DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE)

$684,510,000
+$65,680,000 / 10.6%

CISE Funding
(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Percent
Computing and Communication Foundations (CCF)	$156.92	$41.17	$170.35	$186.95	$16.60	9.7%
Computer and Network Systems (CNS)	188.30	92.25	204.42	227.08	$22.66	11.1%
Information and Intelligent Systems (IIS)	150.93	61.17	163.32	189.74	$26.42	16.2%
Information Technology Research (ITR)	78.35	40.41	80.74	80.74	-	-
Total, CISE	**$574.50**	**$235.00**	**$618.83**	**$684.51**	**$65.68**	**10.6%**
Research	476.24	192.29	$535.90	600.87	64.97	12.1%
Education	56.92	10.74	38.84	38.84	-	-
Infrastructure	28.45	31.97	30.60	30.60	-	-
Stewardship	12.89	-	13.49	14.20	0.71	5.3%

Totals may not add due to rounding.

CISE's mission is to enable the U.S. to uphold a position of world leadership in computer and information science and engineering; to promote understanding of the principles and uses of advanced computer, communications, and information systems in service to society; and to contribute to universal, transparent, and affordable participation in an information-based society. CISE supports ambitious, long-term research and research infrastructure projects within and across the many sub-fields of computing, contributes to the education and training of computing professionals and, more broadly, informs the preparation of a U.S. workforce with computing competencies essential to success in an increasingly competitive, global market.

CISE Subactivity Funding
(Dollars in Millions)
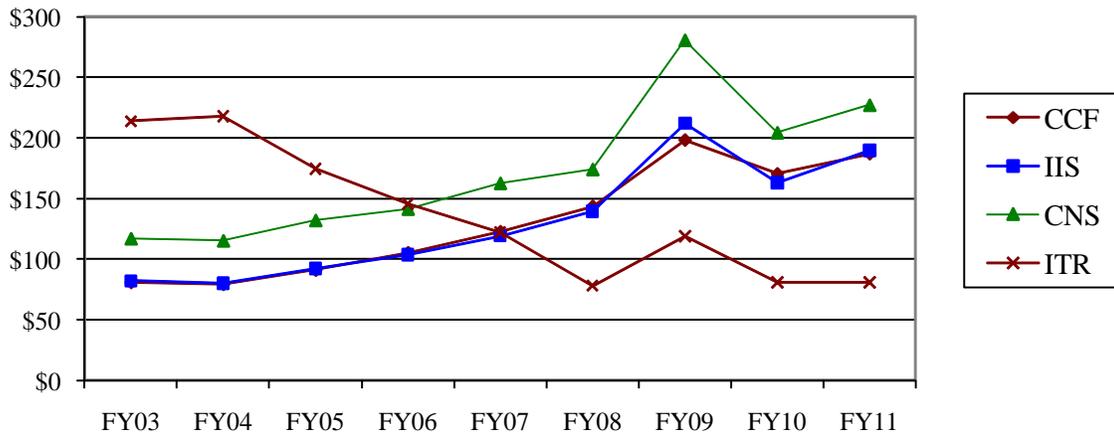
CISE in Context

NSF provides approximately 82 percent of the total federal support for basic research at academic institutions in computer science. In recent years, these investments and the research outcomes they have produced have provided significant value-added to the U.S. economy. Since 1995, networking and information technology (IT) industries have accounted for 25 percent of the Nation's economic growth, although they represent only three percent of the gross domestic product.[1]

Essentially all practical applications of IT are based on ideas and concepts that emerged from basic research investments. These fundamental ideas and concepts have enabled innovative product and application developments that now permeate most areas of modern life. IT not only forms a sizeable portion of the economy in its own right, but drives discovery and innovation in many other areas, including advanced scientific research, healthcare, national and homeland security, and public and private organizational effectiveness and efficiency. Innovation in IT will remain an essential and vital force in productivity gains and economic growth in both the manufacturing and service sectors for many years to come, positioning NSF and CISE as central and essential actors in improving the Nation's economic outlook and advancing a highly trained, technologically astute workforce.

CISE continues to play a leadership role in the multi-agency subcommittee on Networking and Information Technology Research and Development (NITRD), which is co-chaired by the CISE Assistant Director. All research, education, and research infrastructure projects supported by CISE enrich the agency's NITRD portfolio.

CISE supports workshops, conferences, and projects each year that inform and guide the evolution of the research portfolio. Recent examples from 2008 and 2009 include:
- the National Cyber Leap Year Summit;
- Workshop on the Science of Power Management;
- 1st International Conference on Computational Sustainability Future Internet Architectures Summit;
- The First International Workshop on Cyber-Physical Systems, International Conference on Distributed Computing Systems (ICDCS);
- Robotics and Cyber-Physical Systems;
- Workshop on Cyber-Physical Systems: Closing the Loop;
- National Workshop on Research on Transportation Cyber-Physical Systems: Automotive, Aviation, and Rail;
- National Cyber Defense Financial Services Workshop: Usability, Security, and Privacy of Information Systems;
- NSF Security-Driven Architectures;
- Discovery and Innovation in Health IT; and
- Computational Thinking for Everyone: A Workshop Series.

In FY 2011, CISE will continue to strengthen the intellectual foundations of computing, supporting research in algorithms and theoretical computer science, computer architecture, cryptography, information theory, network and communication theory, parallel computing, programming languages, semantics and logics, software engineering, and in emerging models and substrates of computation. As computing systems provide richer functionalities, faster performance, and more efficient energy usage, as they become more ubiquitous and pervasive, and as user and societal expectations of them increase, CISE

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[1] *Leadership Under Challenge: IT R&D in a Competitive World*, President's Council of Advisors on Science and Technology (PCAST) 2007.

investments in the fundamental research essential to systems design for properties such as reliability, security, privacy, and usability become increasingly important. As we seek to better understand human intelligence and to use computing to enhance our quality of life, CISE will continue to invest in forward-looking research in areas such as artificial intelligence, computer vision, graphics, machine learning, intelligent decision-making, natural language processing, robotics, speech, search, information retrieval, and technologies for learning and collaboration.

CISE will play a leadership role in the new multi-directorate, multidisciplinary Cyberlearning Transforming Education (CTE) program to harness the transformative potential of advanced learning technologies across the education enterprise. The directorate will continue to support the preparation of a world-class computing workforce through two programs in particular: CISE Pathways to Revitalized Undergraduate Computing Education (CPATH) and Broadening Participation in Computing (BPC). These programs aim to increase American competitiveness in the global economy.

Factors Influencing the Allocation Across Divisions and Major Programs

The focus of CISE's FY 2011 Request is on stimulating transformative research in emerging high-priority areas such as the multi-agency Comprehensive National Cybersecurity Initiative, which totals $55.0 million in FY 2011, Cyber-Physical Systems, Cyberlearning Transforming Education, Science and Engineering Beyond Moore's Law, and Cyber-enabled Discovery and Innovation, while maintaining viable support levels for the core areas of computing.

Assuring U.S. leadership in advanced manufacturing is an Administration priority as outlined in the National Economic Council's *Framework for Revitalizing American Manufacturing* (December 2009). Through investments in programs such as Cyber-Physical Systems (CPS), i.e., those systems that combine computational and physical elements such as smart cars and embedded medical devices, CISE's Request recognizes the significant role computing will play in this effort. The CPS program, which CISE supports in partnership with the Directorate for Engineering (ENG), seeks to develop new foundations, methods, and tools that will bridge the gap between approaches to the cyber and physical elements of cyber-physical systems design.

CISE Funding for Centers

CISE Funding for Centers
(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Change Over FY 2010 Estimate Percent
Centers	**$8.00**	**-**	**$9.82**	**$9.16**	**-0.66**	**-6.7%**
STC: Center for Embedded Networked Sensing (CCF)	4.00	-	3.32	2.66	-0.66	-19.9%
STC: Team for Research in Ubiquitous Secure Technology (CCF)	4.00	-	4.00	4.00	-	N/A
SLC: Pittsburgh Science of Learning Center for Robust Learning (ITR)	-	-	2.50	2.50	-	N/A

Detailed information on individual Centers can be found in the NSF-Wide Investments chapter.

Centers
- Funding for the Center for Embedded Networked Sensing is reduced as the center moves towards its tenth year of operation in FY 2011.

CISE Administration Priority Programs and NSF Investments

CISE Administration Priority Programs and NSF Investments
(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Percent
Faculty Early Career Development (CAREER)	$42.73	$21.83	$50.96	$54.57	$3.61	7.1%
Graduate Research Fellowships (GRF)	1.16	2.82	2.55	2.55	-	-
Science, Engineering and Education for Sustainability (SEES)	N/A	N/A	17.00	29.36	12.36	72.7%
Cyberlearning Transforming Education (CTE)	N/A	N/A	-	15.00	15.00	N/A
Science and Engineering Beyond Moore's Law (SEBML)	4.00	-	15.00	15.00	-	-

CISE's FY 2011 budget will fund two key NSF programs that support students and early-career researchers. The budget also encourages potentially transformative research and supports critical priorities in global climate change.

Contributing to the development of current and future generations of computing faculty is a priority in the FY 2011 Request and is reflected in CISE's commitment to the CAREER and Graduate Research Fellowship programs.

CISE's FY 2011 Request emphasizes potentially transformative research in multidisciplinary areas such as:
- Science, Engineering, and Education for Sustainability (SEES): In FY 2011, CISE will invest $29.36 million in the NSF-wide SEES portfolio to integrate efforts in climate and energy science and engineering. CISE will contribute to this agency-wide effort with an emphasis on energy-intelligent computing to optimize energy-computational performance in computing and communications systems. CISE also will stimulate research advances in computing and communications to reduce energy consumption in key application areas. For example, advances in computing will enable more efficient, reliable energy delivery in the Smart Grid and will help reduce energy consumption in the Smart Home. Research supported in this area will provide new foundational understanding of the energy requirements inherent in computation and communication.
- Cyberlearning Transforming Education (CTE): In FY 2011, CISE, in partnership with the EHR and SBE directorates, will establish NSF's new multidisciplinary research program designed to fully capture the transformative potential of advanced learning technologies across the education enterprise. The CTE program seeks to enable wholly new avenues of science, technology, engineering, and mathematics (STEM) learning for students and for workforce development and to advance the Nation's ability to study the learning process itself.

In response to the Administration's report, *A Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs* (September 2009), CISE's FY 2011 Request emphasizes investments in the next generation of information and communications technologies, in programs such as

Science and Engineering Beyond Moore's Law (SEBML). SEBML addresses the hardware and software challenges associated with exploiting all the performance opportunities associated with new multi-core computing technologies. In addition, SEBML will support fundamental research to identify promising new technologies for computing, notably in quantum information science.

For more information on Administration priority programs and NSF investments, please refer to the Overview and NSF-wide Investments sections.

Program Evaluation and Performance Improvement

The Performance Information chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

During FY 2009 CISE held three Committees of Visitors who together examined and assessed the quality of the entire CISE portfolio. Other performance indicators, such as funding rates, award size and duration, and numbers of people supported on research and education grants, are factored into the performance assessment process.

Evaluation is a vital part of CISE's STEM education and learning programs such as CPATH and BPC. CPATH evaluation is overseen by SRI International, an independent evaluation firm, with NSF overseeing the overall evaluation process. The evaluation of CPATH is expected to be completed in the summer of 2010. For BPC, the American Association for the Advancement of Science (AAAS) oversees the individual evaluations of BPC Alliances with each BPC project required to run its own evaluation as well. The AAAS evaluation of the BPC Alliances is due in 2010.

Number of People Involved in CISE Activities

	FY 2009 Estimate	FY 2009 ARRA Estimate	FY 2010 Estimate	FY 2011 Estimate
Senior Researchers	5,234	1,534	5,700	6,150
Other Professionals	512	170	550	600
Postdoctorates	330	120	350	400
Graduate Students	5,813	2,343	6,200	6,850
Undergraduate Students	2,151	773	2,350	2,500
Total Number of People	**14,040**	**4,940**	**15,150**	**16,500**

CISE Funding Profile

	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
Statistics for Competitive Awards:			
Number of Proposals	5,661	5,900	6,200
Number of New Awards	1,735	1,450	1,650
Regular Appropriation	1,356	1,450	1,650
ARRA	379	-	-
Funding Rate	31%	25%	27%
Statistics for Research Grants:			
Number of Research Grant Proposals	5,374	5,600	5,800
Number of Research Grants	1,484	1,220	1,370
Regular Appropriation	1,128	1,220	1,370
ARRA	356	-	-
Funding Rate	28%	22%	24%
Median Annualized Award Size	$150,000	$140,000	$140,000
Average Annualized Award Size	$188,082	$180,000	$180,000
Average Award Duration, in years	3.1	3.0	3.0

DIVISION OF COMPUTING AND COMMUNICATION FOUNDATIONS (CCF)

$186,950,000
+$16,600,000 / 9.7%

CCF Funding

(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Change Over FY 2010 Estimate Percent
CCF	**$156.92**	**$41.17**	**$170.35**	**$186.95**	**$16.60**	**9.7%**
Research	150.85	40.15	167.05	183.65	16.60	9.9%
STC: Center for Embedded Networked Sensing	*4.00*	*-*	*3.32*	*2.66*	*-0.66*	*-19.9%*
STC: Team for Research in Ubiquitous Secure Technology	*4.00*	*-*	*4.00*	*4.00*	*-*	*-*
Education	5.47	1.02	2.70	2.70	-	-
Infrastructure	0.60	-	0.60	0.60	-	-

CCF supports research and education on: algorithmic foundations to help us understand the fundamental limits of resource-bounded computation and to obtain optimal solutions within those limits; algorithms that are applicable to areas both within and outside computer science; the theoretical underpinnings and current and future enabling technologies for information acquisition, transmission, and processing in communication and information networks; the foundational aspects of hardware and software, i.e., the reasoning, comparing and establishing properties of existing and newly-conceived software and hardware components, systems, and other artifacts, which are essential to advance the capability of computing systems; and the design of new computing devices based on nanotechnology, biotechnology, or quantum physics. CCF will continue to support two Science and Technology Centers: the Center for Embedded Networked Sensing (CENS) at the University of California at Los Angeles and the Center for Research in Ubiquitous Secure Technology at the University of California at Berkeley (TRUST).

In general, 60 percent of the CCF portfolio is available each year for new research grants, with 40 percent used primarily to fund continuing grants made in prior years.

Factors Influencing the Allocation across CCF Programs

In FY 2011 the allocation of CCF funds is designed to provide increased support for priority core research for the next generation of information and communications technology. The CCF allocation also targets high-priority research areas such as SEES, the Comprehensive National Cybersecurity Initiative (CNCI), and Science and Engineering Beyond Moore's Law (SEBML). In FY 2011, CCF will:

- Support SEES through research in energy-intelligent computing to optimize energy-computational performance in computing and communications systems. Advances will require new foundational understanding of the energy requirements inherent in computation and communication.
- Increase support for the Trustworthy Computing (TwC) program, which includes support for the CNCI, with a focus on the foundations of trustworthy systems, including the science of security, models and logic for privacy, and new cryptographic techniques and applications.
- Explore the emerging interface between computer science and economics, including algorithmic game theory, automated mechanism design, computational tractability of basic economic problems, and the role of information, trust, and reputation in markets.

- Continue emphasis on Cyber-enabled Discovery and Innovation (CDI) through investments in new computational abstractions to represent and manage data and in future generations of computational algorithms and concepts that enable better understanding of complex systems.
- Continue support of SEBML through CCF-supported research to address all the hardware and software challenges associated with exploiting multi-core technologies. In addition, CCF will support fundamental research to identify promising new technologies for computing, notably in quantum information science.

As with all three CISE disciplinary divisions, CCF will participate in CISE crosscutting research, education, and infrastructure programs, including Data-intensive Computing.

DIVISION OF COMPUTER AND NETWORK SYSTEMS (CNS) $227,080,000
+$22,660,000 / 11.1%

CNS Funding

(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Percent
CNS	**$188.30**	**$92.25**	**$204.42**	**$227.08**	**$22.66**	**11.1%**
Research	116.51	61.56	141.68	164.34	22.66	16.0%
Education	43.94	8.72	32.74	32.74	-	-
Infrastructure	27.85	21.97	30.00	30.00	-	-

CNS supports research and education activities that advance our understanding of the fundamental properties of computer systems and networks and their complexity, explore new ways to address the limitations of existing computer and networked systems to make better use of these technologies, and develop better paradigms, abstractions, and tools for designing, analyzing, and building next generation computer and networked systems that are robust, secure, and trustworthy. CNS investments in computer systems research focus on: distributed, mobile, and embedded systems; sensing and control systems; dynamically configured, multiple-component systems; and parallel systems. CNS investments in fundamental network research create new insights into the dynamics of complex networks and explore new architectures for future-generation networks and services. CNS provides scientific leadership in trustworthy computing, supporting research and education activities that will ensure that society's increasingly ubiquitous and distributed computing and communication systems deliver the quality of service they are designed to achieve, without disruption, while enabling and preserving privacy, security, and trust.

CNS also plays a leadership role in coordinating CISE investments in research infrastructure resources and in the development of the computing workforce of the future. Through the Computing Research Infrastructure (CRI) program, which is targeted to the research needs of CISE investigators rather than those of all scientific disciplines, CNS supports the acquisition, enhancement, and operation of state-of-the-art infrastructures and facilities that enable high-quality computing research and education in a diverse range of institutions and projects. CNS supports the BPC program to significantly increase the number and diversity of U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines, and the CPATH program to identify and define the core computing concepts, methods, technologies, and tools to be integrated into promising new undergraduate education models.

In general, about 50 percent of the CNS portfolio is available for new grants. The remaining 50 percent is used primarily to fund continuing grants made in previous years.

Factors Influencing the Allocation Across CNS Programs

In FY 2011 the allocation of CNS funds is designed to provide increased support for priority core research for the next generation of information, networking, and communications technology. The CNS allocation also targets high-priority research areas such as the Comprehensive National Cybersecurity Initiative (CNCI), SEES, and Cyber-Physical Systems. In FY 2011, CNS will:

- Increase support for the Trustworthy Computing program, which includes support for the CNCI, with a focus on new computing and networking security and privacy architectures.

- Contribute to participation in SEES by supporting research to optimize energy-computation performance in computer and network systems and to explore the use of information technology in smart sensing systems that promise to save energy and reduce greenhouse gas emissions.
- Support forward-looking research on Cyber-Physical Systems motivated by grand challenge applications ranging from advanced manufacturing and transportation to healthcare and the environment.
- Continue emphasis on Cyber-enabled Discovery and Innovation (CDI), supporting research leading to a better understanding of how complex systems and networks behave at scale and evolve over time.
- Continue support for the creation, enhancement, and operation of world-class computing research infrastructure that will further CISE research and for education and outreach activities designed to ensure the development of a diverse computing workforce.

As with all three CISE disciplinary divisions, CNS will participate in CISE cross-cutting research programs such as Data-intensive Computing.

DIVISION OF INFORMATION AND INTELLIGENT SYSTEMS (IIS)

$189,740,000
+$26,420,000 / 16.2%

IIS Funding
(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Change Over FY 2010 Estimate Percent
IIS	**$150.93**	**$61.17**	**$163.32**	**$189.74**	**$26.42**	**16.2%**
Research	143.44	60.17	159.92	186.34	26.42	16.5%
Education	7.49	1.00	3.40	3.40	-	-

IIS supports research and education that: develops new knowledge to support people in the design and use of information technology; enhances the capabilities of people and machines to create, discover, and reason by advancing the ability to represent, collect, store, organize, visualize, and communicate data and information; and advances knowledge about how computational systems can perform tasks autonomously, robustly, and flexibly.

IIS research investments support the exploration of novel theories and innovative technologies that advance our understanding of the complex and increasingly coupled relationships between people and computing. Investments in information integration and informatics focus on the processes and technologies involved in creating, managing, visualizing, and understanding diverse digital content as it relates to individuals, groups, organizations, and societies, and as it is hosted on engineered systems ranging from individual devices to globally-distributed systems. IIS also invests in research on artificial intelligence, computer vision, human language research, robotics, machine learning, computational neuroscience, cognitive science, and related areas leading to the computational understanding and modeling of intelligence in complex, realistic contexts.

In general, 55 percent of IIS funding is available for new research grants. The remaining 45 percent is used primarily to fund continuing grants made in previous years.

Factors Influencing the Allocation Across IIS Programs

In FY 2011 the allocation of IIS funds is designed to provide increased support for priority core research for the next generation of information and communications technology. The IIS allocation also targets high-priority research areas such as CTE, CNCI, and SEES. In FY 2011, IIS will:

- Spearhead CISE's participation in CTE through support for research on new modalities of learning including: virtual laboratories and access to remote scientific instruments; the use of mobile and handheld devices, virtual environments, simulations, and serious games in learning; the use of machine learning and data mining on educational data for assessment and learning purposes; the development of social technologies to create and enhance learning communities and support and expand learning's many stakeholders; mobile technologies and new, rich interfaces to facilitate "anytime, anywhere learning;" and the use of affective and assistive technology innovations to tailor learning to individual circumstances.
- Increase support for the Trustworthy Computing program, which includes the Comprehensive National Cybersecurity Initiative, with a focus on research on privacy and usability, reflecting the growing volume of online sensitive information as the public puts more and more of their data "in the cloud", and as electronic health records become a reality.

- Contribute to participation in SEES by supporting research to optimize energy usage through intelligent decision-making for compute- and data-intensive systems.
- Support CDI research, particularly the Data to Knowledge theme, targeting new data technologies that scale to the quantities, speed, dimensionality, and complexity of data that challenges innovation in science and engineering. IIS will also focus on research that enables large-scale collaboration within and across scientific and engineering domains, supporting the Virtual Organizations theme of CDI.
- Continue support for the Social-Computational Systems (SoCS) program, in collaboration with colleagues in the human sciences, to reveal new understanding about the properties that systems of people and computers together possess, and to develop a practical understanding of the purposeful design of systems to facilitate socially intelligent computing.
- Continue support for Collaborative Research in Computational Neuroscience (CRCNS) to make significant advances in the understanding of nervous system function, mechanisms underlying nervous system disorders, and computational strategies used by the nervous system (in collaboration with NIH and other NSF directorates).

As with all three CISE disciplinary divisions, IIS will participate in CISE cross-cutting research, education, and infrastructure programs such as Data-intensive Computing.

DIVISION OF INFORMATION TECHNOLOGY RESEARCH (ITR) $80,740,000
<div align="right">+$0 / 0%</div>

ITR Funding
(Dollars in Millions)

	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY 2010 Estimate Amount	Percent
ITR	**$78.35**	**$40.41**	**$80.74**	**$80.74**	**-**	**-**
Research	78.33	30.41	80.74	80.74	-	-
SLC: Pittsburgh Science of Learning Center for Robust Learning	*-*	*-*	*2.50*	*2.50*	-	-
Education	0.02	-	-	-	-	N/A
Infrastrucuture	-	10.00	-	-	-	N/A

The ITR subactivity provides support for transformative explorations in computer and information science and engineering research and related education activities, emphasizing the funding of high-risk, multi-investigator, often multidisciplinary projects.

In general, 70 percent of the ITR portfolio is available to make new awards. The remaining 30 percent is used primarily to fund continuing grants made in previous years.

Factors Influencing the Allocation Across ITR Programs

In FY 2011 the allocation of ITR funds is designed to:
- Continue support for the Expeditions in Computing program. In planning and implementing *Expeditions*, researchers are encouraged to come together within or across departments or institutions in the identification of compelling, transformative research agendas that promise disruptive innovations in computing and information for many years to come. Funded at levels up to $10 million, *Expeditions* projects represent some of the largest single investments currently made by CISE.
- Continue support to the Pittsburgh Science of Learning Center (SLC) for Robust Learning.
- Provide flexibility for emerging high-priority areas of potentially transformative research.