Inertial Confinement Fusion Ignition and High Yield Campaign

Funding Profile by Subprogram

(dollars in thousands)

	FY 2010 Actual Appropriation	FY 2011 Request	FY 2012 Request
Inertial Confinement Fusion Ignition and High Yield Campaign			
Ignition	106,575	109,506	109,888
Support of Other Stockpile Programs	0	0	0
Diagnostics, Cryogenics, and Experimental Support	72,144	102,649	86,259
Pulsed Power Inertial Confinement Fusion	4,992	5,000	4,997
Joint Program in High Energy Density Laboratory Plasmas	4,000	4,000	9,100
Facility Operations and Target Production	269,775	260,393	266,030
Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**457,486**	**481,548**	**476,274**

Outyear Funding Profile by Subprogram[a]

(dollars in thousands)

	FY 2013	FY 2014	FY 2015	FY 2016
Inertial Confinement Fusion Ignition and High Yield Campaign				
Ignition	74,410	65,000	60,000	55,000
Support of Other Stockpile Programs	35,590	45,000	50,000	55,000
Diagnostics, Cryogenics, and Experimental Support	76,267	70,159	70,517	69,617
Pulsed Power Inertial Confinement Fusion	5,000	5,000	5,000	5,000
Joint Program in High Energy Density Laboratory Plasmas	9,500	9,500	9,500	9,500
Facility Operations and Target Production	275,614	277,009	290,220	300,909
Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**476,381**	**471,668**	**485,237**	**495,026**

Mission

The Inertial Confinement Fusion (ICF) Ignition and High Yield Campaign provides the experimental capabilities and scientific understanding in high-energy density physics necessary to maintain a safe, secure, and reliable nuclear weapons stockpile without underground testing. Science-based weapons assessments and certification requires advanced experimental capabilities that can create and study matter under extreme conditions that approach the high energy density (HED) environments found in a nuclear explosion. The ICF Campaign provides this capability through the development and use of advanced experimental tools and techniques, including state-of-the-art laser and pulsed power facilities. The demonstration of ignition in the laboratory will provide important information to support assessment and certification of the stockpile, and it is the most important component of the ICF

[a] Outyear funding profile does not include adjustments in response to the FY 2013 change in Self-Constructed Asset Pool (overhead rate at Lawrence Livermore National Laboratory). These adjustments will be reflected in the FY 2013 President's Budget.

Campaign and a major goal for National Nuclear Security Administration (NNSA) and the U.S. Department of Energy (DOE).

The ICF Campaign supports the NNSA's Stockpile Stewardship Program (SSP) through three strategic objectives:

- Achieve thermonuclear ignition in the laboratory and develop it as a routine scientific tool to support stockpile stewardship.[a]

- Develop advanced capabilities, including facilities, diagnostics, and experimental methods that can access the HED regimes of extreme temperature, pressure, and density required to assess the nuclear stockpile.

- Maintain the U.S. preeminence in HED science and support broader national science goals.

Virtually all of the energy from a nuclear weapon is generated while it is in the HED state. High energy density physics (HEDP) experiments conducted at ICF facilities are required to validate the advanced theoretical models used to assess and certify the stockpile without nuclear testing. The National Ignition Facility (NIF) extends HEDP experiments to include access to thermonuclear burn conditions in the laboratory, a unique and unprecedented scientific achievement. The NIF, located at the Lawrence Livermore National Laboratory (LLNL), was built to demonstrate thermonuclear ignition in the laboratory. The NIF is a 192-beam, high-energy, high-power laser system capable of delivering up to 1.8 megajoules (MJ) of energy in a pulse of a few nanoseconds duration. The NIF provides NNSA extraordinary opportunities for scientific progress and discovery in the areas of thermonuclear ignition and matter under extreme HED conditions. Creating laboratory conditions of extreme densities and temperatures relevant to HED phenomena occurring in nuclear detonation is one of the most challenging requirements for science-based weapons assessment and certification.

Other advanced HED experimental capabilities within the ICF Campaign include the pulsed power Z-machine at Sandia National Laboratories (SNL) and the Omega Laser Facility at the University of Rochester's Laboratory for Laser Energetics (LLE). The Z-machine was refurbished to provide increased precision, more shot availability, and higher current. These performance levels of the Z-machine are required for weapons materials measurements. The Omega Laser Facility at LLE combines the 60-beam, 30-kilojoule ultraviolet OMEGA compression laser system with the high-energy, short pulse capability of the OMEGA Extended Performance (EP) laser system. The OMEGA EP laser system can be used to produce high energy x-rays for the advanced radiography capability needed for many weapons physics experiments.

The three largest HED facilities, NIF, OMEGA, and Z, are essential components of the SSP infrastructure and are the central tools to investigate thermonuclear ignition, HED weapons issues, and

[a] Thermonuclear ignition is an explosive, self sustained nuclear fusion reaction that once initiated, continues until the fuel is exhausted ("burned") or dispersed. Thermonuclear ignition is often referred to as ignition and thermonuclear burn or fusion ignition. Nuclear fusion reactions are at the core of the processes that power the Sun and other stars. Achieving ignition by compressing and heating deuterium (D) and tritium (T) atoms (i.e. the thermonuclear fuel) to millions of degrees Celsius has never been demonstrated in the laboratory.

basic HED science. The following table shows the distribution of experimental shot opportunities planned for FY 2012 by category of experiments for the three facilities. These are approximate distributions that will be adjusted based on the needs of the SSP and the final distribution is subject to decisions made under the existing facility governance plans.

FY 2012 Planning Assumption for Experimental Shots
by Category for the Major HED Facilities

Category NIF		OMEGA	Z
National Ignition Campaign (NIC)			
Ignition Development	55%	15%	0%
Platform Development	5%	15%	0%
Diagnostic Development	5%	15%	0%
Weapons HEDP	20%	25%	66%
Advanced Fusion Concepts	0%	0%[a]	22%
Basic HED Science Users Programs, and other National Nuclear Security applications	15%	30%	12%

The National Ignition Campaign (NIC) is a multi-site integrated effort focused on achieving thermonuclear ignition in the laboratory and is the largest program element within the FY 2012 ICF Campaign. Its objectives are to perform experiments aimed at achieving ignition on the NIF in FY 2012 and, if ignition is achieved, to develop a reproducible platform for ignition and HED applications by the end of FY 2012. This represents extension of the cryogenic Tritium-Hydrogen-Deuterium (THD) experiments to a full equi-molar mix of Deuterium and Tritium (DT) for ignition experiments. Through FY 2012, the entire effort in the Ignition subprogram and about 75 percent of the Facility Operations and Target Production subprogram is devoted to the NIC. This includes all ignition experimental activity at the NIF, a large ignition preparatory effort at OMEGA, and the development and fabrication of complex ignition targets. Most of the funding in FY 2012 within the Diagnostics, Cryogenics and Experimental Support subprogram is devoted to the NIC. The NIC will transition the NIF to routine facility management and operations by the end of FY 2012. The participants in the NIC are LLNL, LLE, Los Alamos National Laboratory (LANL), SNL, and General Atomics (GA).

In response to a Government Accountability Office (GAO) review in FY 2010, NNSA has formed a NIC Review Panel to analyze the progress of the NIC and to advise NNSA and the NIC partners on the scientific and technical challenges facing the NIC.

Early experimental work at the NIF has focused on assessing uncertainties in the physics understanding of ignition and optimizing or “tuning” the important parameters (e.g., laser beam pointing and wavelengths). This provided information such as the coupling efficiency of the laser energy to the target and the ablation rate and symmetry of the capsule as the implosion proceeds. The first layered cryogenic capsule implosion occurred in September 2010 using a mixture of tritium-hydrogen-deuterium fuel. The first ignition attempt using a 50:50 mixture of deuterium-tritium is anticipated in

[a] In FY 2012, Advanced Fusion Concepts experimental proposals continue to compete for shot time on OMEGA through the Basic Science Users Programs.

early FY 2012. Experiments that vary the important parameters and obtain data to validate physics models in the burning plasma regime will follow. These efforts will further the understanding of ignition and allow a reproducible ignition platform to be optimized for SSP applications.

The ICF Program is using experience acquired in the initial NIF experiments and those on OMEGA and Z to refine its plans and the logistics required to implement them. In some cases, installation and certification of key equipment on the NIF during FY 2010 took longer than originally anticipated. In August 2010, ignition tuning and diagnostic calibration campaigns resumed with laser energies up to 1.2 MJ in full-scale ignition hohlraums, including the first layered cryogenic capsule implosion experiment on the NIF on September 29, 2010. The research program is responding rapidly to the results obtained to modify the target, diagnostics, and laser parameters to improve the implosion performance.

Ignition and thermonuclear burn will allow routine access to physical regimes hitherto unavailable in the laboratory. The demonstration of thermonuclear ignition will be of major importance for DOE's energy and fundamental science missions.

Benefits

Each of the 6 subprograms within the ICF Campaign makes unique contributions to the Government Performance and Results Act (GPRA) Unit Program Number 39.

- The *Ignition* subprogram supports research to achieve thermonuclear fusion in the laboratory and includes advanced theoretical modeling, systems engineering, target and experimental design, and experimental execution.

- The *Support of Other Stockpile Programs* subprogram develops and uses HED/ICF experimental capabilities and personnel to resolve important stockpile questions in cooperation with other components of the Office of Stockpile Stewardship. Consistent with NNSA's priorities, the request for funding in this subprogram is delayed to focus on the highest priority, achieving ignition on the NIF. As indicated in the Outyear Funding Profile by Subprogram, funding will be requested in FY 2013, after the completion of the NIC. This subprogram was used extensively through FY 2007 until the ICF focus was applied specifically to the quest for ignition.

- The *Diagnostics, Cryogenics, and Experimental Support* subprogram supports the advanced technological development needed for the first ignition experiments on the NIF and for the execution of weapons-based HED experiments. Efforts include the design, development, and engineering of a complex array of diagnostic and measurement systems, including the NIF cryogenic target system. After completion of the NIC, there will be continued investments in diagnostics to ensure the measurements needed to meet QMU-derived requirements.

- The *Pulsed Power Inertial Confinement Fusion subprogr*am supports the assessment of pulsed power as a means to achieve thermonuclear fusion in the laboratory, including computational target design, experiments, and experimental infrastructure.

- The *Joint Program in High Energy Density Laboratory Plasmas (HEDLP)* subprogram funds academic programs through a joint solicitation with DOE's Office of Science to steward the study of laboratory HED plasma physics. This includes the HED physics activities and the National Laser Users' Facil*ity (NLUF) program at LLE.*

- *The Facility Operations and Target Production* subprogram supports safe and secure experimental operations at the NIF, OMEGA, and Z, as well as activities in target research, development, and fabrication.

The ICF Campaign shares performance measures and joint milestones with the Science Campaign, providing experimental data required to validate physics models that are the basis of weapons simulation design codes. These codes along with the advanced, high-performance computing platforms developed within the Advanced Simulation and Computing (ASC) Campaign are used for the annual assessment and certification of the U.S. nuclear stockpile. The ASC Campaign provides advanced simulation codes and computer platforms for analyzing ignition designs and high yields requirements and for simulating complex target designs. The ICF, Science, and ASC Campaigns are all part of the Office of Stockpile Stewardship in Defense Programs and coordination among the Campaigns is achieved, in part, through the Predictive Capability Framework (PCF) that provides planning, prioritization, scheduling, and linkage of the major weapons assessment activities. The data analysis methodologies, models and simulation codes developed by the Office of Stockpile Stewardship support the analysis performed to meet Directed Stockpile Work (DSW) commitments, including maintenance, research and development, understanding the impact of aging weapons systems, closing Significant Finding Investigations (SFIs) identified from surveillance or other sources, and certifying refurbished devices resulting from DSW's Life Extension Program (LEP).

The ICF Campaign and the Office of Fusion Energy Sciences sponsor the Joint Program in High Energy Laboratory Plasmas (JPHEDLP). The ICF capabilities also serve DOE's missions to develop advanced energy systems (Office of Fusion Energy Sciences), to further our understanding of fundamental science (Office of Basic Energy Sciences), and to maintain the world's preeminent HED workforce.

Annual Performance Results and Targets

The Department is in the process of updating its strategic plan, and has been actively engaging stakeholders including Congress. The draft strategic plan is being released for public comment concurrent with this budget submission, with the expectation of official publication this spring. The draft plan and FY 2012 budget are consistent and aligned. Updated measures will be released at a later date and available at the following link http://www.mbe.doe.gov/budget/12budget/index.htm.

FY 2010 Accomplishments

National Ignition Campaign (NIC)

- Successfully demonstrated the ability to drive and symmetrically compress a surrogate germanium-doped plastic (CH-Ge) fuel capsule in a hohlraum at point-design scale with energies up to 1.2 MJ.
- Demonstrated hohlraum x-ray drive temperatures of about 300 electron volts (eV) during initial NIC experiments, meeting the requirements for ignition.
- Demonstrated the complex integration of the subsystems required for an ignition campaign, including a target physics design, the laser, target fabrication, cryogenic fuel layering and target positioning, target diagnostics, control and data systems, tritium handling, and personnel and environmental protections systems by performing the first integrated cryo-layered capsule experiment on the NIF,

with 1 MJ of laser energy imploding a capsule containing a mixture of THD (tritium-hydrogen-deuterium) fuel.

- Produced areal densities of 0.3 grams per square centimeter during layered cryogenic deuterium-tritium (DT) implosion experiments on OMEGA, the highest value measured in the laboratory before the first NIF THD implosion. This is an important precursor to demonstration of ignition on the NIF.
- Formed a NIC Review Panel to review the progress of the NIC via individual member reports and to advise NNSA and the NIC partners on ignition activities through the end of the NIC in FY 2012.

Diagnostic Development and Installation

- Constructed and calibrated the first set of ignition nuclear diagnostics. This included the LLE-developed Neutron Time of Flight systems that will be vital to the first ignition experiments.
- Installed the Magnetic Recoil Spectrometer (MRS) on the NIF. Conceived by the Massachusetts Institute of Technology (MIT), the MRS measures the areal density in cryogenic target implosions. The LLE led the design and construction of this important diagnostic in collaboration with LLNL and MIT.
- Expanded role of SNL in nuclear and x-ray diagnostics for the NIF. The total DT neutron yield diagnostic was built and installed and used on low-fusion-yield experiments during FY 2010.
- Prototyped the two-frame neutron imaging system for the NIF. Among other roles, this collaborative diagnostic effort, led by LANL, will provide key imaging of down scattered neutrons in ignition and near-ignition implosions.
- Designed and built a fiducial laser system for the NIF that provides an on-shot temporal calibration of a diagnostic used to measure implosion velocity with a precision of 2 percent (LLE lead).
- Performed polar drive diagnostic commissioning shots on the NIF. Polar drive produces predictable high neutron yield shots that are vital in the development and calibration of nuclear diagnostics at the NIF.
- Ensured that the initial ignition diagnostics are available as required and provided important new ideas for advanced diagnostics through a LLNL-led series of international workshops.

Target Development and Production

- Fabricated and delivered by GA, more than 5,000 fully characterized target components, including many of the critical components and sub-assemblies of first-of-a-kind gas filled cryogenic targets shot during the energetics campaign on the NIF.
- Developed a new polishing/ablation process for producing ultra-smooth plastic CH-Ge capsules. A collaborative effort between GA and LLNL, the new process provides nearly 10x tighter specifications for surface finish.

National Ignition Facility (NIF)

- Made significant progress in preparing the NIF and associated systems to support ignition experiments, including installing safety systems and shielding to handle high neutron yields, tritium and other hazardous materials. Management Prestart Reviews were conducted for operation with hazardous materials and neutron production.

- Improved the precision, overall performance, and reliability of the NIF laser systems through tuning over several hundred shots at high energy. These shots were used to recalibrate beam diagnostics and refine the modeling parameters for both the injection and main laser systems as well as the final optics systems for energy and pulse shape. Other laser shots were used to improve pointing accuracy, validate focus at target chamber center, and develop strategies for managing its configurations.
- Installed and commissioned an ignition cryogenic target positioner on the NIF.
- Commenced experiments for NIF users, including, radiation transport HED experiments in support of the SSP, the first University Use Program experiments studying the astrophysics of super novae by the University of Michigan, and the first radiation effects experiments.
- Received eighty-six proposals in response to a solicitation for HED science experiments on the NIF. The proposals were reviewed by LLNL's Science on NIF Review Committee.

Omega Laser Facility

- Performed 1,707 target shots at the Omega Laser Facility in FY 2010 that were rated as effective in producing the data desired by the users (>95% of all shots). Users included scientists from LANL, LLE, LLNL, and various universities and companies through the National Laser Users' Facility (NLUF) Program, as well as the United Kingdom's Atomic Weapons Establishment and France's Commissariat a l'Energie Atomique.
- Hosted by LLE, the second Omega Laser Facility User's Group (OLUG) Workshop, which was attended by 115 scientists, including 45 students and postdocs, representing NNSA, 31 universities, laboratories, and private industry, with representation from five different countries.
- Installed new diagnostics on the OMEGA Extended Performance (EP) laser system to measure the intensity contrast of the laser pulse on each shot. The intensity contrast is the ratio of the peak intensity to the intensity that hits the target before the main pulse.
- Designed a fourth harmonic probe beam for OMEGA's EP laser system. The probe will be used to measure the characteristics of the plasmas created by the laser system and the details of high intensity petawatt laser interactions with targets.

Z Facility

- Conducted more than 130 experiments on Z in support of the ICF, Science, and Engineering Campaigns, including a few laboratory astrophysics experiments. Users, determined by a formal proposal based process, included scientists at LANL, LLNL, SNL, the Atomic Weapons Establishment (United Kingdom), and several universities (University of Texas at Austin, Ohio State University, and University of Nevada, Reno).
- Developed a 25-kilovolt x-ray backlighting source using the Z-Petawatt laser. The backlighter will be used to diagnose plasma conditions within imploding targets on Z.
- Prepared Z for high-priority experiments to obtain plutonium data on the facility. New hardware was designed, procured, installed, and tested and the operations crew was trained on procedures and use of the new equipment to ensure safe operation with minimal risk. A series of non-plutonium tests was conducted to requalify the containment system components to make engineering improvements and to confirm the readiness of Z for experiments. This effort involved both the ICF and Science Campaigns and relied on considerable expertise from LANL for plutonium operations.

- Met the requirement for January 2011 tests of an important stockpile component by producing, in a joint effort with Science Campaign, 85 kilojoules (kJ) of stainless steel K-shell emission on Z.

Pulsed Power ICF

- Obtained spectroscopic data of the temperature and density conditions in pulsed power ICF targets on Z and compared stagnating plasma conditions with computer simulations.
- Completed a series of experiments on Z to evaluate an advanced fusion concept that increases energy coupling efficiency by using magnetic pressure to compress the fuel directly through and compared the data with simulations.
- Performed the first fully kinetic, collisional, electromagnetic simulations of the time evolution of imploding z-pinch fusion plasma (the first simulations of this type for any fusion plasma).

Joint Program in High Energy Density Laboratory Plasmas (HEDLP)

- Conducted the solicitation of the National Laser Users' Facility (NLUF) Program for access to the Omega Laser Facility in FY 2011 and FY 2012.
- Studied the evolution of astrophysical jets by directly comparing new telescope observations with experiments performed on the OMEGA laser system. The results were reported in the *Astrophysical Journal* by a team led by P. Hartigan of Rice University. This is the first time that new astrophysical images from the Hubble Space Telescope were obtained for the express purpose of comparing to laboratory experimental data.
- Achieved the highest positron production rate in a laboratory setting to date. The experiment conducted by H. Chen of LLNL used a 1 kJ, 10 picosecond OMEGA EP laser pulse incident on a thick gold target. Approximately 10^{12} positrons were detected in a nearly mono-energetic 20 mega electron volts (MeV) beam emitted from the rear side of the target.
- Published in *Science* (C.K. Li, MIT) the results of an experiment probing x-ray–driven implosions with charged particles. Three types of spontaneous electric fields were discovered with time-gated proton radiographic imaging and spectrally resolved proton self-emission, providing insight into x-ray–driven implosions.

Major Outyear Priorities and Assumptions

The outyear requirements for the ICF Campaign total $1,928,312,000 for FY 2013 through FY 2016. The achievement of ignition and thermonuclear burn and its application to the major unresolved weapons physics issues will remain the highest priority of the ICF Campaign. Once the NIC has successfully achieved ignition and thermonuclear burn in the laboratory, subsequent experiments will develop a reproducible ignition platform to address important weapons physics questions.

One of the objectives of the NIC is to transition the NIF to routine operations for ignition and other HED experiments in support of the SSP by the end of FY 2012. Capabilities will include: data systems supporting experimental operations; optics and targets management systems; target production capability for the baseline ignition platform and some HED targets for SSP experiments; a second operational cryogenic target positioner; a core set of optical, x-ray, neutron, and radiographic diagnostics sufficient to support initial ignition, HED, and other user applications during routine facility operations; the ability to support classified operations; and, continuous phase plates (CPPs) required for the ignition experiments and the manufacturing capability to develop and fabricate additional CPPs. Beginning in

FY 2013, a significant portion of the Program effort will be devoted to using HED/ICF tools, including ignition conditions and methods to address stockpile assessment and certification issues. This will include work in materials dynamics, plutonium equation-of-state and constitutive properties, hydrodynamics, x-ray opacities, and understanding the boost process. This work requires an increasingly sophisticated array of diagnostics, including those that can operate in the ignition or near-ignition environment. These diagnostics must be developed to take full advantage of NIF ignition by obtaining the data required to address stockpile certification issues.

To plan for this transition and to coordinate the weapons work on the three HED facilities, the Office of Stockpile Stewardship formed a new planning body, the HED Council. In FY 2010, the HED Council oversaw development of a three year implementation plan describing the program of HED physics experiments required to satisfy critical Stockpile Stewardship needs. A major goal of the three-year plan is to provide for the transition of the NIF to principal use for supporting Stockpile Stewardship. By 2013, approximately 65 percent of available shots on the NIF are planned to address specific Stockpile Stewardship needs.

The ICF Campaign will continue to fund the operations of its HED physics capabilities, both facilities and technical expertise, to support current and future needs of the NNSA's national security mission. These needs may include advanced ignition concepts such as fast ignition or various forms of direct drive or other HED capabilities. Changes in LLNL's Self-Constructed Asset Pool rate may require NNSA to balance funding levels between ICF and other Programs. Basic HED research may expand in response to various priorities, such as energy initiatives. Following the achievement of thermonuclear ignition, the NNSA will reevaluate the relative importance of these potential missions and the roles of the various ICF Campaign program elements and facilities to meet national needs and priorities.

Detailed Justification

	(dollars in thousands)		
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request
Ignition	**106,575**	**109,506**	**109,888**

This subprogram is the central focus of the effort to demonstrate thermonuclear ignition in the laboratory and develop its use to address key weapons issues. It includes experimental programs on the NIF, OMEGA, and Z to understand and diagnose ignition conditions, experimental design, the development of specific, experimental methods focused on achieving ignition and systems engineering improvements. This effort is supported by detailed theoretical designs and simulations (in 2- and 3-dimensions) of the performance of ignition targets. Ignition target design is closely coupled with the ASC and the Science Campaign.

The FY 2012 effort is part of the National Ignition Campaign. In FY 2011, the NIC will perform a series of experiments to tune the ignition target design and install and qualify the target diagnostics required for ignition, taking into account the results of the initial experiments performed in FY 2009 and FY 2010. In the first half of FY 2012, the NIC will attempt to compress, implode, and ignite a layered 50:50 deuterium-tritium fueled capsule with a ~1.3 megajoule energy NIF pulse based upon the results of the tuning campaigns. After the results of the initial ignition attempt are determined, the NIC will refine the experimental tuning campaigns, including experiments with tritium-rich, hydrogen, and deuterium fuel (THD) to optimize the performance of 50:50 deuterium-tritium fueled capsule implosions with the goal of achieving ignition and demonstrating a reliable and repeatable ignition platform with as large a performance margin as possible.

If the first ignition attempt is successful, tuning campaigns will be used to develop a robust ignition platform; however if the first attempt does not achieve ignition, tuning campaigns will be used to refine the laser and target performance to demonstrate ignition and subsequently to develop a robust ignition platform. The results of the FY 2010/2011 tuning campaigns and the FY 2012 initial ignition attempt will provide guidance for the subsequent tuning campaigns. The tuning campaigns optimize the individual components that govern the ignition physics. These components include hohlraum energetics, symmetry, and shock timing. The level of x-ray radiation that drives the target, control of laser plasma instabilities, and hot electron preheating are part of the energetics campaign. The symmetry campaign sets the laser beam pointing, relative power, relative wavelength, and hohlraum geometry to generate a spherically symmetric implosion. The shock timing campaign tunes the laser pulse shape and x-ray drive history to launch an appropriately timed series of shock waves that compress the target as required for ignition. The THD implosions measure the integrated performance of layered cryogenic capsule implosions to verify the results of the individual tuning campaigns. Other physics issues are tuned in smaller campaigns.

The first three parts of the tuning campaigns are somewhat interdependent and so iteration among them and the results of the THD implosions are required to verify the tuning. After

	(dollars in thousands)		
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request

verification, additional 50:50 deuterium-tritium implosions will be carried out to achieve and optimize ignition. The detailed plan will be updated using the results of prior campaigns.

An important component of the achievement of the goals of the NIC will be ongoing support experiments at OMEGA. Crucial operations include re-calibration, tuning, and adjustment of diagnostics and the development of new or refined experimental techniques and diagnostics. Research on the development of the Polar Drive ignition alternative for the NIF will continue on OMEGA. This will include Polar Drive cryogenic target implosions and the validation of the Multi-FM beam smoothing technique.

The Ignition subprogram will closely collaborate with the Science Campaign effort to perform vital HED (non-ignition) weapons physics experiments on the NIF and OMEGA in FY 2012.

Diagnostics, Cryogenics, and Experimental Support	**72,144**	**102,649**	**86,259**

This subprogram develops specialized technologies needed for ignition and HED experiments on ICF facilities. It includes the design and engineering of a complex array of diagnostic and measurement systems and the associated information technology subsystems needed for data acquisition, storage, retrieval, visualization, and analysis. The data generated will be used to tune the ignition design and to provide key information required by other SSP experiments. Installation and calibration of the diagnostic systems required for the achievement of ignition on the NIF will peak in FY 2011.

In FY 2012, the request will continue to support stockpile stewardship questions by developing advanced diagnostics that can operate in the harsh environment created by an igniting target, necessary. The advanced diagnostic effort will focus on incorporating new techniques as they are developed and adding new capabilities as required. The harsh environment created by an igniting target will require advanced diagnostics that can operate in very high neutron and x-ray fluxes. These important tools are required on a schedule specified by certification and assessment plans. Long lead times are required for the design, development, fabrication, installation and activation of these diagnostics that are needed starting in FY 2013. These diagnostics must be developed to take full advantage of NIF ignition and other HED facility capabilities by obtaining the data required to address stockpile certification issues. Experimental concepts will be tested on the Omega Laser Facility.

The Diagnostics, Cryogenics and Experimental Support subprogram includes design and construction of the NIF cryogenic target system. This effort will also peak in FY 2011 but continue in FY 2012 to address a very complex experimental system that is required to produce a precise frozen layer of deuterium-tritium nuclear fuel on the inner wall of an ignition capsule.

	(dollars in thousands)		
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request

Other FY 2012 activities include: the development and activation of optical systems required to produce the spatial beam smoothing needed in ignition experiments and subsequent weapons physics campaigns, and integration and experimental commissioning of the NIF target area.

Pulsed Power Inertial Confinement Fusion	**4,992**	**5,000**	**4,997**

This subprogram funds computational target design, experiments, and experimental infrastructure to assess pulsed power as a means to achieve thermonuclear fusion in the laboratory. In FY 2012, activities will continue to focus on using the new diagnostics (such as neutron and x-ray imaging) to demonstrate consistent fusion plasma conditions that can be used for a variety of applications. Magnetic implosions that directly drive the target will remain a focus of the research activities in FY 2012.

Joint Program in High Energy Density Laboratory Plasmas	**4,000**	**4,000**	**9,100**

High Energy Density Laboratory Plasmas (HEDLP) is a joint program with the DOE's Office of Science to support basic high energy density physics research. This subprogram provides support for external users at the Omega Laser Facility through the National Laser Users' Facility (NLUF) Program and a joint solicitation for HEDLP research to be performed at universities and DOE laboratories. It includes some of the HED-related Stockpile Stewardship Academic Alliances funding and other ICF funded university programs.

In FY 2012, 12-30 percent of the NIF, OMEGA, and Z facility time will be devoted to basic HED science experiments. Many of the researchers who carry out this work are from Universities and receive funding through the Joint program. For example, eleven university-based research teams will perform experiments on the Omega Laser Facility through NLUF, in research areas such as laboratory astrophysics, properties of materials under extreme conditions, and high intensity laser-matter interactions. This supports the intellectual vitality of the program and the pipeline of future graduates available to be recruited by NNSA laboratories.

Facility Operations and Target Production	**269,775**	**260,393**	**266,030**

This subprogram supports operations of ICF facilities including NIF, OMEGA, and Z, in a safe and secure manner, and supports fabrication of the very sophisticated targets required for ignition and ignition-related weapons physics experiments.

More than 300 shots are planned on the NIF in FY 2012 and there will be a continuing strong requirement for ICF and SSP work on the OMEGA and Z facilities. It is anticipated that there will be more than 1,500 shots on the Omega Laser Facility and more than 150 on the Z facility.

	(dollars in thousands)		
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request

Accomplishment of the full agenda of weapons SSP deliverables is only possible with these 3 facilities working together. Funds to support Z experiments are also requested in the Science Campaign budget. Improved efficiency of operations at the NIF is anticipated as experience is gained in operating the facility. In FY 2012, all NNSA HED facilities will move towards operation as user facilities. One responsibility of a user facility is to be responsive to user requests for enhanced facility performance and capability. This subprogram supports capability enhancement in response to user requests.

Other activities carried out in the Facilities Operations and Target Production subprogram include: (1) support for shot directors and operational staff at all the NNSA facilities, (2) maintenance and ongoing facility improvements, (3) support staff for the final optics inspections system and its associated optics conditioning, initiation and mitigation processes to increase the lifetime of optics exposed to ultraviolet light at NIF, (4) operation of the Electra Laser at the Naval Research Laboratory to support future Inertial Fusion Energy (IFE) research, depending on the results of the National Academy of Sciences ongoing IFE review, and (5) at Headquarters, funding for support for the Campaign, including external reviews.

Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**457,486**	**481,548**	**476,274**

Explanation of Funding Changes

	FY 2012 vs. FY 2011 Request ($000)
Ignition	
The funding increase supports the intense activity to achieve ignition and the development of a robust NIF ignition platform consistent with the current version of the NIC Execution Plan. The increase supports experiments on OMEGA that are essential to this effort. This activity includes real-time experimental data analysis and theoretical interpretation.	**+382**
Diagnostics, Cryogenics, and Experimental Support	
The decrease is consistent with NNSA's plan for a one-time increase in FY 2011 to prioritize diagnostic installation and activation at the NIF to achieve ignition. In FY 2012 and beyond, the focus will be on incorporating new techniques and adding new capabilities as required at a slightly reduced and targeted pace for diagnostic installation and activation at the NIF.	**-16,390**
Pulsed Power Inertial Confinement Fusion	
No funding change.	**-3**
Joint Program in High Energy Density Laboratory Plasmas	
The increase provides an additional $1,600,000 for the next 3-year cycle of the solicitation for the Joint Program and $3,500,000 for a cooperative agreement with the University of Nevada, Reno into this budget element.	**+5,100**
Facility Operations and Target Production	
The increase funds operations and ICF target research and development that support efforts on inertial fusion performed in cooperation with the DOE Office of Science.	**+5,637**

Total Funding Change, Inertial Confinement Fusion Ignition and High Yield Campaign -5,274

Capital Operating Expenses and Construction Summary

Capital Operating Expenses[a]

	(dollars in thousands)		
	FY 2010 Actual Appropriation	FY 2011 Request	FY 2012 Request
General Plant Projects	20	20	21
Capital Equipment	5,515	5,636	5,760
Total, Capital Operating Expenses	**5,535**	**5,656**	**5,781**

Outyear Capital Operating Expenses

	(dollars in thousands)			
	FY 2013	FY 2014	FY 2015	FY 2016
General Plant Projects	21	22	22	23
Capital Equipment	5,887	6,017	6,149	6,284
Total, Capital Operating Expenses	**5,908**	**6,039**	**6,171**	**6,307**

[a] Funds are appropriated for Operations and Maintenance, which includes operating expenses, capital equipment and general plant projects. The program no longer budgets separately for capital equipment and general plant projects. Funding shown reflects estimates based on actual FY 2010 obligations.

Advanced Simulation and Computing Campaign

Funding Schedule by Subprogram

(dollars in thousands)

	FY 2010 Actual Appropriation	FY 2011 Request	FY 2012 Request
Advanced Simulation and Computing Campaign			
Integrated Codes	140,882	165,947	160,945
Physics and Engineering Models	61,189	62,798	69,890
Verification and Validation	50,882	54,781	57,073
Computational Systems and Software Environment	157,466	175,833	181,178
Facility Operations and User Support	155,650	156,389	159,859
Total, Advanced Simulation and Computing Campaign	**566,069**	**615,748**	**628,945**

Outyear Funding Profile by Subprogram

(dollars in thousands)

	FY 2013	FY 2014	FY 2015	FY 2016
Advanced Simulation and Computing Campaign				
Integrated Codes	160,170	163,287	167,194	171,377
Physics and Engineering Models	69,567	70,922	72,617	74,434
Verification and Validation	56,794	57,899	59,284	60,767
Computational Systems and Software Environment	170,462	173,782	177,937	182,389
Facility Operations and User Support	159,111	162,210	166,088	170,243
Total, Advanced Simulation and Computing Campaign	**616,104**	**628,100**	**643,120**	**659,210**

Mission

The Advanced Simulation and Computing (ASC) Campaign provides leading edge, high-end simulation capabilities to meet the requirements of weapons assessment and certification, including weapon codes, weapons science, computing platforms, and supporting infrastructure. The ASC Campaign serves as the computational surrogate for nuclear testing to determine weapon behavior. The ASC Campaign underpins the Annual Assessment of the stockpile, and is an integrating element of the Predictive Capability Framework.

The ASC simulations are central to our national security and play an essential role in simulating device performance to ensure that systems in the stockpile meet all specifications in the "stockpile-to-target sequence." Our ability to model the extraordinary complexity of nuclear weapons systems is essential to establishing confidence in the performance of our aging stockpile. In the absence of testing, only through ASC simulations and above ground experiments can the National Nuclear Security Administration (NNSA) determine the effects of changes to the systems on which deterrence relies.

The ASC tools are also used to address areas of national security beyond the U.S. nuclear stockpile. Through coordination with other government agencies, ASC plays an important role in supporting nonproliferation, emergency response, nuclear forensics and attribution activities. Resources have been used to characterize special nuclear material (SNM) and improvised devices. There is a growing effort to enhance the capabilities of these tools to enable the identification of a perpetrator or supporting states through forensic analysis of post-explosion radionuclide debris. The ASC simulation capabilities have been used by Department of Homeland Security (DHS) to assess various mitigation strategies.

Benefits
The ASC Campaign is comprised of five subprograms that support activities in the areas of weapon codes, weapon science, computational infrastructure, and computing center operations. Each subprogram is a unique contributor to Governmental Performance and Results Act (GPRA) Unit Program Number 40.

The ASC Program's primary customer is Directed Stockpile Work (DSW). ASC codes and computing infrastructure support DSW work such as design, analysis, baselining, and Significant Findings Investigations (SFI) resolution. Stockpile work, science and simulation are bound together through the Predictive Capability Framework (PCF). In the context of simulation, predictive capability can best be understood in contrast to baseline models that were carefully calibrated to the underground test results and which employed sophisticated approaches to interpolation within the underground data or minimal extrapolation from tested regimes. As long as the calculated configurations were close to the as-tested regime, one could be confident in the results. When refurbishment and aging are also included, the simulations must be able to provide accurate results for weapon behavior away from the baseline. NNSA must use models and numerical representations of the physics and engineering that most accurately capture the reality of this extended space.

The PCF is a scientific roadmap that captures the technical underpinnings needed to deliver a predictive capability to the nuclear security enterprise. Participants in the PCF include Science Campaign, ASC, Engineering Campaign, DSW Research & Development, and Inertial Confinement Fusion Ignition and High Yield Campaign. The PCF identifies a list of long-term goals that link the progress in the predictive capabilities to the progress in the five enabling capabilities, four of which (theory/model capabilities, code/algorithm capabilities, computational facilities, and Verification & Validation (V&V) capabilities) are developed by the ASC program. With the completion of major new experimental facilities and increased utilization of peta-scale level computing, the PCF launches a new phase of science-based stockpile stewardship aligned to the challenges of an aging and changing stockpile.

Annual Performance Results and Targets
The Department is in the process of updating its strategic plan, and has been actively engaging stakeholders including Congress. The draft strategic plan is being released for public comment concurrent with this budget submission, with the expectation of official publication this spring. The draft plan and FY 2012 budget are consistent and aligned. Updated measures will be released at a later date and available at the following link http://www.mbe.doe.gov/budget/12budget/index.htm.

FY 2010 Accomplishments

Predictive Capability

- Sandia National Laboratories (SNL) released version 4.16 of its SIERRA engineering mechanics simulation code, which incorporates a consolidated thermal-fluid-aero simulation capability and new capabilities in failure modeling, contact and implicit-explicit algorithm interoperability. SIERRA 4.16 has also made significant improvements in robustness and is now deployed throughout the nuclear security enterprise as well as at the United Kingdom's Atomic Weapons Establishment and in major Department of Defense (DoD) installations.

- Sandia released Trilinos version 10.0, which will provide significant improvement for solvers and massively parallel infrastructure needs for engineering mechanics and simulations. The new release includes new infrastructure for uncertainty quantification (UQ) and for coupling to DAKOTA, SNL's UQ and optimization framework.
- Los Alamos National Laboratory (LANL) resolved a major long-standing uncertainty in weapons physics simulation known as the "energy balance" problem. A broad range of experimental data, from both modern experimental facilities and the legacy underground test database, were used to validate the simulation capabilities of the ASC codes to represent the applicable physics with sufficient fidelity.
- Launched the Predictive Capability Assessment Project (PCAP) to develop metrics for quantitatively assessing improvement in predictive accuracy of ASC simulation tools in coordination with the Science Campaigns and DSW R&D.
- Commenced a collaborative project between LANL and the Lawrence Livermore National Laboratory (LLNL) to better determine the plutonium fission neutron spectrum, via new measurements at the Los Alamos Neutron Science Center (LANSCE) accelerator and improved theory predictions that will have a significant impact on our understanding of weapons criticality, and is of importance also to the broader nuclear energy community.
- Developed a new multi-scale strength model for Tantalum and implemented into ASC codes at LLNL.

Simulation for the Stockpile

- Sandia's RAMSES code suite was used for the first-ever blind comparison to experimental data of the predicted response of a weapon-related silicon circuit in a short-pulsed neutron environment. Important features of the response, including non-linear threshold effects, were predicted with uncertainty quantification.
- Completed a comprehensive Qualification of Margins and Uncertainties (QMU) assessment of thermal safety for the B61 stockpile system. A Sandia study team integrated multiple failure modes within a probabilistic network framework to provide a system level assessment of probability of loss of assured safety for a thermal safety scenario.
- A LANL ASC simulation code was used to quickly investigate the anomalous results from a DARHT hydro test in December 2009 which disagreed with the predictions of several ASC simulation codes.
- Demonstrated that a physics algorithm, developed by a team of experienced weapons designers working on the Roadrunner supercomputer at LANL, optimized to take full advantage of the IBM cell processors, was uniformly about ten times faster than the standard algorithm on real problems of interest. This enabled the Roadrunner supercomputer at LANL to preform large-scale weapon physics calculations that will continue to provide unprecedented insight into the performance of the nuclear explosives package.
- Used high resolution 3-D simulations of the B83 at LLNL to conclude that an effect encountered in stockpile to target sequence operation resulted in a minimal impact on yield.

High-Performance Computer Platforms

- Awarded the contract to deliver the next tri-lab capability supercomputer, Cielo, to Cray, Inc. The design, procurement and deployment of Cielo were accomplished by a joint partnership between

LANL and SNL. Cielo will be more than ten times as powerful as the Purple machine which it replaces as the tri-lab capability computing platform.

- LANL's Roadrunner supercomputer is now accredited for full operations in the classified computing environment.
- Performed advanced application preparation work at LLNL for Sequoia and demonstrated capabilities through science runs before transition of Dawn to classified computing. Deployed and supported the Sequoia hardware environment including file systems, archival storage, visualization clusters, and networking infrastructure, as well as the software environment.
- Planned for the next capacity tri-lab procurement and common computing software environment and supported the systems software and tools on the current systems.

ASC Collaborations

- Red Storm architecture team was selected as a winner of a Federal Laboratories Consortium's 2010 Award for Excellence in Technology Transfer.
- Formalized collaboration on a joint technology roadmap and strategy for reaching exascale computing in the next ten years between SNL, LANL, and Oak Ridge National Laboratory (ORNL).
- In a collaborative effort with DOE's Office of Science established the six-lab Exascale Steering Committee, consisting of LANL, LLNL, SNL, ORNL, Argonne and Lawrence Berkeley national laboratories, for the purpose of identifying exascale applications and technology for DOE missions and to scope out the tenets of an Exascale Initiative. Multiple Scientific Grand Challenge Workshops were held one on national security, as well as workshops to focus on major technology and architecture challenges and cross-cutting technologies.

Major Outyear Priorities and Assumptions

The outyear projections for the Advanced Simulation and Computing (ASC) Campaign total $2,546,534,000 for FY 2013 through FY 2016. Simulation will continue to be pervasive throughout the nuclear weapons enterprise. ASC will continue to support annual assessments, certification, and SFI resolution through provision of simulation codes and high-performance computing resources. The laboratories will accelerate the application of verification and validation activities into software development and simulation; we will continue efforts to move the existing culture toward a more rigorous approach to certification, one that relies more heavily on explicit incorporation of margins and performance uncertainties. Final deliveries of existing platforms procurements will take place. The ASC budget shifts throughout the outyears are largely the result of shifts in the Integrated Codes subprogram that reflect marginal changes in work involving specialized lab code projects that addresses the improvement of weapons system simulations and corresponding peer review.

The age of our stockpiled weapons and the dearth of designers with test experience in the nuclear security enterprise make it a National imperative that we maintain the technical expertise, apply scientific rigor to the code development process, and understand the physical processes that are being modeled. The out-year request will continue to address the critical skills at the National Laboratories that provide foundational simulation capabilities needed for future Life Extension Programs, significant findings investigations and a Comprehensive Test Ban Treaty environment.

Detailed Justification

(dollars in thousands)	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request
Integrated Codes (IC)	**140,882**	**165,947**	**160,945**

This subprogram primarily addresses the improvement of weapons system simulations to predict, with reduced uncertainties, the behavior of devices in the stockpile. It also enables analysis and design for future warhead modifications and stockpile options. The products of this subprogram are the large-scale integrated simulation codes that are needed for Stockpile Stewardship Program (SSP) maintenance, the Life Extension Programs (LEP), Significant Finding Investigation (SFI) resolution, and a host of related requirements, including dismantlements. Specifics include continued research into engineering code applications and manufacturing process codes; investigation and development of future non-nuclear replacement components; algorithms, computational methods and software architectures; advancement of key basic research initiatives; explorations into emerging code technologies and methodologies; and a small amount of maintenance of the legacy codes. This subprogram also includes university partnerships that foster continued collaborations such as the Predictive Science Academic Alliances Program and Computational Science Graduate Fellowship (CSGF) Program. The functional and performance requirements of this subprogram are established by designers, analysts, and code developers. It also relies upon the Physics and Engineering Models subprogram for the development of new models to be implemented into the modern codes. The subprogram also engages the Verification and Validation (V&V) subprogram in assessing the degree of reliability and level of uncertainty associated with the outputs from the codes.

The FY 2012 activities include the following: develop coupled multi-physics capabilities for device simulation based on scientific representation of device behavior with a reduced reliance on calibration to underground test data; produce more accurate numerical methods for treating complex geometries in 2D and 3D computer codes; develop the capability to simulate effects of replacement components and analyze various Stockpile-to-Target Sequence scenarios and modifications; accelerate code performance through more powerful numerical algorithms and improved approximations; maintain interactions with academic colleagues in computer science, computational mathematics, and engineering; conduct basic research relevant to the ASC Campaign in computer science, scientific computing, and computational mathematics; and continued support of the CSGF program.

The request supports the code development at the level needed for robust peer review as we move to support the implementation of the Comprehensive Test Ban Treaty. The request assures viable programs at both physics labs to fully support peer review for refurbishments, SFIs, modifications, and annual assessments as deemed necessary by the Subject Matter Experts (SMEs). It also positions the code developers to efficiently and effectively execute the ASC Code strategy for a rich, sustainable portfolio of simulations codes for the Enterprise and the continued drive toward predictive simulation. New capabilities will address the needs of the B61 LEP including engineering design for performance in normal environments as well as migrating ASC production codes to more efficient computing environments.

(dollars in thousands)			
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request
Physics and Engineering Models (PEM)	**61,189**	**62,798**	**69,890**

This subprogram develops microscopic and macroscopic models of physics and material properties, improved numerical approximations of transport, and models for the behavior of other critical phenomena. This subprogram is charged with the development, initial validation, and incorporation of new models into the Integrated Codes. Therefore, it is essential that there be a close interdependence between these two subprograms. There is also extensive integration with the experimental programs of the SSP, mostly funded and led by the Science Campaign.

The FY 2012 activities include: develop and implement the Equation of State and constitutive models for materials within nuclear devices; improve understanding of phase diagrams and the dynamic response of materials; continue physics-based modeling on the aging of key materials; explore fundamental chemistry models of high explosives; improve representation of corrosion, polymer degradation, and thermal-mechanical fatigue of weapons electronics; improve models of melting and decomposition of foams and polymers in safety-critical components; support of the Stockpile-to-Target-Sequence requirements by improving models of microelectronic and photonic materials in hostile environments.

The request supports a model development portfolio for scientific exploration in key areas towards achieving predictive simulation capability including: nuclear physics, atomic physics, equation of state, materials, material aging, high explosives, mix and burn, and engineering performance. The request will also supports advanced models for high explosives, material strength, and equation of state to address the initial conditions for boost, Predictive Capability Framework peg posts, and improvements in nuclear data and hydrodynamics to address boost.

Verification and Validation (V&V)	**50,882**	**54,781**	**57,073**

This subprogram provides a rigorous, defensible, scientifically based measure of confidence and progress in predictive simulation capabilities. The V&V subprogram applies systematic measurement, documentation, and demonstration of the ability of the codes and the underlying models in various operational states and functional regimes to predict behavior. The V&V subprogram is developing and implementing UQ methodologies as part of the foundation to the QMU process of weapons assessment and certification. The V&V subprogram also drives software engineering practices to improve the quality, robustness, reliability, and maintainability of the codes that evaluate and address the unique complexities of the stockpile.

In light of the QMU methodology put forth by the NNSA to be applied to annual assessments, we must have a healthy V&V program to perform UQ. More generally, as nuclear test data is becoming less relevant with an aging stockpile and as weapons designers with test experience leave the Enterprise, it becomes increasingly important that the codes of the Enterprise are verified and validated so future generations of designers are comfortable relying on these foundational tools.

(dollars in thousands)			
	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request

In FY 2012, V&V will focus on UQ assessments that include: integral V&V assessment; application of the Predictive Capability Assessment Project methodology to a stockpile system; expansion of the Primary Metric Project test suites to include more relevant Nevada National Security Site events; and further development of the Secondary Calculational Assessment Methodology Project.

Computational Systems and Software Environment (CSSE)	**157,466**	**175,833**	**181,178**

The CSSE builds integrated, balanced and scalable computational capabilities to meet the predictive simulation requirements of the NNSA. It strives to provide users of ASC computing resources a stable and seamless computing environment for all ASC-deployed platforms. The complex and diverse demands of the ASC performance and analysis codes and the scale of the required simulations require the ASC Campaign to be far in advance of the mainstream high-performance computing community. To achieve its predictive capability goals, the ASC Campaign must continue to invest in and consequently influence the evolution of computational environments. The CSSE provides the stability that ensures productive system use and protects the large investment in simulation codes.

A balanced and stable computational infrastructure is a key enabling technology for delivering the required computing capabilities. Along with the powerful capability, capacity and advanced systems that the campaign fields, the supporting software infrastructure that is deployed on these platforms include many critical components, from system software and tools, to Input/Output (I/O), storage and networking, post-processing visualization and data analysis tools, to common computing environments. The immediate focus areas include moving toward a more standard user environment and improving its usability, deploying more capacity computational platforms, planning for and developing peta-scale computing capability, and making strategic investments to meet program requirements at an acceptable cost.

The FY 2012 activities include continuing acquisition of Sequoia at LLNL and Cielo at LANL (with SNL) and beginning acquisition of capacity systems TLCC2 through the Tri-laboratory Linux Capacity Cluster. Maintenance will continue on LANL's Roadrunner and the Sequoia Initial Delivery system at LLNL. The ASC Campaign will continue to operate high-performance capacity computing scalable units to meet growing demands especially in the area of modern (QMU-based) weapons certification and assessment. The CSSE will also maintain a common, usable, and robust application-development and execution environment for ASC-scale applications and platforms; produce an end-to-end, high-performance I/O, networking-and-storage archive infrastructure encompassing ASC Campaign platforms and operating systems, large-scale simulations, and data-exploration capabilities. The ASC Campaign will provide a reliable, available, and secure environment for distance computing through system monitoring and analysis, modeling and simulation, and technology infusion. Development and deployment will continue on high-performance tools and technologies to support visual and interactive exploration of massive and complex data. The Campaign will provide system management of the ASC Campaign computers and their necessary networks and archival storage systems. This includes the deployment of effective data management, extraction, delivery, and archiving, as well as efficient remote or collaborative scientific data exploitation. Continued development and deployment of scalable data manipulation and rendering systems that leverage inexpensive, high performance commodity graphics hardware will continue. Additionally, ASC will stimulate research and development efforts through advanced architectures that explore alternative computer designs, promising dramatic improvements in performance, scalability, reliability, packaging, and cost.

The request will permit the acquisition of 25 percent to 30 percent more computational resources to be applied to capability class problems that use a major portion of the system. Similarly, demand for capacity class resources, those problems which require smaller jobs but a higher number of runs, has exceeded planned capacity platform acquisitions. Specifically, the request will be used to procure an additional 15 percent to 20 percent more computing resource capacity.

The request will initiate a strategy for a more persistent and portable computing environment for users to transition seamlessly between current production systems to future architectures. Over the next five to seven years, computational science at the laboratories will go through a growth spurt beginning with production access to a 20-Petaflop system. To accommodate this transition, computer science investments are needed in system software and tools, input/output, storage and networking, post-processing and a common computing environment.

The request initiates funding for an R&D effort addressing the technologies required to build and operate exascale supercomputers, that operate at one million trillion operations per second, or a one thousand fold increase over petascale. 'Exascale' denotes the next generation of high performance computers that are foreseen to address critical national security problems. In FY 2012, investments include critical technologies, such as low-power memory, and advanced interconnect optics. Likewise, the request supports investments in new software programming models for operating at these high speeds in basic functions such as storage techniques, file systems, and performance tools.

	FY 2010	FY 2011	FY 2012
Facility Operations and User Support	**155,650**	**156,389**	**159,859**

This subprogram provides the necessary physical facility and operational support for reliable production computing and storage environments as well as a suite of services enabling effective use of ASC Tri-Laboratory computing resources. Facility operations include planning, integration and deployment, continuing product support, software license and maintenance fees, procurement of operational equipment and media, quality and reliability activities and collaborations. Facility Operations may also cover physical space, power and other utility infrastructure, and Local Area Network/Wide Area Networking for local and remote access, as well as requisite system administration, cyber-security and operations services for ongoing support and addressing system problems.

The scope of the User Support function includes planning, development, integration and deployment, continuing product support, and quality and reliability activities collaborations. Projects and

(dollars in thousands)

	FY 2010 Actual Approp	FY 2011 Request	FY 2012 Request

technologies include computer center hotline and help-desk services, account management, web-based system documentation, system status information tools, user training, trouble-ticketing systems, and application analyst support.

The FY 2012 activities maintain continuous and reliable operation and support of production computing systems and all required infrastructure to operate these systems on a 24-hour a day, 7-day a week basis, with an emphasis on providing efficient production quality stable systems. Facility Operations operate laboratory ASC computers and support integration of new systems ensuring that the physical plant has sufficient resources, such as space, power, and cooling, to support future computing systems. User Support provides the authentication and authorization services used by applications for the purposes of remote access and data movement across ASC-related locations. The ASC Campaign will also develop and maintain a wide-area infrastructure (e.g., links and services) that enable remote access to ASC applications, data, and computing resources, to support computational needs at the plants permitting distant users to operate on remote computing resources as if they were local. The subprogram will provide analysis and software environment development, support for ASC laboratory computers and provide user services and helpdesks for ASC laboratory computers.

The request will fund investments in people and equipment to enhance system and environment administration and operations, network capability, power and user support services. These investments will transition the national laboratories from a high performance computing environment in which users view peta-scale computing as a novel tool to one where running jobs on a 20-Petaflop system is routine.

Total, Advanced Simulation and Computing Campaign	**566,069**	**615,748**	**628,945**

Explanation of Funding Changes

	FY 2012 vs. FY 2011 Request ($000)
Integrated Codes	
The decrease reflects some consolidation of the code projects within the ASC program in order to maintain verification and validation activities.	**-5,002**
Physics and Engineering Models	
The increase supports a model development portfolio towards achieving predictive simulation capability for scientific exploration in key areas – including nuclear physics, atomic physics, equation of state, materials, high explosives, mix and burn, and engineering performance. The increase will also address critical skill shortfalls at the laboratories to provide foundational simulation capabilities needed for future Life Extension Programs, significant findings investigations and a Comprehensive Test Ban Treaty environment.	**+7,092**
Verification and Validation	
The increase will address uncertainty quantification and individually address the key factors contributing to simulation certainties.	**+2,292**
Computational Systems and Software Environment	
The increase reflects funding for initial investments in an initiative to begin researching and developing the technologies required to build exascale supercomputers. The increase is also offset by adjustments in the funding profiles for the Cielo, Sequoia, and Tri-laboratory capacity procurements that were accelerated in FY 2011, thereby reducing their FY 2012 requirements.	**+5,345**
Facility Operations and User Support	
The increase is consistent with the cost cycle to operate and maintain the existing computing centers of the nuclear security enterprise at the national laboratories as new platforms are installed and older systems are retired.	**+3,470**
Total Funding Change, Advanced Simulation and Computing Campaign +13,197	

Capital Operating Expenses and Construction Summary

Capital Operating Expenses[a]

(dollars in thousands)

	FY 2010 Actual Appropriation	FY 2011 Request	FY 2012 Request
General Plant Projects	1,211	1,238	1,265
Capital Equipment	72,760	74,361	75,997
Total, Capital Operating Expenses	**73,971**	**75,599**	**77,262**

Outyear Capital Operating Expenses

(dollars in thousands)

	FY 2013	FY 2014	FY 2015	FY 2016
General Plant Projects	1,293	1,321	1,350	1,380
Capital Equipment	77,669	79,378	81,124	82,909
Total, Capital Operating Expenses	**78,962**	**80,699**	**82,474**	**84,289**

[a] Funds are appropriated for Operations and Maintenance, which includes operating expenses, capital equipment and general plant projects. The program no longer budgets separately for capital equipment and general plant projects. Funding shown reflects estimates based on actual FY 2010 obligations.