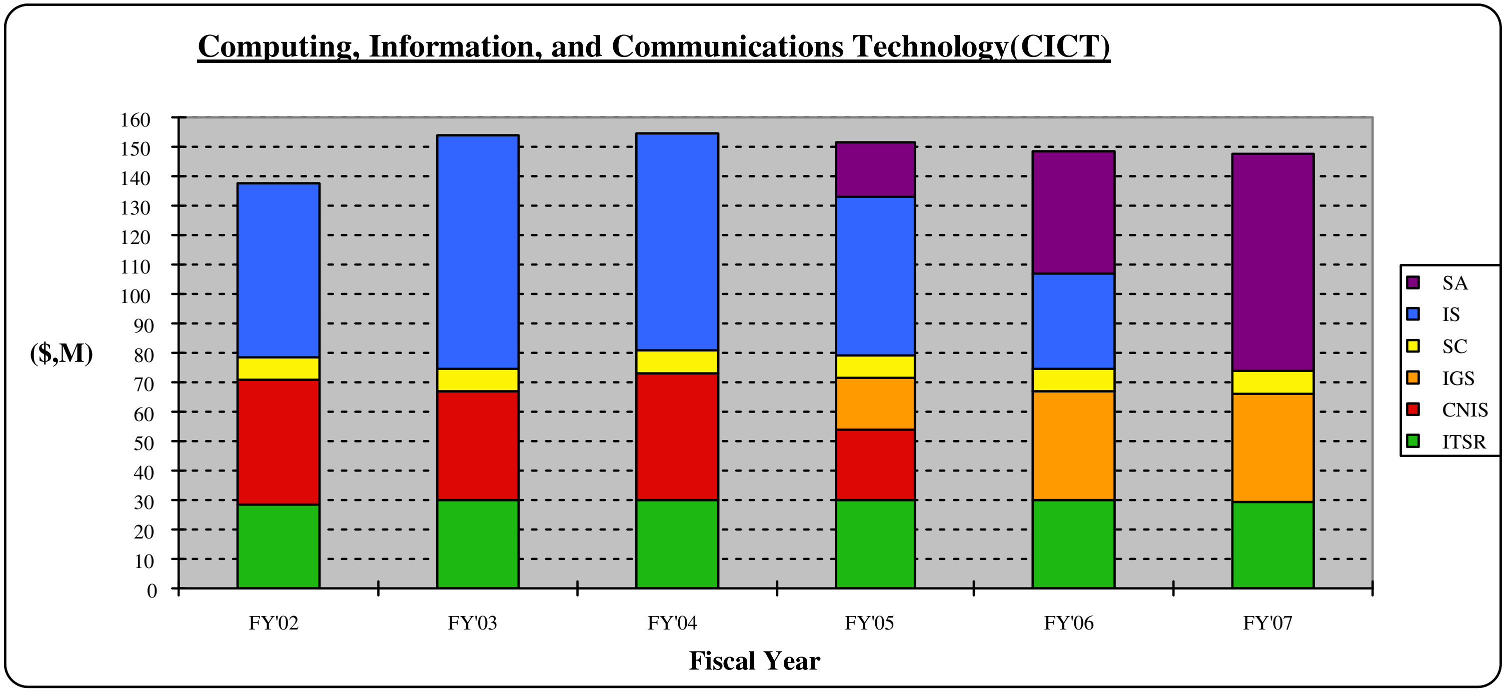
- **Requirements**
  - Goal
  - Technical Objectives
- **Program Structure**
  - Organization
  - Integrated Capability
- **Program Processes**
  - Overall Investment Strategy
  - Program Level Customers
  - Example Selection Process (CICT IS)
- ➡ **Resources**

CICT Program Budget



Note: Budget does not include Congressional Earmarks of $13.6M

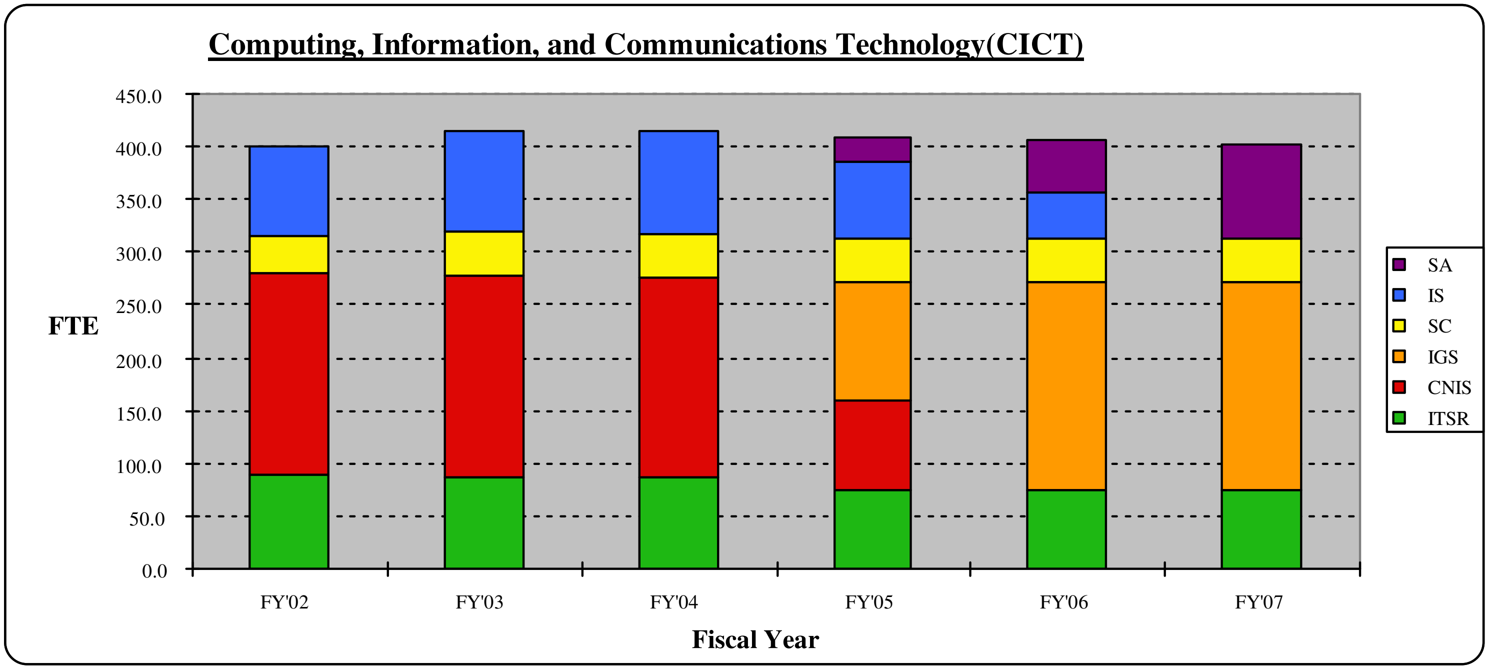
CICT Program Budget



Budget by Project	FY'02	FY'03	FY'04	FY'05	FY'06	FY'07
IS	59.3	79.6	73.8	54.2	32.4	0.0
SA				18.2	41.3	73.8
CNIS	42.7	37.0	42.8	23.7	0.0	0.0
IGS				17.5	37.0	36.9
SC	7.1	7.6	7.6	7.6	7.6	7.6
ITSR	28.4	29.7	30.1	30.3	29.7	29.5
Total	137.5	153.9	154.3	151.5	148.1	147.9

Note: Budget does not include Congressional Earmarks of $13.6M.

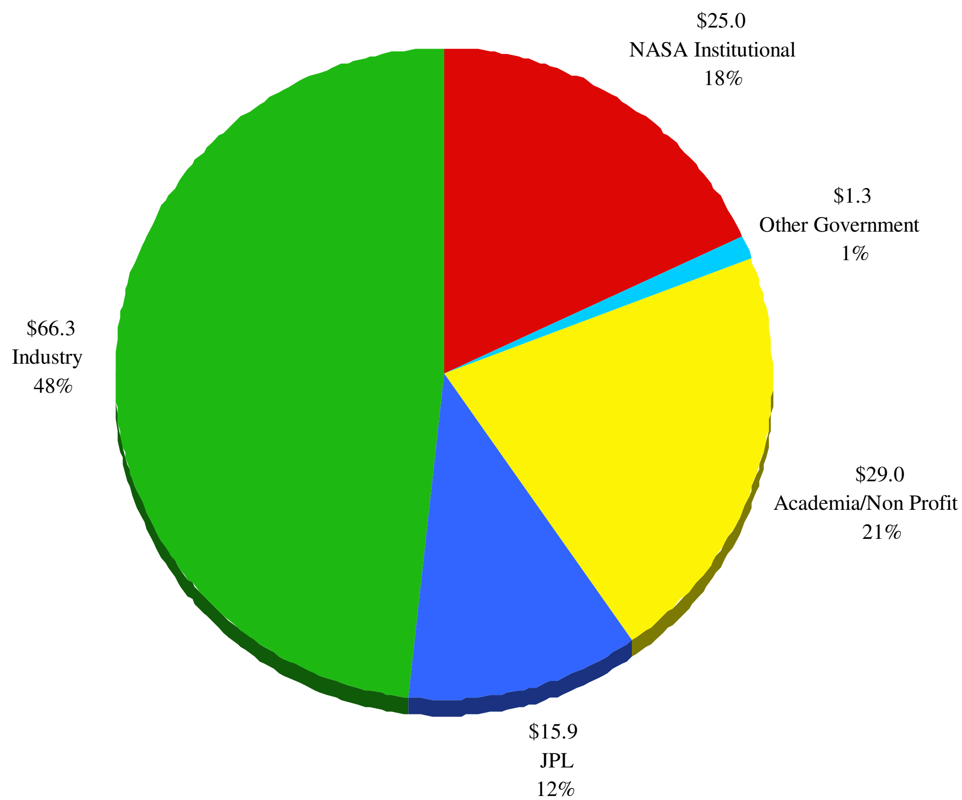
CICT Program Workforce



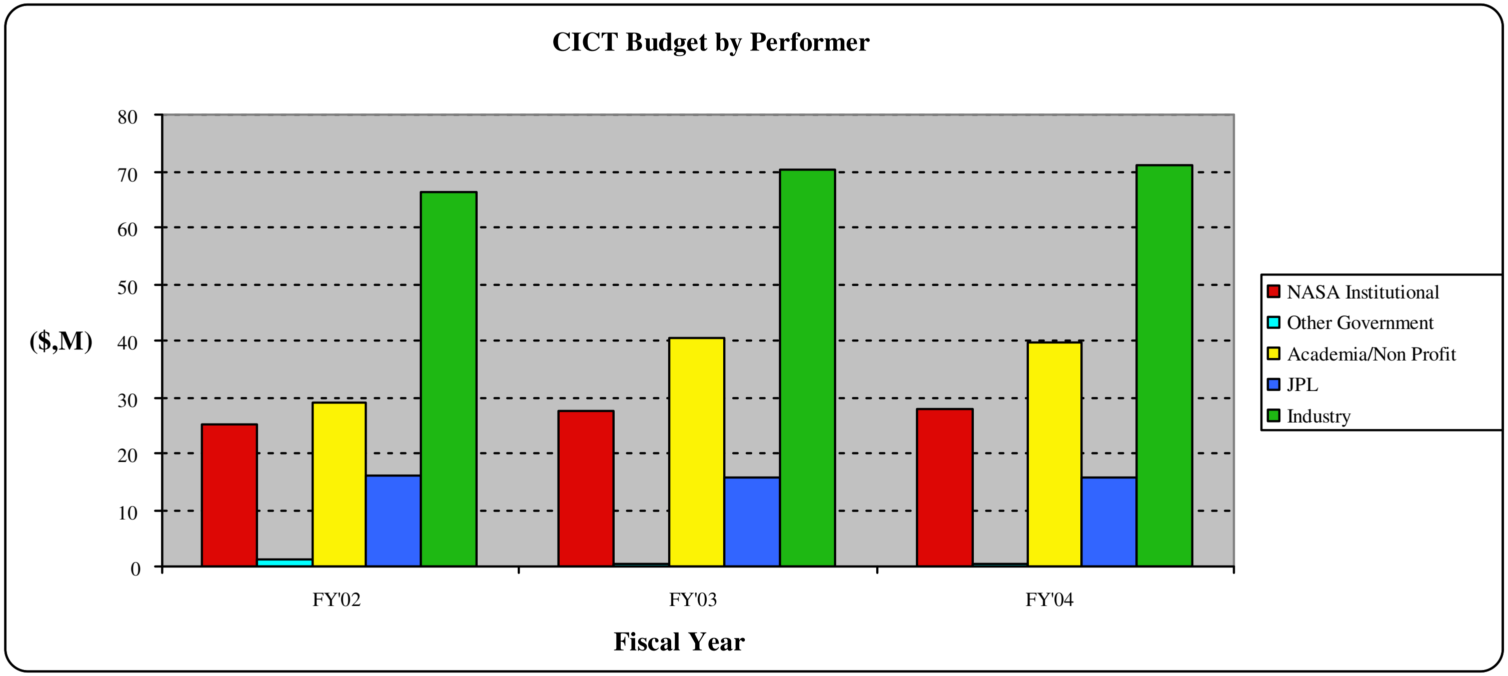
Workforce by Project	FY'02	FY'03	FY'04	FY'05	FY'06	FY'07
IS	85.0	95.0	97.0	73.0	43.0	0.0
SA				23.0	51.0	90.0
CNIS	189.0	191.0	187.0	85.0	0.0	0.0
IGS				112.0	197.0	197.0
SC	36.0	42.0	42.0	42.0	42.0	42.0
ITSR	90.0	87.0	88.0	74.0	74.0	74.0
Total	400.0	415.0	414.0	409.0	407.0	403.0

CICT Program Budget

CICT FY 2002 Budget by Performer
$M

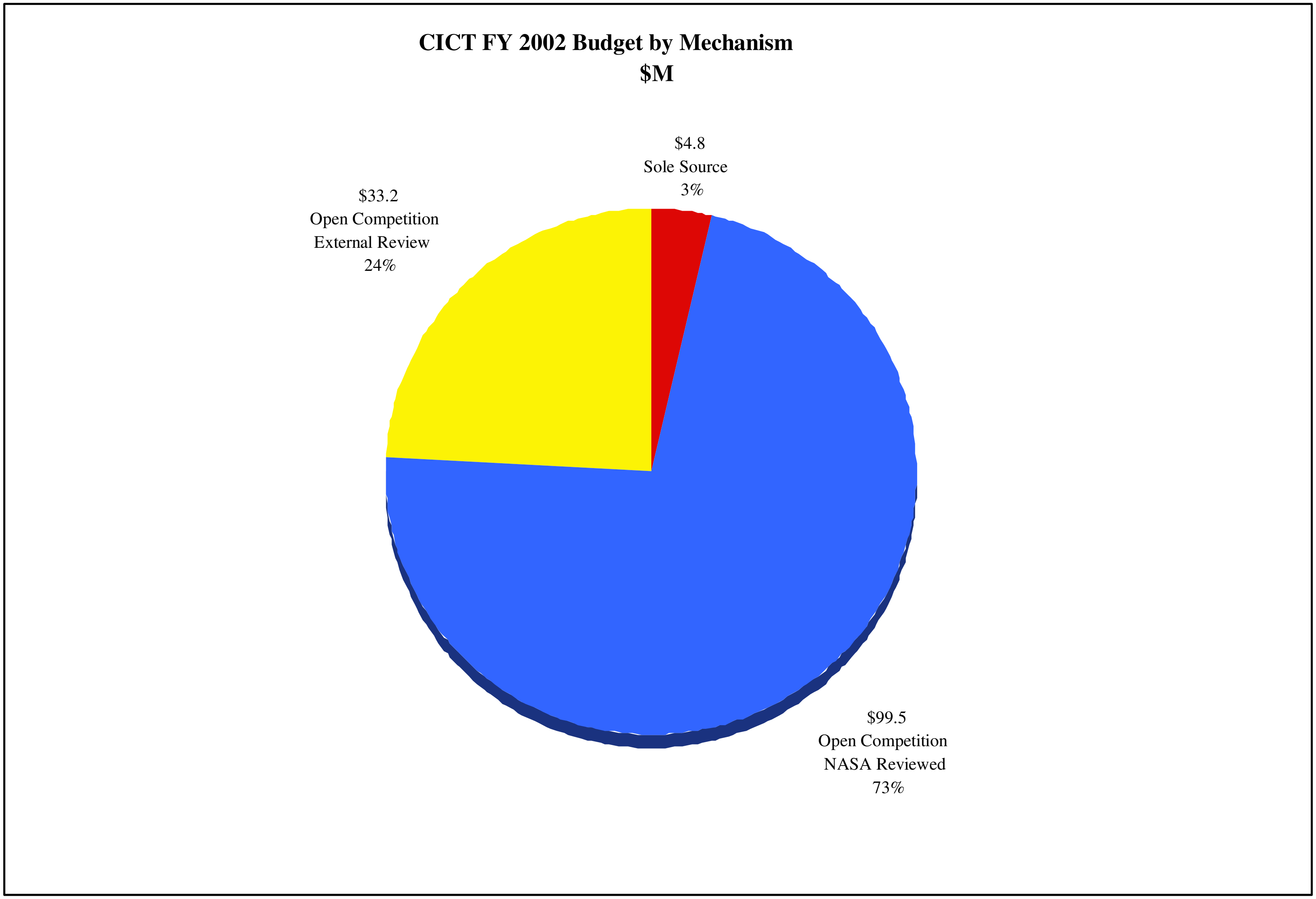


CICT Program Budget

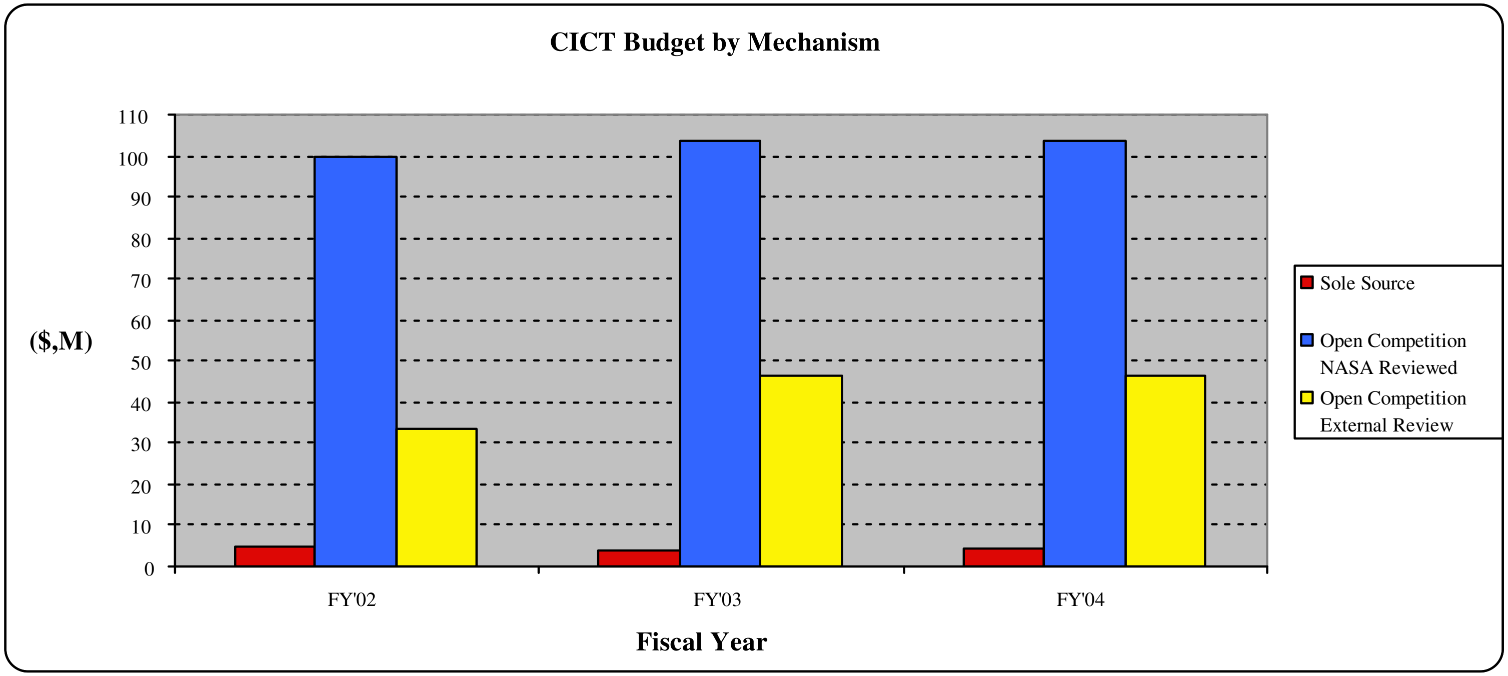


Performer	FY'02	FY'03	FY'04
NASA Institutional	25.0	27.4	27.6
Other Government	1.3	0.4	0.4
Academia/Non Profit	29.0	40.2	39.5
JPL	15.9	15.8	15.7
Industry	66.3	70.1	71.1
Total	137.5	153.9	154.3

CICT Program Budget

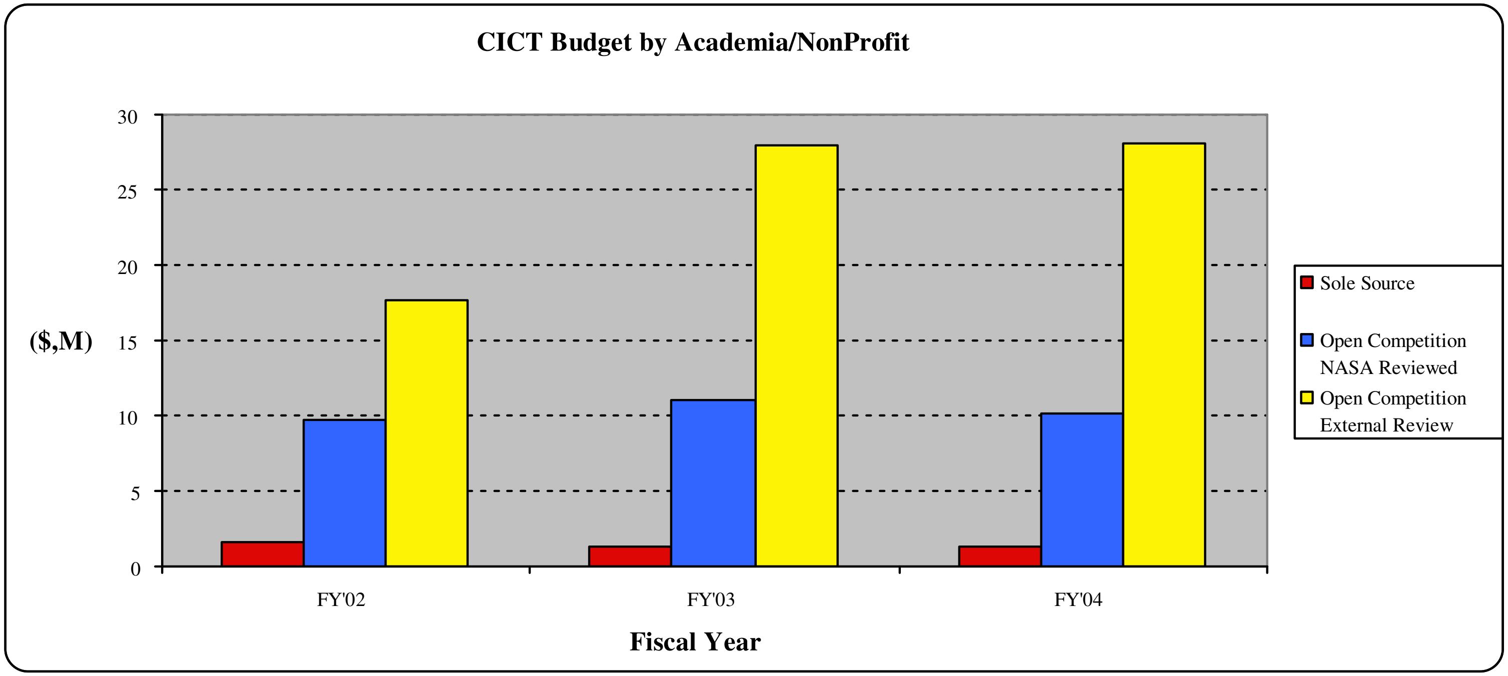


CICT Program Budget



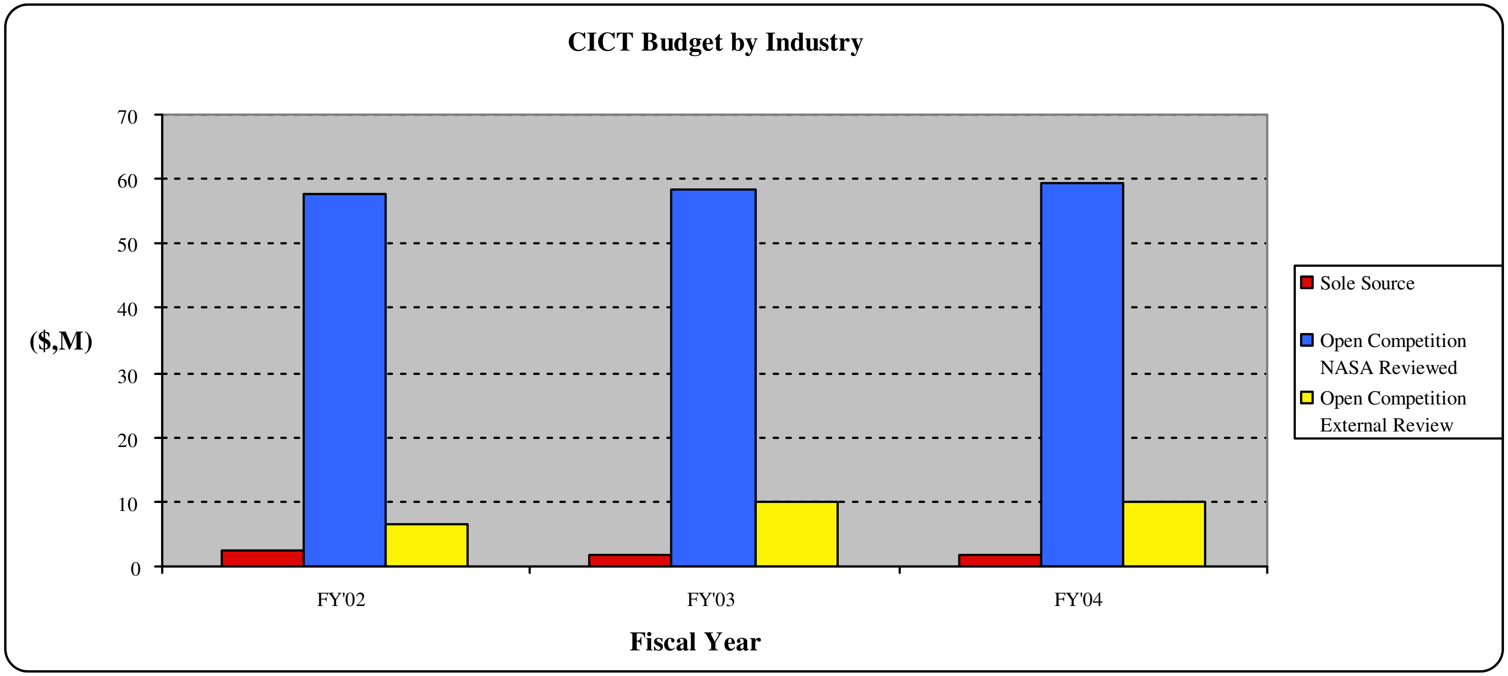
Mechanism	FY'02	FY'03	FY'04
Sole Source	4.8	3.9	4.2
Open Competition NASA Reviewed	99.5	103.8	103.8
Open Competition External Review	33.2	46.2	46.4
Total	137.5	153.9	154.3

CICT Program Budget



Mechanism	FY'02	FY'03	FY'04
Sole Source	1.6	1.4	1.3
Open Competition NASA Reviewed	9.7	11.0	10.1
Open Competition External Review	17.7	27.9	28.1
Total	29.0	40.2	39.5

CICT Program Budget



Mechanism	FY'02	FY'03	FY'04
Sole Source	2.3	1.7	1.7
Open Competition NASA Reviewed	57.6	58.3	59.4
Open Competition External Review	6.4	10.1	10.0
Total	66.3	70.1	71.1