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National Ignition Campaign Execution Plan

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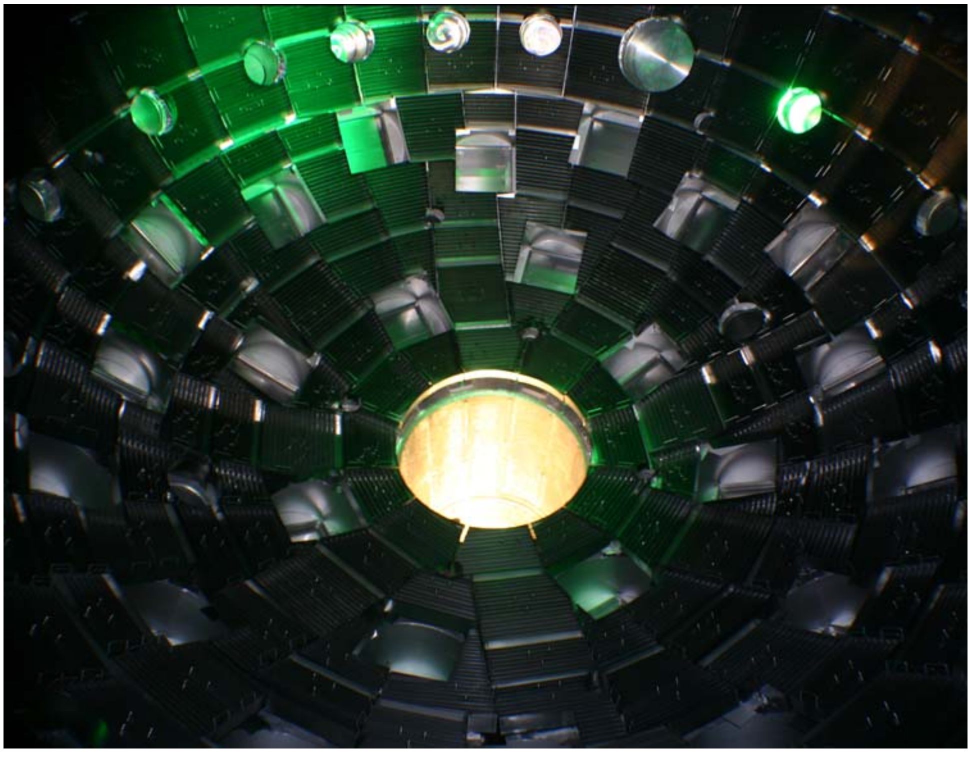
National Nuclear Security Administration



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National Ignition Campaign Execution Plan

Revision 0

Approval

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Acting Deputy Administrator for Defense Programs National Nuclear Security Administration	6/27/05 Date
Acting Assistant Deputy Administrator Office of ICF and the NIF Project	6/27/05 Date
For National Ignition Campaign Manager National Nuclear Security Administration	6/27/05 Date
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1. Justification of Mission

The Stockpile Stewardship Program is a single, highly integrated technical program for maintaining the safety and reliability of the U.S. nuclear stockpile in an era without nuclear testing.[1] A significant component of the Stockpile Stewardship Program is the National Ignition Campaign (NIC). The NIC plan integrates the activities required to perform a credible ignition experimental campaign on the National Ignition Facility (NIF) in FY2010 and continued campaigns past FY2010. The Stockpile Stewardship Program will then have a unique laboratory capability for studying thermonuclear ignition and burn in dense deuterium-tritium (DT) plasmas.

As stated in the NIF Justification of Mission Need,[2] "The mission of the National ICF Program is threefold: (1) to play an essential role in accessing physics regimes of interest in nuclear weapon design and to provide nuclear weapon-related physics data, particularly in the area of secondary design; (2) to provide an aboveground simulation capability for nuclear weapon effects on strategic, tactical, and space assets (including sensors and command and control); and (3) to develop inertial fusion energy for civilian power production. These ICF applications require the achievement of ignition[*] and propagating thermonuclear fusion burn. To achieve this goal, DOE is proposing the NIF."

The ignition mission was identified in the early 1990s by the Department of Energy (DOE) Fusion Policy Advisory Committee and National Academy of Sciences Inertial Fusion Review Group as the next important step in fusion research. In 1995, the DOE Inertial Confinement Fusion (ICF) Advisory Committee affirmed the program's readiness for an ignition experiment. "Most Committee members believe that the probability of ignition has increased above 50%, and some believe that it is well above this level."[3] This mission was endorsed by the Secretary of Energy.[4] The role of ignition in support of Stockpile Stewardship was reaffirmed by the NNSA High-Energy Density Physics study[5] in 2001 and the Defense Science Board Taskforce review of the Employment of the National Ignition Facility in 2004.[6] Also in 2004, Congress[7] reiterated the need to achieve ignition by FY2010 and requested the JASON to assess the plan and prospects for achieving ignition at NIF by FY2010.

[*] The NIC has adopted the same definition of ignition used in the 1997 National Academy of Sciences review of the ICF Program:[8] gain ≥ 1, i.e., fusion energy output is greater than or equal to laser drive energy.

2. Campaign Description

Introduction— The objective of the NIC is to develop and execute a credible ignition experimental campaign in FY2010, fully consistent with available resources and science and technology requirements. The NIC is a major research effort of the National Nuclear Security Administration (NNSA). Tasks include:

- Developing an integrated ignition point design, with fusion energy output greater than or equal to laser drive energy
- Providing the required quantity of targets with specifications consistent with the point design
- Providing a cryogenic system capable of supporting the current point design at a shot rate consistent with the NIC shot plan
- Operating the NIF laser consistent with the requirements of the ignition plan
- Providing laser beam characteristics consistent with target illumination specifications in the point design requirements document (to be prepared by the end of FY2005)
- Providing diagnostic systems to characterize laser/target illumination, hohlraum energetics, symmetry, ablator performance, shock timing, and fusion ignition
- Providing personnel and environmental protection systems and storage capabilities consistent with the experimental plan and the *NIF Final Safety Basis Document*[9]
- Planning and executing an integrated national effort, including preliminary experimental work on other facilities leading to experimental campaigns on NIF
- Conducting a direct-drive program leading to a decision on polar direct-drive facilitization and ignition experimental campaigns on NIF
- Establishing the physics basis for ignition using 2ω light
- Developing the use of short-pulsed lasers for radiography and ignition applications

The NIC Primary Criteria and Functional Requirements are outlined in Appendix B.

Participants—NIC participants include General Atomics (GA), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and the University of Rochester Laboratory for Laser Energetics (UR/LLE). At the time this document was being prepared, the NNSA budget for the Naval Research Laboratory (NRL) was eliminated in FY2006 and beyond. NRL has not participated in the NIC planning process and is not currently participating in the NIC.

Management—The NIC, and all aspects of it, is an Enhanced Management Program as defined in *NA-10 Defense Programs Program Management Manual*.[10]

Organization—The NIC functional organization is illustrated in Figure 2-1.

Cost and Schedule—Cost and schedule objectives are described in Appendices C and D, respectively.

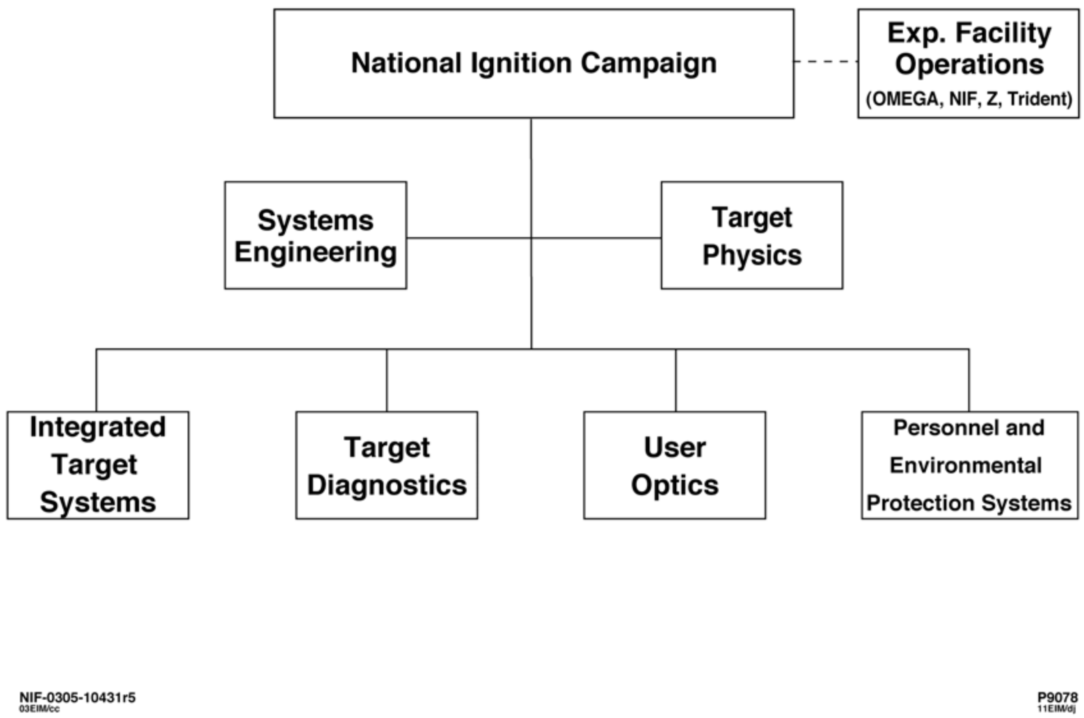

Figure 2-1. NIC functional organization structure.

2.1 NIC Summary

Fusion occurs in ICF when the DT fuel is heated to sufficient temperatures that the deuterium and tritium collide and fuse producing primarily a helium nucleus (alpha particle) and a neutron. The energy released by this collision is 17.58 MeV (2.81×10^{-12} joules). For the purpose of the NIC, ignition is defined as fusion energy output greater than or equal to laser energy incident on the target. The NIC encompasses a plan to perform the necessary research, technology development, procurement, engineering, and integration of hardware to perform a credible ignition experimental campaign on the NIF in FY2010 and continued campaigns past FY2010. The NIC will use indirect-drive ICF where the NIF laser is used to heat a container, or hohlraum, containing the fuel capsule. The laser energy is absorbed by the hohlraum walls and is converted to x-rays that compress and heat the fusion fuel. Subsequent to 2011, direct-drive ignition, fast ignition, and 2ω ignition may be pursued.

2.2 Scope Description

The NIC is the collection of science, technology, and engineering needed to perform an experimental campaign (a series of shots with a defined and common objective[s]) on NIF, which represents a credible attempt at achieving ignition in FY2010, and subsequent experimental campaigns past FY2010. The NIC includes the following:

- The design, fabrication, and execution of ignition experimental campaigns
- The experiments on NIF and supporting NNSA experimental facilities prior to FY2010 ignition experimental campaigns which are needed to verify and validate the ignition design and mitigate risks

- The diagnostics, user optics, cryogenic target system, targets, personnel and environmental protection systems, and NIF operations personnel and operating inventory
- The equipment and technology needed to maintain a sustained effort on ignition beyond the initial experimental campaigns

The NIC is separate from the NIF Project but relies on the NIF Project to meet its current schedule. The planning and schedules of the NIF Project and the NIC are highly integrated. Both need to be executed and completed on the present schedule to successfully complete the NIC goal of conducting a credible ignition experimental campaign in FY2010. Likewise, the NIC is separate from Campaign 4 and 10.2, but requires capabilities funded by these campaigns (see note on page 29 for more detail). The high-level NIC timeline is summarized in Figure 2.2.

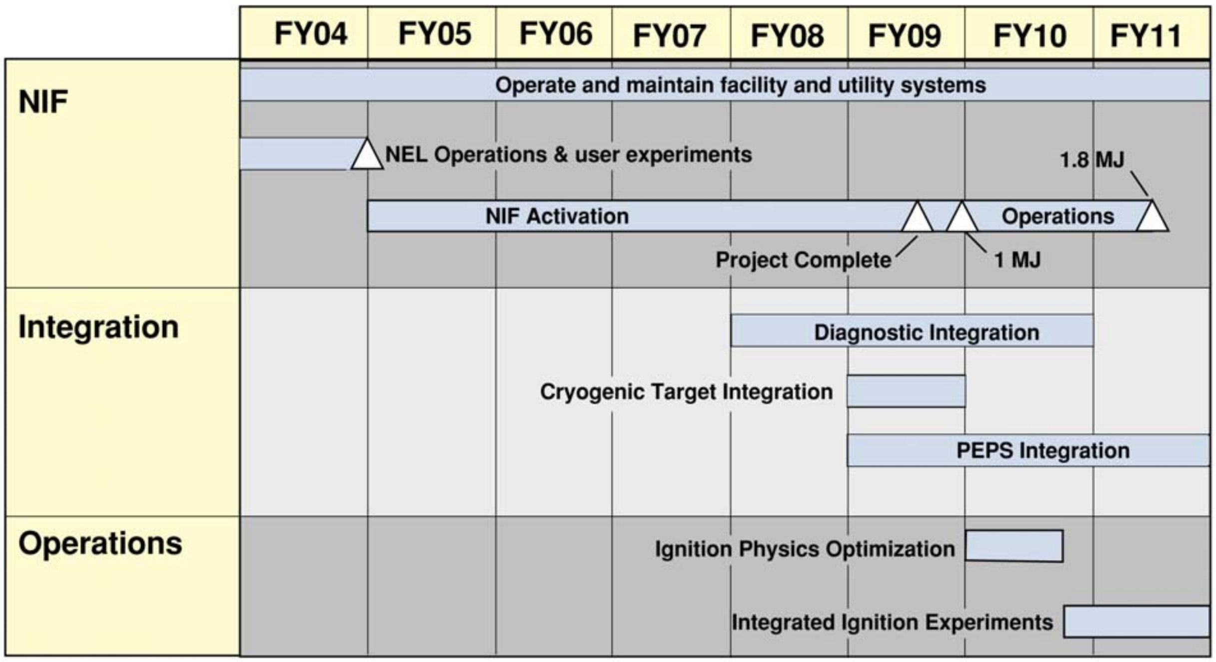

Figure 2-2. NIF Project and Ignition Campaign integration timeline.

The following is a brief description of the major subsystems and functional elements contained in the NIC.

Campaign Management—Experimental campaign planning and preparation are managed using the Work Authorization Point (WAP) process.[11] This rigorous authorization process ensures that all aspects of the activity (equipment, personnel, and procedures) meet requirements and have been prepared to safely and efficiently achieve the activity's objectives.

Systems Engineering—A number of operational capabilities are needed to support user experimental campaigns. Laser performance models are used to specify the laser and diagnostics setups in accordance with experimental campaign requirements. Expert group review and analysis is also performed to ensure that the systems are operated within their allowable limits. Additional capabilities required to successfully conduct campaigns include: configuration management, requirements management, experiment control, and system integration and user interfaces for accessing diagnostic and laser data.

Target Physics— Target physics performs theory, modeling, and calculations to validate the ignition target point design, designs experiments on NIF, and supports facilities to verify aspects of the design. In addition, target design activities on alternative designs as risk mitigation are performed. The experimental component of this element designs and executes ignition experimental campaigns as well as supporting experiments on NIF and other facilities for verification, validation, and risk mitigation. This area also supports research and technology development on diagnostics, targets, and cryogenic layering in support of ignition experimental campaigns. Target Physics provides specialized equipment, as required, for ignition experimental campaigns on NIF and for supporting facilities to execute the ignition plan.

Integrated Target Systems (ITS)

The ITS contains two major functional elements:

> **Target Fabrication—**Target fabrication is the manufacturing of ignition targets as well as targets required for supporting experiments. This includes the capsule, the hohlraum, and any features needed for diagnostics or alignment. Target fabrication also provides the equipment needed to manufacture and characterize the target components and assemblies.
>
> **Cryogenic Target System—**The ignition target design requires a layer of cryogenic DT fuel inside the fuel capsule. The cryogenic target system fields the target, forms and characterizes the layer and maintains a layer quality until the experiment is initiated. The target is loaded into the manipulator and filled with DT fuel. The main components of the system are the ignition target insertion component, the target positioner, the DT fill system, layering capability, diagnostics for layer characterization, and a removable shroud.

Target Diagnostics—The diagnostics to support ignition experimental campaigns are used to verify laser performance and measure target performance as an integral part of the experimental campaigns. The scope includes design, integration, test, control, and operation of diagnostics. Testing includes off-line and on-line testing and calibration and may use other Defense Program (DP) facilities.

User Optics—User optics are optics and laser capabilities that are user requested and not part of the NIF Project. User optics provide a capability to modify the far field focal spot using continuous phase plates and a capability for beam conditioning using polarization-smoothing crystals and smoothing by spectral dispersion. User optics provide the disposable debris shields for the experimental campaigns. User optics also provide some of the optics inventory to be acquired before the start of NIF operations. In addition, user optics includes process development for manufacturing and refurbishing user and final optics as well as ongoing optics damage research and development.

Personnel and Environmental Protection Systems (PEPS)—The PEPS are the systems required to contain and process hazardous materials and protect workers and the public from radiation produced by the target experiments. Systems are implemented to decontaminate and, as needed, to dispose of contaminated components and experimental byproducts. Shielding systems are implemented to reduce radiation doses to workers and to minimize radioactivity generated from neutron activation of materials.

Table 2-1 provides a high-level description of the subsystems required for the FY2010 ignition experimental campaign.

Table 2-1. FY2010 NIC subsystem descriptions.

Subsystem	Baseline	Option
Capsule	Graded dopant Be and CH, fill tube, cryo layer	Machined doped Be
Hohlraum	Cocktail with low-Z liner, LEH shields, low pressure He	Gas filled
Cryogenic Target System	Indirect drive, warm transport, 1 shot/24h, external x-ray phase contrast, beta layering, opposed port remover	IR layering, optical in-chamber characterization, clam shell remover
User Optics	One set of CPPs (inner outer cone designs), PS, thick crystals, DDS	
Target Diagnostics	192 energy diags., (48) 3ω power diags., pulse sync, SXI (2), FABS (2), NBI (2), SXD (2), GXD (2) and 1 add'l. DIM, FXI (2), Dante, Protex, NTOF, VISAR/PSBO, gamma bang time, neutron imaging, FABS 36B, HEXRI, ARC, misc. snouts	MRS, Carbon-12 activation
Personnel Environmental Protection System (PEPS)	Accommodate Be and DU, 100 ci/yr Tritium, 20 MJ yield single shot; optics storage	
Laser System	192 beams OQ'd 1 MJ, inner/outer cone UV λ's SSD (90 GHz, 1ω), 50:1 Haan pulse	SSD @ 150 GHz, 1ω
Facility Operations	Operations inventory, CIM capability to support ~150 shots in FY10, ~250 shots in FY11	

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Acronym definitions for Table 2-1: Advanced Radiographic Capability (ARC), conditioning, initiation, and mitigation (CIM), continuous phase plate (CPP), Disposable Debris Shield (DDS), Diagnostic Instrument Manipulator (DIM), depleted uranium (DU), Full Aperture Backscatter System (FABS), Framing X-ray Imager (FXI), laser entrance hole (LEH), Gated X-Ray Detector (GXD), High-Energy X-ray Imager (HEXRI), infrared (IR), Magnetic Recoil Spectrometer (MRS), Near Backscatter Imager (NBI), neutron time of flight (NTOF), operational qualification (OQ), passive shock breakout (PSBO), smoothing by spectral dispersion (SSD), Streaked X-ray Detector (SXD), Static X-ray Imager (SXI), and Velocity Interferometer System for Any Reflector (VISAR).

In addition to these subsystems, the NIF Project must be completed and the laser facility activated to successfully execute these plans.

2.3 Primary Criteria and Functional Requirements

The NIC Primary Criteria and Functional Requirements (Appendix B) represents the top-level system requirements that must be achieved to support the NIC and to ensure that operations meet applicable federal, state, and local requirements for the protection of workers, the public, and the environment.

2.4 NIC WBS

The NIC WBS is the administrative organizing element for the NIC and supporting program elements. The summary NIC WBS is provided in Figure 2-3. The NIC WBS will be defined as needed to a level consistent with work packages and deliverables.

NIC WBS*

I. National Ignition Campaign

- I.1 Management
- I.2 Systems Engineering
- I.3 Target Physics
- I.4 Integrated Target Systems
  - I.4.1 Target Fabrication
  - I.4.2 Cryogenic Target System
- I.5 Target Diagnostics
- I.6 User Optics
- I.7 Personnel and Environmental Protection System

*A more detailed WBS will be prepared.

Figure 2-3. NIC Work Breakdown Structure.

2.5 Assurance Criteria

The NIC must meet the following summarized assurance criteria:

- The activities in the plan will be confined within the envelope of the radiological limits imposed by the safety basis documentation and the *Final Site-Wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement (SW/SPEIS)*[12]
- Waste management shall minimize the generation of waste at the source, per applicable DOE orders
- Safeguards and security will physically protect and control data and equipment

3. Management Roles and Responsibilities

The NNSA has responsibility for the safety and reliability of the nuclear weapons stockpile. NNSA has implemented the Stockpile Stewardship Program (SSP) to meet this responsibility, of which ignition is a major component.[1] The Deputy Administrator for Defense Programs oversees the strategy and role of ignition in the SSP. The NIC Director reports to the NNSA NIC Manager, who reports to the Assistant Deputy Administrator.

Figure 3-1 depicts the NIC administrative management structure.

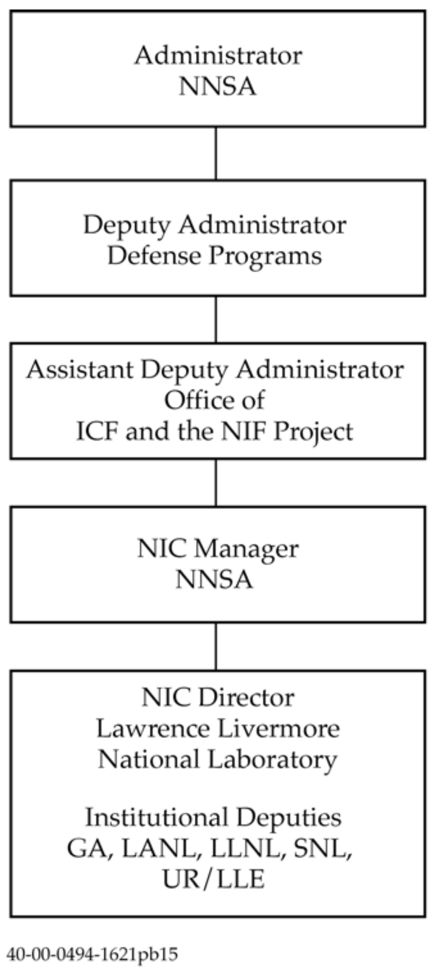

Figure 3-1. NIC administrative management structure.

3.1 Administrator, NNSA (NA-1)

The NNSA Administrator has the overall responsibility for the execution of the NIC. The NNSA Administrator will:

- Chair the Level 0 NIC Change Control Board (NCCB) to approve/disapprove changes at Level 0 (as defined in Table 4-1)
- Approve the establishment of the Level 0 NIC technical, cost, and schedule objectives

3.2 Deputy Administrator, Defense Programs (NA-10)

The Deputy Administrator for Defense Programs is responsible for formulating policy, overall direction, and budget guidance for Defense Programs' Stockpile Stewardship Program. The Deputy Administrator will:

- Chair the Level 1 NCCB to coordinate the NNSA decisions on all proposed changes that are within the Level 1 approval thresholds or decision points (as identified in Table 4-1)
- Provide the authority for the disposition of Level 1 NIC Change Proposals
- Establish and implement the NIC policy through this *NIC Execution Plan*
- Review and coordinate the approval of the NNSA-controlled objectives and initiate critical decisions and other required reviews
- Provide the overall resources to the ICF Ignition and High Yield Campaign needed to maintain the approved schedules
- Ensure that the NIC schedule and top-level deliverables are appropriately coordinated and consistent with overall Defense Programs goals and plans

3.3 Assistant Deputy Administrator, Office of ICF and the NIF Project (NA-16)

The Assistant Deputy Administrator is responsible for formulating policy, overall direction, and budget guidance for the ICF research and development program. The Assistant Deputy Administrator assures the ICF Ignition and High-Yield Campaign is planned and implemented in a manner that supports the Stockpile Stewardship Program. The Assistant Deputy Administrator reports directly to the Deputy Administrator for Defense Programs and will:

- Establish and implement the NIC policy through this *NIC Execution Plan*
- Secure resources and issue formal ICF and NIC technical guidance and direction. Review the status of NIC technical, cost, and schedule performance
- Review and coordinate the approval of the NNSA-controlled objectives and initiate critical decisions and other required reviews
- Provide guidance regarding the required timing of NIF capabilities to best support the goal of ignition experimental campaigns in FY2010
- Maintain a close interface with Stockpile Stewardship user groups and with Energy and Science Program users
- Approve contract and NNSA performance measures for the NIC and evaluate performance against the established measures
- Monitor and evaluate the performance of the NIC

3.4 NIC Manager, NNSA (NA-161)

The Director of the Office of Inertial Confinement Fusion (NA-161) will serve as the Federal NIC Manager.

The NIC Manager is responsible for the formal day-to-day NIC interfacing and monitoring. The NIC Manager reports to the Assistant Deputy Administrator and will:

- Provide NNSA NIC management, including monitoring all aspects of the NIC phases relative to the established objectives (including technical, cost, and schedule components) and ensuring the adequacy of the NIC management system

- Chair the Level 2 NCCB to coordinate the NNSA decisions on all proposed changes that are within the Level 2 approval thresholds or decision points (as identified in Table 4-1)
- Implement NIC policy through this Plan
- Be responsible for NNSA management of all research and development programs supporting the NIC
- Establish the NIC review process
- Secure resources and issue NIC Work Authorizations. Review the status of technical, cost, and schedule performance of the NIC
- Review and coordinate the approval of the NNSA-controlled objectives and initiate critical decisions and other required reviews
- Coordinate with DOE and NNSA field organizations, as required, to obtain support for NIC management activities
- Function as the formal communications channel with DOE/NNSA Headquarters, apprising the Assistant Deputy Administrator of any NIC-related issues
- Develop, monitor, and evaluate performance against the NIC performance measures
- Provide regular reporting on NIC progress to senior NNSA management as defined in the NNSA Program Management Manual
- Approve annual funding plan for NIC participants and any changes in funding transfers between sites that have been recommended by the NIC Director

3.5 NIC Director, Lawrence Livermore National Laboratory

The NIC Director is responsible for implementing the NIC and providing overall management of all NIC activities and will:

- Chair the Level 3 NCCB to coordinate NIC decisions on all proposed changes that are within the Level 3 approval thresholds or decision points (as identified in Table 4-1)
- Execute all aspects of the NIC, including managing work scope, schedule, and cost objectives and coordinating NIC-related activities of the participating laboratories and industrial contractors
- Be responsible for all research and development programs required to successfully complete the NIC
- Monitor progress and implement necessary corrective actions, where required, to resolve problems and conflicts that affect NIC implementation
- Interface with the NIC Manager
- Establish and maintain the objectives in accordance with this Plan and report their status to the NNSA and program participants in a timely and accurate manner
- Implement, utilizing the principles of the Integrated Safety Management (ISM) system, applicable Environment, Safety, and Health (ES&H) requirements, quality assurance, and security in the execution of the NIC

3.6 NIC Institutional Deputy Directors

NIC Institutional Deputy Directors will represent participating NNSA sites in managing the Campaign. They are responsible for supporting the NIC Director in NIC implementation while representing their institution. NIC Institutional Deputy Directors will:

- Represent their institution on the NIC in terms of resource allocation, priority, and conflict resolution
- Execute assurance responsibilities, incorporating Integrated Safety Management principles for Environment, Safety and Health; quality assurance; and security, as appropriate
- Periodically inform institutional senior management as to the status and progress of NIC activities

4. NIC Execution

This chapter describes the management processes that will be used to implement the NIC.

4.1 Objectives Establishment

The NIC objectives, including technical, cost, and schedule, are formally established in this *NIC Execution Plan* and provide the basis from which all proposed future changes are measured. The NIC objectives will be revised to reflect any future changes once they are approved through the established NCCB process. Summaries of the current objectives are contained in Appendices B, C, and D. A listing of NIC Level 0-2 milestones is contained in Appendix E.

4.1.1 Technical Objectives

The technical objectives are currently documented in the NIC Primary Criteria and Functional Requirements in Appendix B and will be established on approval of this plan.

The complete hierarchy of criteria and their approved level relationship is shown in Appendix F. As preliminary and detail designs are accomplished, more system design requirements, interface control documents, and design media in the form of top-level drawings, calculations, and specifications will be formulated. In addition, key approved environmental and safety documents shall augment the objectives.

4.1.2 Cost Objectives

The initial cost objectives of the NIC are provided in Appendix C and will be established upon approval of this plan.

4.1.3 Schedule Objectives

The initial schedule for the NIC is provided in Appendix D and will be established upon approval of this plan.

4.2 Change Control

Establishment and maintenance of the NIC technical, cost, and schedule objectives are an important aspect of the control of the NIC. Changes to the objectives will be carefully controlled and approved by appropriate NCCBs. The purposes of the NIC change control system are to assure that:

- The technical, cost, and schedule impacts of proposed changes are developed and considered by all appropriate parties
- The evaluations, produced by the appropriate parties, are considered in the approval or rejection of the proposed changes
- Appropriate parties are informed of proposed changes and their disposition
- Change documentation is controlled and updated as appropriate to reflect approved changes
- Action on all change requests is deliberate and without undue delay and carried out without interfering disproportionately with NIC progress

4.2.1 Change Control and Configuration Control

The objectives, including technical, cost, and schedule components, established upon approval of this *NIC Execution Plan* are subject to the NCCB review process. NCCBs will be established at four levels (0, 1, 2, and 3) to approve, disapprove, or endorse (i.e., recommend approval to a higher-level NCCB) all proposed objective changes. The NIC Director may form lower-level NCCBs as necessary.

Table 4-1. NIC change control thresholds.

	Administrator, NNSA (Level 0)	Deputy Administrator, Defense Programs (Level 1)	NIC Manager, NNSA (Level 2)	NIC Director, Lawrence Livermore National Laboratory (Level 3)
Technical (Scope) Threshold	• Any change to scope that affects the Mission Statement.	• Any deviation from the primary criteria (Appendix B).	• Any deviation in functional requirements (Appendix B).	• Any change in System Design Requirements that affect ignition system performance.
Cost (Dollar) Threshold	• Any change in the total NIC cost objective (Appendix C).	• Changes greater than $25M that do not affect the total NIC cost objectives. • Changes requiring modification of the NIC funding profile.	• Changes greater than $10M that do not affect the total NIC cost objectives.	• Changes less than $10M that do not affect the total NIC cost objectives.
Schedule (Milestone) Threshold	• Changes to Level 0 milestones in excess of six months.	• Changes to Level 0 milestones of less than six months. • Changes to Level 1 milestones in excess of six months.	• Changes to Level 1 milestones of less than six months. • Changes to Level 2 milestones in excess of six months.	• Changes to Level 2 milestones of less than six months. • Changes to Level 3 milestones in excess of six months.

The change board hierarchy is shown in Appendix G, and change thresholds are listed in Table 4-1. Membership of the Level 0, Level 1, Level 2, and Level 3 NCCBs will be at the discretion of the respective board's chairperson and will include members of the relevant participating institutions. The Level 0, Level 1, Level 2, and Level 3 NCCB Chairpersons shall have full decision-making authority; the boards are advisory rather than voting boards. The chairperson of each board, at his or her discretion, may provide disposition of a requested change without conducting a board meeting.

For directed changes, the Deputy Administrator's directive will be the authorization for implementing the change. Directed changes do not require change board approval unless they impact the NIC objectives. If the NIC Director determines an impact to the objectives has occurred, the impact will be submitted as a change request for review by the appropriate NCCB.

The NIC Director will establish appropriate control of specified NIC documents through the process of issuing, reviewing, and approving changes. These are the chief change control processes for NIC documents and are central to the NIC configuration control system, which will ensure that the NIC documents are current.

4.3 NNSA Budget Authorization Process

Funding requests that support the NIC are made as part of the NNSA annual budget request process for inclusion in the Defense Programs' Corporate Review Budget, the Office of Management and Budget, and the Congressional budget submissions.

The NIC Director shall establish annual budget guidance for the NIC participants based on the negotiated scope of work to be accomplished by each. This will result in the funding distributions recommended to the NNSA NIC Manager and will be consistent with the scope of work to be accomplished. Funding distribution will be coordinated by the NNSA NIC Manager and the Assistant Deputy Administrator.

The NNSA will distribute the funds via the Approved Financial Plan process. The Work Authorization System will be used by NNSA for the general authorization of funds for work at the participating organizations (i.e., laboratories and contractors). All work will be planned and executed in accordance with the *NA-10 Defense Programs Program Management Manual*.[10]

4.4 Acquisition Strategy

The University of California, operating LLNL and LANL; Lockheed-Martin, which operates SNL; UR/LLE and GA will conduct the acquisition of needed products and services in support of their assigned responsibilities within the NIC structure in accordance with their prime contracts with the NNSA. LLNL, designated as the lead Laboratory, will have responsibility for the integration of all procurements required for fabrication, installation, activation, and startup of the NIC.

The overall NIC acquisition strategy will utilize applicable approved procurement policies and procedures. To the maximum extent practical, NIC subcontracts for supplies, equipment, and services will be awarded on the basis of competitive solicitations to responsive and responsible offerors. Fixed-price awards are the preferred contracting method and, when appropriate, cost-plus-fixed-fee contracts will be utilized. Cost-plus-award-fee and fixed-price-incentive contracts will be considered for use if it can be determined to be in the best interest of the NIC. Details of the use of the various contract types to minimize risk and to acquire products and services in consonance with prudent business practices to the best overall value to NIC will be discussed in the *NIC Acquisition Plan*,[13] to be developed after approval of this *NIC Execution Plan*. Review and approval of procurement actions by the cognizant DOE contracting officer will be obtained as required by dollar thresholds set by DOE.

A subcontract for supplies, equipment, services, or construction items may be awarded without competition when there is sufficient justification for a sole-source or single-source procurement. This determination will be documented and approved by the appropriate Procurement Representative for the dollar level of the action in accordance with applicable participating laboratory procurement procedures.

Vendor source lists will be generated to maximize the number of potential sources and to obtain open competition. Qualified vendors will be identified from responses to announcements in the Commerce Business Daily or other public notices, from individual expression of interest, from knowledge developed as part of development activities in the core ICF Program, from trade literature and professional presentations, or from reviews of relevant prior procurement histories. Potential vendors will be required to demonstrate their qualifications with suitable documentation. NIC technical personnel and procurement and material Quality Assurance personnel, including Business Affirmative Action Office representatives as necessary, will visit interested new small businesses/small disadvantaged businesses to validate capabilities. All of the resulting data will be used to compile bid lists for procurement actions.

4.5 Reviews

The NIC Director will conduct quarterly status reviews of the NIC for the NNSA. Video teleconferencing (VTC) will be used to the maximum extent possible to minimize unnecessary travel expenses. These reviews are integral to the NIC technical, schedule, and cost tracking and reporting processes. Independent reviews may be conducted to address various aspects of the NIC as needed.

4.6 Performance Control and Reporting Systems

The NIC control and reporting requirements will conform to those outlined in the *NA-10 Defense Programs Program Management Manual*.[10] This document provides guidance for a graded approach to NIC management to minimize overall NIC cost and schedule risk. The NIC control system will be closely integrated with the change control and work authorization processes and will provide the required status and variance analysis for the specified reporting period. The NIC uses this integrated control system to provide effective planning and reporting, as well as day-to-day management capabilities.

This system will:

- Identify and organize all of the work scope required to complete the NIC
- Provide the means to break the work scope into tasks, with a time-phased budget and a resource plan
- Measure and report actual costs and schedule performance against the approved task plans and the established objectives
- Generate and maintain the cost and schedule estimates for the NIC
- Forecast future funding requirements
- Provide the basis for NIC budget submissions and validations
- Monitor and control procurement and contracting activities and commitments

4.6.1 Control Systems

Each month, based on the current month and cumulative data, the responsible NIC Control Account Managers will prepare a status report. If pre-determined variance thresholds are exceeded, the status report will include a variance analysis, which may include the cause of the variance, the expected impact on the NIC, a recovery plan, and a current estimate-at-completion (EAC), if necessary.

In the event of directed changes due to changes in Congressional or NNSA priorities that affect the NIC scope, cost and/or funding profile, and schedule, the NIC will be replanned. Replanning consists of modifying plans for all or part of the NIC WBS to re-establish the performance objectives.

4.6.2 Reporting

The NIC Director will be responsible for collecting, maintaining, and integrating sufficient information to satisfy all of the NIC management reporting requirements.

The NIC Director shall maintain complete financial data at the NIC WBS levels appropriate for its assigned work. The cost account managers will prepare monthly and cumulative planned-versus-actual performance for each reporting period.

Monthly reports shall be transmitted from the NIC Director to the NIC Manager by the 25th working day after the end of the month.

4.7 Assurances

The predominant assurance objective is that the NIC will be conducted in a safe, secure, and environmentally sound manner and will ensure the reliable performance of the ignition experimental campaigns. To achieve these objectives, the NIC will utilize a risk-graded approach for quality assurance, safeguards and security, and ES&H protection.

4.7.1 Quality Assurance

Quality Assurance will be planned and managed consistent with the *NIC Quality Assurance Program Plan*,[14] prepared in accordance with DOE Order 414.1, *Quality Assurance*.[15] The *Quality Assurance Program Plan*[14] utilizes a graded approach in which levels of risk are assessed and then an appropriate level of quality assurance and control requirements established. A *NIC Risk Management Plan*[16] will be developed.

4.7.2 Environmental Safety and Health Planning

The *NIC ES&H Management Plan for LLNL Activities*[17] will describe how the NIC ensures the health and safety of workers and protects the public and the environment. It will describe the policy, responsibilities, and documented evaluations and regulatory approvals that have been obtained prior to the beginning of installation and then prior to operation. The plan will describe each area (radiation protection including As Low As Reasonably Achievable (ALARA) requirements, safety, environmental impact [e.g., waste generation, effluents], tritium management) in a specific section. Each participant is responsible for implementing similar plans in accordance with their specific institutional requirements.

4.7.2.1 NEPA Determination

The achievement of ignition in NIF is included as a section of the *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management (SSM PEIS).*[18] The *Notice of Intent*[19] for the *SSM PEIS* stated that the National Environmental Protection Act (NEPA) document is sufficiently detailed to address site selection, construction, and operation of the NIF. The *Record of Decision*[20] resulting from the *SSM PEIS*[18] was issued in December 1996.

4.7.2.2 Safety Documents

The primary NIC safety documents are the *ES&H Management Plan for LLNL Activities*[17] for LLNL, the *NIF Final Safety Basis Document*,[9] *Tritium Facility Documented Safety Analysis (DSA)*,[21] and the B298 Hazards Analysis reports. In addition, Facility Safety Procedures, Integration Work Sheets, and appropriate Operational Safety Procedures will be prepared prior to operation. Work at off-site facilities (e.g., OMEGA) will be performed under that institution's documented safety and environmental requirements.

4.7.2.3 Safety Program

For all work carried out on the NIF site, including system installations and experiments, the *NIF Project Site Safety Program*,[22] which defines safety and environmental requirements and controls at the NIF site, will be followed.

5. Method of Accomplishment

The NIC management team, with participation by GA, LLNL, LANL, SNL, and UR/LLE as appropriate, prepares the design, procures equipment and materials, and performs installations, safety and system analyses, and commissioning for all NIC tasks. A summary of the scope for each participating site is found in Appendix H. The NNSA will maintain oversight and coordination through the NNSA Office of ICF and the NIF Project. All activities will be integrated through the guiding principles and five core functions of the DOE ISM.

The WAP process, as described in Section 2.2, is the framework for planning, coordinating, and authorizing work on NIF and will be used for NIC activities on NIF.

5.1 NIC Execution

5.1.1 Theory and Calculations

Theory, modeling, and calculations are performed to validate the ignition point design. These calculations are supported by data from ICF research and technology activities.

5.1.2 Design

A system's conceptual design is selected after subsystem design requirements are delineated, consistent with the Primary Criteria and Functional Requirements (presented in Appendix B), and design options are reviewed. Based on this design, a cost and schedule estimate will be developed.

The majority of the NIC systems are in the Preliminary or Final Design phases. The Preliminary Design forms the cost and schedule estimate basis. It is reviewed at the intermediate and final stages. Preliminary Design of the ignition support systems includes diagnostics, user optics, target fabrication, and cryogenic handling systems.

5.1.3 Final Design

The Final Design provides detailed equipment procurement and installation packages. The Final Design is the basis for the final cost and schedule estimate, acceptance test procedures, and acceptance criteria.

5.1.4 Procurement, Acceptance, and Installation

The NIC includes the engineering necessary to support equipment installation, including inspection and field engineering in support of the development of the system configuration as-built drawings. Main activities include coordinating the procurement of parts and services and providing engineering support to resolve any installation-related issues (e.g., fit problems, interferences).

Procured NIC equipment (e.g., PEPS, cryogenics, user optics, target handling system) is delivered, staged, and installed in the NIF Laser and Target Area Building. These system installations will be under the direction of the NIF Operations Area Management.

5.1.5 Operational Testing and Commissioning

The NIC equipment will be installed and activated prior to the phased turnover for operations using a formal installation qualification and operational qualification process. The transfer points are based on the readiness to operate (e.g., training and qualification of operators, test procedure results, and as-built drawings).

5.1.6 Operations

The operation of facilities for the NIC, including NIF and other facilities at the participating institutions, will remain under the responsible operating organizations. The NIC shall plan, integrate, and carry out activities in these facilities.

5.2 Security and Safeguards

The operation of the NIC may generate data that requires safeguarding. The NIC itself represents a large investment of government funds and assets that must be protected. Ignition security requirements will be added to the NIF Security Plan,[23] which will be prepared and submitted as required for Livermore Site Office Safeguards and Security Division Director approval prior to experimental operations.

6. Effective Date and Amendments

This *NIC Execution Plan* will be implemented immediately upon approval. This approved plan is a controlled document and provides the overall NIC objectives. All revisions are subject to the NCCB system requirements as discussed in Section 4. Updated technical, schedule, and cost plans resulting from NCCB decisions, as well as appendix changes of this document, may be appended to this plan without concurrence of the original approvers.

7. References

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16. LLNL, *NIC Risk Management Plan*, Lawrence Livermore National Laboratory, Livermore, CA (to be prepared).
17. LLNL, *National Ignition Campaign Environment, Safety, and Health Management Plan for LLNL Activities*, Lawrence Livermore National Laboratory, Livermore, CA (to be prepared).

18. U.S. Department of Energy, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, U.S. Department of Energy, Washington, D.C., DOE/EIS-0236 (September 1996).
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20. U.S. Department of Energy, *Record of Decision for the Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, Lawrence Livermore National Laboratory, NIF-0001345 (December 1996).
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22. LLNL, *NIF Project Site Safety Program,* UCRL-ID-125990, Lawrence Livermore National Laboratory, Livermore, CA, March 31, 2004.
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Appendix A—Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
ARC	Advanced Radiographic Capability
CIM	Conditioning, Initiation, and Mitigation
CM	Configuration Management
CPP	Continuous Phase Plate
DDI	Direct-Drive Ignition
DDS	Disposable Debris Shield
DIM	Diagnostic Instrument Manipulator
DOE	Department of Energy
DP	Defense Programs
DSA	Documented Safety Analysis
DT	Deuterium, Tritium
DU	Depleted Uranium
EAC	Estimate at Completion
ES&H	Environment, Safety, and Health
FABS	Full Aperture Backscatter System
FXI	Framing X-ray Imager
GA	General Atomics
GXD	Gated X-ray Detector
HEDP	High-Energy-Density Physics
HEXRI	High-Energy X-ray Imager
ICF	Inertial Confinement Fusion
IR	Infrared
ISM	Integrated Safety Management
LANL	Los Alamos National Laboratory
LEH	Laser Entrance Hole
LIL	Ligne d’Integration Laser
LLNL	Lawrence Livermore National Laboratory
MPR	Management Prestart Review

MRS	Magnetic Recoil Spectrometer
MTE	Major Technical Effort
NBI	Near Backscatter Imager
NCCB	National Ignition Campaign Change Control Board
NEL	NIF Early Light
NEPA	National Environmental Policy Act
NIC	National Ignition Campaign
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
NRL	Naval Research Laboratory
NTOF	Neutron Time of Flight
OQ	Operational Qualification
QMU	Quantification of Margins and Uncertainties
PDD	Polar Direct Drive
PEPS	Personnel and Environmental Protection Systems
PPBE	Planning, Programming, and Budgeting Evaluation
PS	Polarization Smoothing
PSBO	Passive Shock Breakout
SNL	Sandia National Laboratories
SSD	Smoothing by Spectral Dispersion
SSP	Stockpile Stewardship Program
SXD	Streaked X-ray Detector
SXI	Static X-ray Imager
TIC	Target Inserter and Cryostat
UR/LLE	University of Rochester Laboratory for Laser Energetics
VISAR	Velocity Interferometer System for Any Reflector
VTC	Video Teleconferencing
WAP	Work Authorization Point
WBS	Work Breakdown Structure

Appendix B—NIC Primary Criteria and Functional Requirements

Overview

The objective of the NIC is to develop and execute a credible ignition experimental campaign in FY2010, fully consistent with available resources and science and technology requirements. The NIC is a major research effort of the National Nuclear Security Administration (NNSA).

Tasks include:

- Developing an integrated ignition point design, with fusion energy output greater than laser drive energy
- Providing the required quantity of targets with specifications consistent with the point design
- Providing a cryogenic system capable of supporting the current point design at a shot rate consistent with the NIC shot plan
- Operating the NIF laser consistent with the requirements of the ignition plan
- Providing laser beam characteristics consistent with target illumination specifications in the point design requirements document (to be prepared)
- Providing diagnostic systems to characterize laser/target illumination, hohlraum energetics, symmetry, ablator performance, shock timing, and fusion ignition
- Providing personnel and environmental protection systems and storage capabilities consistent with the experimental plan and the *NIF Final Safety Basis Document*[9]
- Planning and executing an integrated national effort, including preliminary experimental work on other facilities leading to experimental campaigns on NIF
- Conducting a direct-drive program leading to a decision on polar direct-drive facilitization and ignition experimental campaigns on NIF
- Establishing the physics basis for ignition using 2ω light
- Developing the use of short-pulsed lasers for radiography and ignition applications

Target Physics

Primary Criteria

- The design of the ignition target shall use the indirect-drive geometry
- The ignition target shall be designed to have a credible probability to ignite and burn using validated 2D and 3D radiation hydrodynamics codes
- The design code used for ignition should be validated using experimental data from existing facilities to the extent possible

Functional Requirements

- The ignition design target should be designed using 1.0 MJ of 3ω light in the NIF geometry with alternative designs developed using up to 1.8 MJ of 3ω as well as 2ω light
- The ignition design shall specify the laser pulse shape and energy consistent with the NIF energy, pulse length, and dynamic range limits at the time of NIF Project completion

- The ignition design shall specify the beam spot, focusing, and pointing consistent with the NIF focusing and pointing specifications and user optics fabrication technology
- The NIF experimental plan shall be consistent with the NIF capabilities at the end of project, and the operations costs shall be consistent with the NIF operations budget
- The experimental plan should use existing facilities to determine the appropriate target configuration for NIC experimental campaigns
- The experimental techniques and diagnostics should be demonstrated to the required accuracy on existing facilities to the extent possible

Target Fabrication

Primary Criteria

- Targets shall be manufactured to meet point design specifications
- Targets shall contain deuterium-tritium cryogenic fuel
- There shall be sufficient capacity to manufacture targets consistent with the ignition experimental campaign schedule

Functional Requirements

- Capsules shall be manufactured using beryllium and CH (plastic) to the sphericity and surface roughness specified by the ignition design requirements
- The capsules shall be filled with deuterium-tritium fuel using a fill tube
- Dopants and impurities in the capsule should be within the tolerances as specified in the NIF target design requirements
- The hohlraum shall be manufactured to the NIC target design requirements including the dimensions and materials
- The hohlraum shall provide the thermal environment to produce a deuterium-tritium cryogenic fuel layer to the NIC target design requirements
- The hohlraum should allow for the characterization of the deuterium-tritium cryogenic fuel layer in at least two orthogonal directions
- The cryogenic fuel layer quality shall be demonstrated to the accuracy specified by the NIC target design requirements

Cryogenic Target Systems

Primary Criteria

- The system shall be capable of fielding ignition target designs at up to 1.8 MJ, maintaining the NIF target positioner stability and accuracy requirements
- The system shall be able to form and maintain a uniform cryogenic deuterium-tritium layer on the inside of a capsule in a hohlraum target

Functional Requirements

- The system shall be able to cool the target to 18° K and maintain temperature stability as required
- The system shall be able to perform one shot every 24 hours for non-yield shots, and the shot rate shall be limited by neutron activation for yield shots
- The system shall be designed to operate within the NIF radiological environment

- All target parameters set and controlled by the system shall be recorded at shot time
- The fuel layer shall be characterized before the target is moved from outside of the target chamber to target chamber center

Target Diagnostics

Primary Criteria

- Target Diagnostics shall provide the diagnostic systems necessary to execute the NIC experimental plan

Functional Requirements

- Diagnostics for experiments on energetics, asymmetry, ablator characterization, and shock timing and for the characterization of ignition implosions shall be available at the beginning of those experimental campaigns
- The support systems necessary to utilize the diagnostics including controls, timing, procedures, staff training, alignment capability, diagnostic manipulators, data acquisition, and analysis tools shall be available, as required, for each experimental campaign

User Optics

Primary Criteria

- An initial set of continuous phase plates (CPPs), DDSs, SSD capability, polarization smoothing crystals, and sufficient spares to support the FY2010 ignition experimental campaign as specified in the NIF target design requirements shall be provided

Functional Requirements

- Sufficient disposable debris shield cassettes shall be provided to support the initial ignition experimental campaigns in FY2010
- Optics manufacturing and refurbishment capabilities should be facilitated to support ignition experimental campaigns after FY2010

Personnel and Environmental Protection Systems

Primary Criteria

- Equipment and practices shall be in place to ensure that NIF is in compliance with the *NIF Final Safety Basis Document*[9] and the *Final Site-Wide Environmental Impact Statement (SW/SPEIS)*[12]

Functional Requirements

- Equipment and practices shall be in place to use beryllium and depleted uranium at the beginning of target experiments
- Equipment and practices shall be in place to use 100 Ci of tritium annually at the beginning of target experiments
- Equipment and practices shall be in place to monitor neutron yield in subignition experiments at the beginning of target experiments
- Equipment and practices shall be in place to allow one 20-MJ yield shot in FY2010
- Equipment and practices should be in place for routine yield experiments as specified in the *NIF Final Safety Basis Document*[9] and the *Site-Wide Environmental Impact Statement (SW/SPEIS)*[12] by FY2012

Operational Capability

Primary Criteria

- Analysis tools and validated operating models shall be implemented to support the ignition experimental campaign in FY2010

Functional Requirements

- A Laser Performance and Operations Model (LPOM) tool shall be available that is sufficiently accurate to ensure power balance
- Software tools shall be in place to perform laser shots at a rate consistent with the ignition experimental plan
- Analysis tools shall be in place to review the data after a laser shot to support user requirements

Appendix C —NIC Cost Objectives*†

Table C-1. National Ignition Campaign (indirect drive) ($K) by Site

Site	FY05	FY06	FY07	FY08	FY09	FY10	FY11
GA	12,290	12,280	12,895	12,280	14,830	15,490	15,900
LANL	12,179	12,332	12,498	12,751	12,945	13,253	13,253
LLNL	299,300	337,462	340,030	301,520	285,078	292,701	292,701
SNL	877	1,080	1,130	1,190	1,210	1,239	1,239
LLE	4,680	9,316	9,575	10,314	7,032	4,637	4,486
Grand Total	**329,326**	**372,470**	**376,128**	**338,055**	**321,095**	**327,320**	**327,579**

Table C-2. National Ignition Campaign (indirect drive) ($K) by MTE

MTE	FY05	FY06	FY07	FY08	FY09	FY10	FY11
C10.1 Ignition	39,169	50,473	55,132	70,018	71,267	74,461	74,493
C10.3 NIF Diag., Cryogenics, and Exp. Support	44,307	43,563	45,959	66,141	66,748	74,041	73,902
C10.7 Facility Ops. and Target Production	21,934	24,191	32,622	54,846	128,799	178,818	179,184
C10.9 NIF Demonstration Program	94,943	112,330	132,415	136,912	54,281	0	0
Const 96-D-111, National Ignition Facility	128,972	141,913	110,000	10,139	0	0	0
Grand Total	**329,326**	**372,470**	**376,128**	**338,055**	**321,095**	**327,320**	**327,579**

Table C-3. Direct Drive Ignition ($K) by Site

Site	FY05	FY06	FY07	FY08	FY09	FY10	FY11
GA	1,470	1,590	1,635	1,680	1,734	1,790	1,840
NRL	11,049	0	0	0	0	0	0
LLE	39,390	33,242	32,362	41,515	51,770	48,343	48,448
Grand Total	**51,909**	**34,832**	**33,997**	**43,195**	**53,504**	**50,133**	**50,288**

Table C-4. Direct Drive Ignition ($K) by MTE

MTE	FY05	FY06	FY07	FY08	FY09	FY10	FY11
C10.1 Ignition	36,336	25,580	24,631	28,950	32,377	28,996	28,139
C10.7 Facility Ops./Target Productions	15,573	9,252	9,366	14,245	21,127	21,137	22,149
Grand Total	**51,909**	**34,832**	**33,997**	**43,195**	**53,504**	**50,133**	**50,288**

Note: HED capabilities, currently C4 and C10.2 funded, are required for the NIC. These include development and operation of diagnostic calibration facilities (x-rays, optical, and neutron) by Bechtel Nevada and LLNL, development by Bechtel Nevada of dual-purpose diagnostics and capabilities applicable to both ICF and underground test readiness, and micromachining infrastructure and target metrology capability at LLNL.

* Draft, pending FY07 Planning, Programming, and Budgeting Evaluation (PPBE) process resolution.
† Includes NIF Project funding for completion.

Appendix D—NIC Schedule Objectives

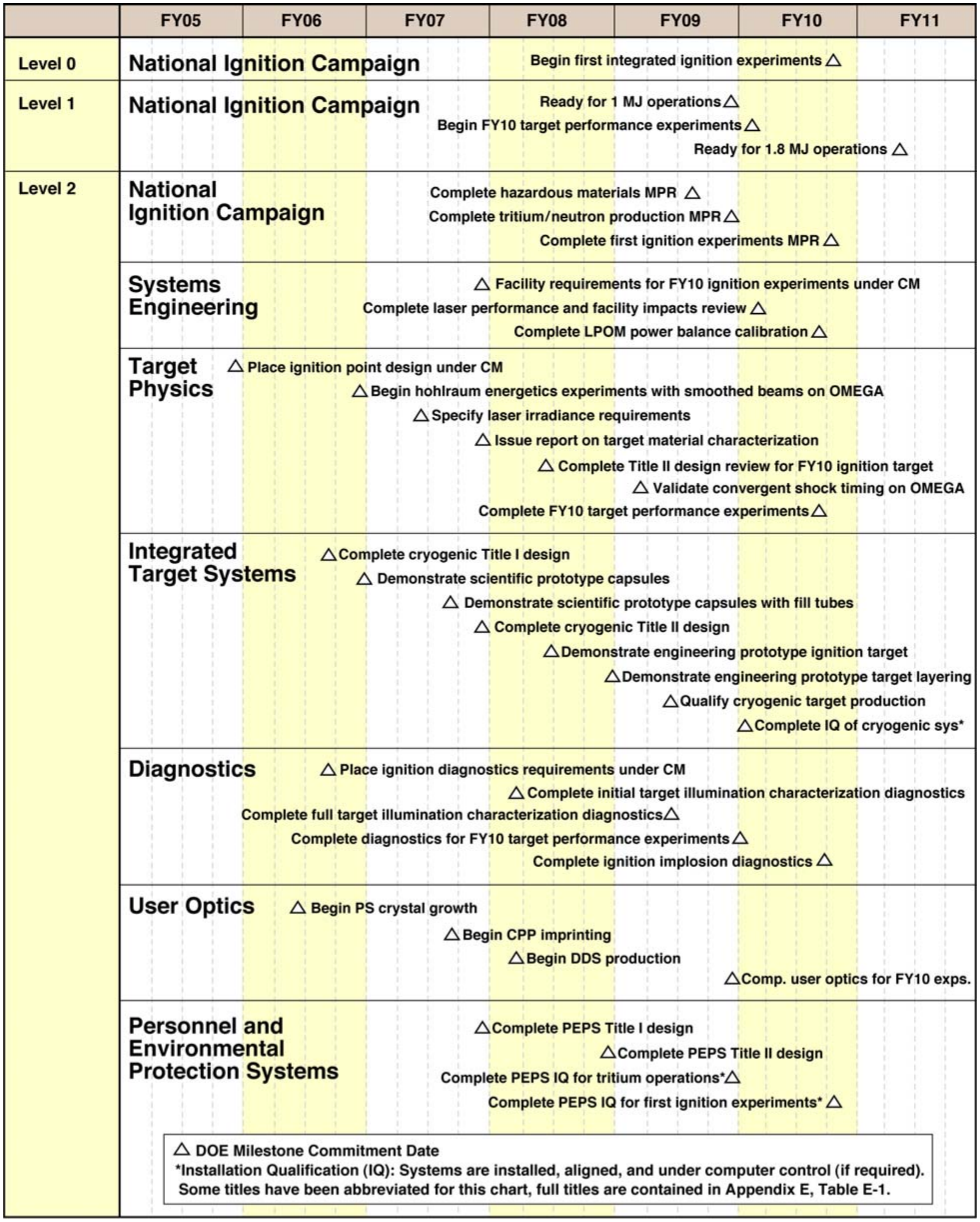

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Figure D-1. NIC Level 0-2 milestones.

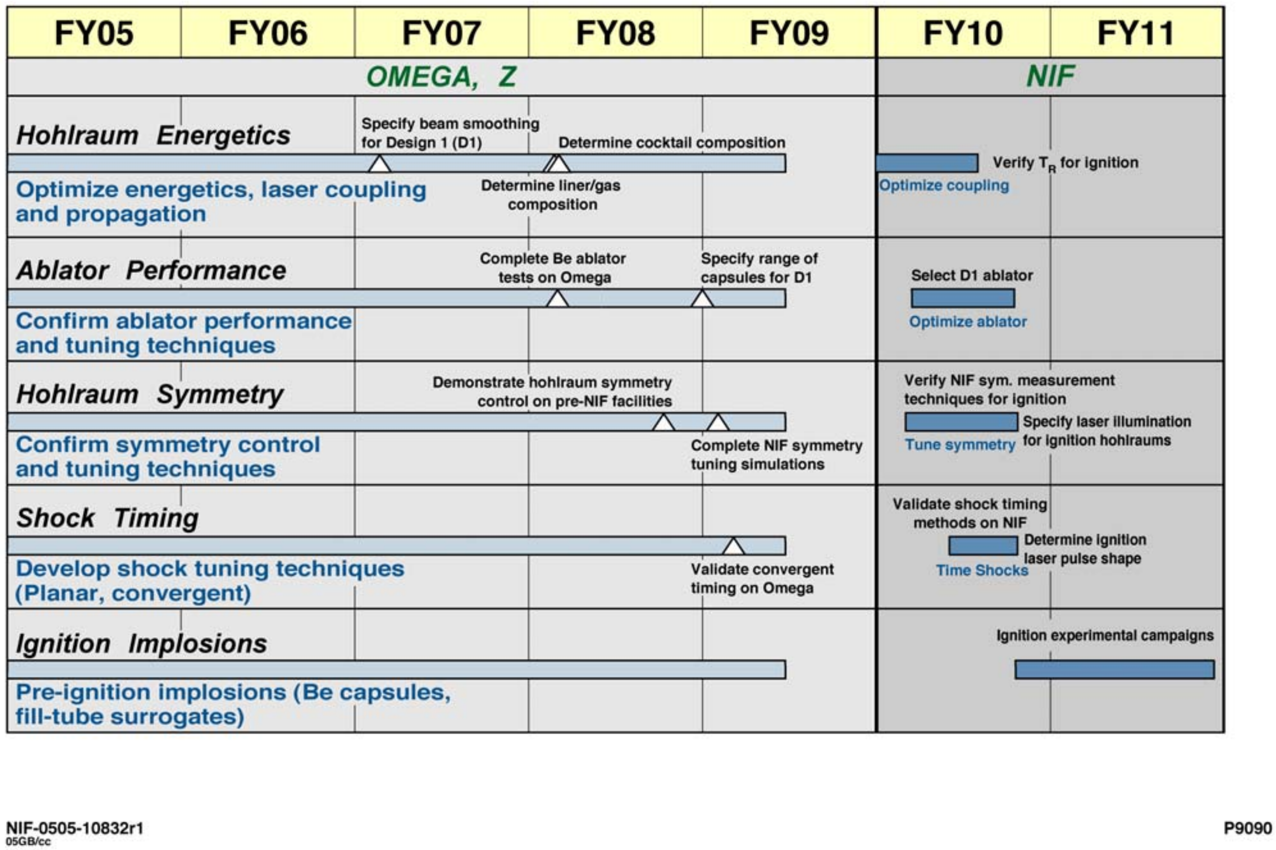
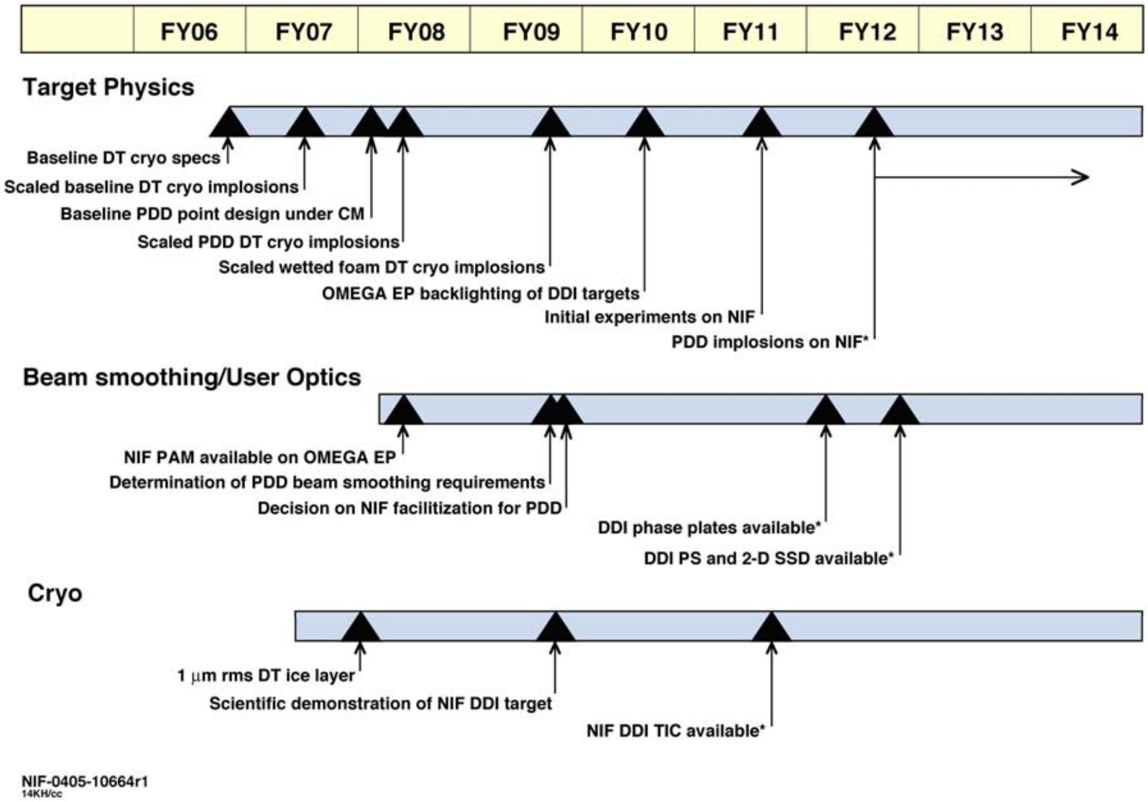


Figure D-2. NIC experimental plan.



***Contingent on FY2009 polar direct drive optics procurement decision and overall ignition progress.**

Figure D-3. Direct-drive ignition plan FY06-FY14. Acronyms in this chart include: deuterium tritium (DT), direct-drive ignition (DDI), polar direct drive (PDD), preamplifier module (PAM), smoothing by spectral dispersion (SSD), and target inserter and cryostat (TIC).

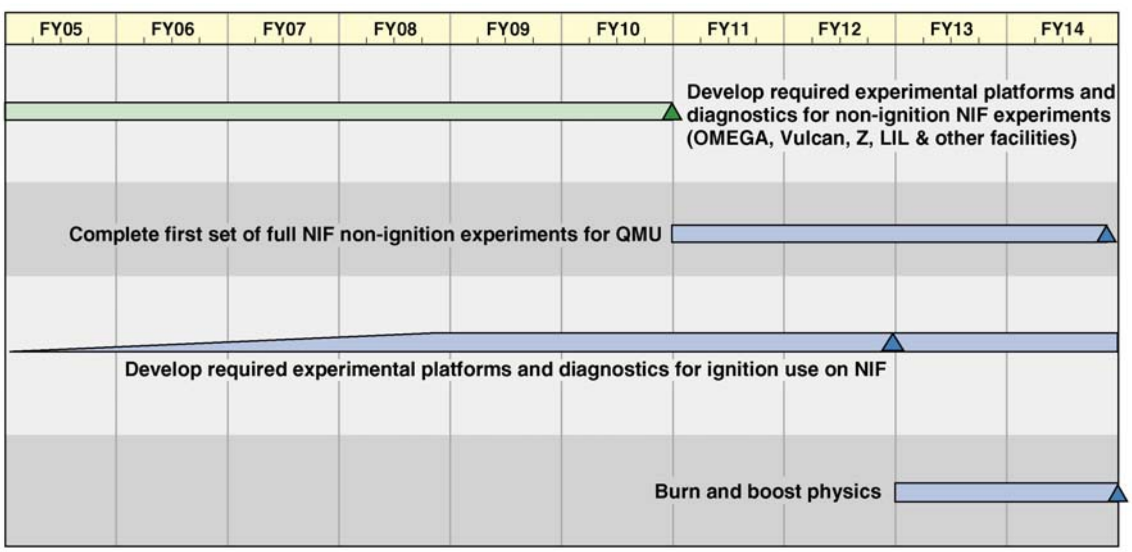


Figure D-4. Draft high-energy-density plan FY05-FY14. Acronyms include Quantification of Margins and Uncertainties (QMU) and Ligne d'Integration Laser (LIL).

Appendix E—Level 0-2 Milestones

Level	Area	Milestone Title	Target FY	Target quarter
0	NIC	Begin first integrated ignition experiments	FY10	Q4
1	NIC	Ready for 1 MJ operations	FY09	Q4
1	NIC	Begin target performance experiments for FY10 ignition experiments	FY10	Q1
1	NIC	Ready for 1.8 MJ operations	FY11	Q2
2	NIC	Complete hazardous materials management prestart review (MPR)	FY09	Q3
2	NIC	Complete tritium/neutron production MPR	FY09	Q4
2	NIC	Complete first ignition experiments MPR	FY10	Q4
2	SE	Place facility requirements for FY10 ignition experiments under configuration management	FY07	Q4
2	SE	Complete laser performance and facility impacts reviews for ignition implosion experiments	FY10	Q1
2	SE	Complete Laser Performance Operations Model (LPOM) calibration for power balance	FY10	Q3
2	Target Physics	Place ignition point design under configuration management	FY05	Q4
2	Target Physics	Begin hohlraum energetics experiments with smoothed beams on OMEGA	FY06	Q4
2	Target Physics	Specify laser irradiance requirements	FY07	Q2
2	Target Physics	Issue report on target material characterization	FY07	Q4
2	Target Physics	Complete Title II design review for FY10 ignition target design	FY08	Q2
2	Target Physics	Validate convergent shock timing on OMEGA	FY09	Q1
2	Target Physics	Complete target performance experiments for FY10 ignition experiments	FY10	Q3
2	Integrated Target Systems	Complete cryogenic target system Title I design	FY06	Q3
2	Integrated Target Systems	Demonstrate scientific prototype ignition capsules (Be and plastic)	FY06	Q4
2	Integrated Target Systems	Demonstrate scientific prototype ignition capsules with fill tubes (Be and plastic)	FY07	Q3
2	Integrated Target Systems	Complete cryogenic target system Title II design	FY07	Q4
2	Integrated Target Systems	Demonstrate engineering prototype ignition target	FY08	Q2
2	Integrated Target Systems	Demonstrate engineering prototype target layering	FY08	Q4
2	Integrated Target Systems	Qualify cryogenic ignition target production capability	FY09	Q2
2	Integrated Target Systems	Complete installation qualification of cryogenic system in NIF	FY10	Q1

2	Diagnostics	Place ignition diagnostics requirements under configuration management	FY06	Q3
2	Diagnostics	Complete initial target illumination characterization diagnostics	FY08	Q1
2	Diagnostics	Complete full target illumination characterization diagnostics	FY09	Q2
2	Diagnostics	Complete diagnostics for FY10 target performance experiments	FY10	Q1
2	Diagnostics	Complete ignition implosion diagnostics	FY10	Q3
2	User Optics	Begin polarization smoothing (PS) crystal growth	FY06	Q2
2	User Optics	Begin continuous phase plate (CPP) imprinting	FY07	Q3
2	User Optics	Begin disposable debris shield (DDS) production	FY08	Q1
2	User Optics	Complete User Optics for FY10 Ignition Campaign	FY09	Q4
2	PEPS	Complete Personnel and Environmental Protection Systems (PEPS) Title I design	FY07	Q4
2	PEPS	Complete PEPS Title II design	FY08	Q4
2	PEPS	Complete installation qualification (IQ) of PEPS for tritium operations	FY09	Q4
2	PEPS	Complete IQ of PEPS for first ignition experiments	FY10	Q4

Polar direct-drive milestones

Level	Area	Milestone Title	Target FY	Target quarter
1	DDI	Decision on NIF facilitization for polar direct drive (PDD)	FY09	Q4
2	DDI	Baseline deuterium-tritium (DT) cryogenic target specifications	FY06	Q4
2	DDI	Demonstrate 1 μm rms roughness DT ice layer	FY07	Q4
2	DDI	Place baseline PDD point design under configuration control	FY08	Q1
2	DDI	Determine PDD beam smoothing requirements	FY09	Q3
2	DDI	Demonstrate scientific prototype of NIF direct drive ignition (DDI) target	FY09	Q3

Appendix F—Hierarchy of Criteria

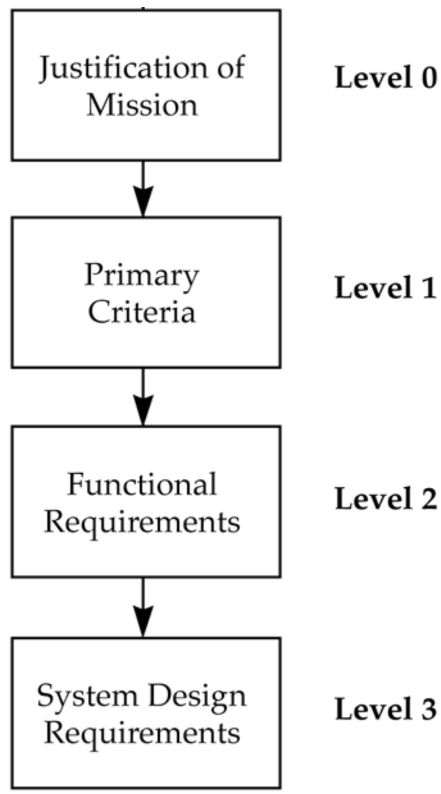


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Figure F-1. Hierarchy of criteria.

Appendix G—NCCB Hierarchy

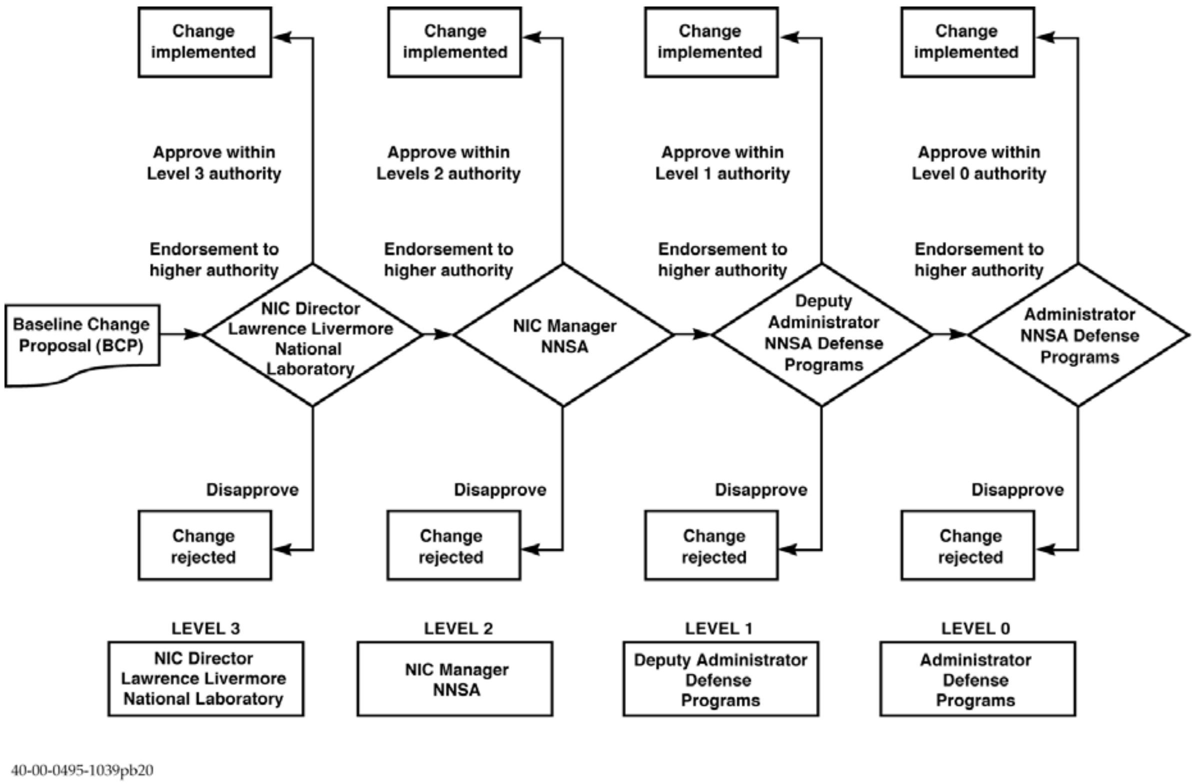

Figure G-1. NCCB hierarchy.

Appendix H—Participant Scope Summaries

H-1. General Atomics

General Atomics (GA) is the Inertial Confinement Fusion Target Fabrication Contractor. It has many years of experience of manufacturing targets for all of the ICF facilities. General Atomics is a major player in all aspects of the integrated target system for the NIC. GA will, with others, develop the techniques for the fabrication and characterization of the ignition capsule and the cryogenic ignition hohlraum. Working at the NIF site, GA will support target development and fabrication and cryogenic fielding of the NIC targets. Working with other sites, GA will support the manufacture and assembly of targets for supporting experiments on the other facilities.

H-2. Los Alamos National Laboratory

Los Alamos National Laboratory is building on its strong history of involvement in indirect drive in formulating its contributions to the National Ignition Campaign (NIC). LANL will continue to make major contributions to five principal areas that build on Lab strengths that are major areas of uncertainty with strong prospects for risk mitigation, and that continue to achieve strong synergy with other high-energy-density programs.

- **Laser-matter interaction / hohlraum development –** A joint LANL -LLNL plan for laser-matter investigations has been developed. LANL will provide unique tools and methods to our collaborative effort with LLNL including improved predictive simulations, new experimental methods, and deployment of experiments to validate simulations. LANL contributions also include the formulation of laser-plasma-instability mitigation methods including hohlraum fill material, special compositional mixtures, or hydrodynamic fluctuations.
- **Ablator development, characterization and testing –** A joint LANL -LLNL plan for ablator work has been developed, involving an accurate predictive model of melt, and study of microstructure seeding of instability that will lead to validation of specifications for the ablator. LANL will provide unique methods (such as diagnostics of melt and material-structure-derived shock imprint) needed to validate ablator specifications.
- **Capsule fabrication research –** Los Alamos has metallurgy characterization capability that has been central in the development of sputtered capsules. The Los Alamos phase contrast imaging system was a central part of the investigation of cryo-layering in Be capsules, and this work will continue. Los Alamos has utilized state of the art diamond Be machining methods to demonstrate machining as a potential backup for mandrel-based fabrication (such as sputtering). The goal is to produce a machined capsule that meets ignition specifications by FY2007.
- **Ignition Target Design –** Los Alamos provides an important collaborative theoretical design capability which also serves to independently corroborate the LLNL design work. One area of Los Alamos concentration is the analysis of fill-tube or joint defects. Los Alamos will supply a 2-3 layer Be capsule ignition design appropriate to machined capsules. LANL also has a strong design effort related to the specification of key diagnostics and interpretation of their signals, such as neutron imaging and burn history.

Los Alamos is also developing unique hot spot models that will increase the confidence in some aspects of ignition design.

- **Advanced Fusion Diagnostics –** Los Alamos will take the lead in providing the NIF neutron imaging system and be a major participant in the development of advanced radiography; reaction history work (gamma-ray bang-time) is not presently in financial baseline.

After validation of the "Title 2" final design of the NIF target in early FY08, Los Alamos efforts will continue in target design and simulations and diagnostic development, while experimental efforts will switch to preparations for the FY2010 NIF implosion campaigns and contributions to symmetry and shock timing diagnosis. During the main ignition implosion campaigns, LANL will have a major role in:

- Hohlraum energetics experiments including diagnosis of laser-matter interaction and implementation of mitigation strategies
- Key diagnostic acceptance tests for burn diagnostics
- Diagnosis of early-time drive symmetry
- Be capsule implosion shots including the precursor non-ignition experiments and the first attempts for ignition

H-3. Lawrence Livermore National Laboratory

The Lawrence Livermore National Laboratory (LLNL) will have overall responsibility for implementing this *NIC Execution Plan*, and managing and coordinating NIC activities. LLNL will provide procedures, processes, and systems for controlling and maintaining the NIC technical, cost, and schedule objectives. These will be applied to budget and schedule planning, change control, configuration management, requirements management, quality assurance, and reporting. LLNL will also provide and implement proven processes for managing the preparation, authorization, and execution of work on NIF, chief among them being the NIF work authorization process (WAP).

LLNL will have additional specific responsibilities described below:

- LLNL will operate, maintain, and manage the NIF and supporting facilities
- LLNL will provide systems engineering, performance modeling, campaign planning and management, and user support
- LLNL, in collaboration with other NIC participants, will establish and maintain the ignition target point design, and perform theory, modeling, and calculations necessary to validate the ignition target point design
- LLNL will collaborate on designing and executing experimental campaigns on NIF, as well as at other participating facilities
- LLNL, in collaboration with other participants, will provide integrated target systems for fabricating, characterizing, and fielding targets, including cryogenic ignition targets, for the NIC
- LLNL, in collaboration with other participants, will provide target diagnostics systems for characterizing and measuring target illumination, x-rays, and neutron yield

- LLNL will provide user optics, including beam conditioning capabilities, disposable debris shields, and operating inventory
- LLNL will provide the personnel and environmental protections systems (PEPS) required to process hazardous materials, and to protect workers and the public from radiation produced by target experiments

H-4. Sandia National Laboratories

Sandia National Laboratories will contribute staff, Z/ZR shots, and associated experimental equipment and targets to support four major task areas of the National Ignition Campaign. The scope of the SNL work includes:

- **Cryogenic Target System.** SNL will be accountable for designing the x-ray shield for the NIC cryogenic target system and for conducting tests on Z/ZR to validate the shield design. SNL will develop a manufacturing plan to fabricate approximately 150 shields per year to support NIF cryogenic target experiments that are scheduled to begin in FY2010. SNL will participate in the regularly scheduled reviews of the cryogenic target system project and will coordinate this activity with NIC project management.
- **NIF Diagnostics.** SNL will help develop and review the strategy for radiation, neutron, and EMP shielding of NIF diagnostics. SNL will also help develop and review the strategy for mitigating the x-ray generated debris produced by NIF diagnostics. SNL will conduct tests of NIF diagnostic components and systems in the radiation, neutron, and EMP environment generated on Z/ZR that is relevant to NIF operation. SNL will also conduct tests to evaluate the utility of using the Z-Petawatt laser system to conduct EMP tests of NIF diagnostic components and systems.
- **National ICF Experimental Campaign.** SNL will conduct experiments on Z to validate computational models of the melting of shocked beryllium capsule material. It is anticipated that the Be melt experiment will use a magnetically-driven flyer plate to launch a strong shock in a Be target and that VISAR will be the primary diagnostic. SNL will continue to collaborate on experiments at the OMEGA facility in areas such as ablator x-ray burnthrough, hohlraum x-ray spectra and its effects upon ablators, and albedo properties of “cocktail” hohlraum walls.
- **Radiography using Short-Pulse Lasers.** SNL will lead a multi-laboratory effort to identify unique high-impact applications for short-pulse laser radiography of capsule implosions on NIF. SNL will develop a plan to test short-pulse laser radiography of NIF-scale integrated capsule implosions on ZR beginning in FY2008.

H-5. University of Rochester, Laboratory for Laser Energetics

The Laboratory for Laser Energetics (LLE) at the University of Rochester is actively involved in and fully committed to the National Ignition Campaign (NIC). In addition to leading the national development of the direct-drive Inertial Confinement Fusion (ICF) ignition option, LLE will use its scientific and engineering expertise to help develop the x-ray drive baseline concept for the NIC.

LLE will lead, in collaboration with the national laboratories, the NIC shock timing campaign. This includes technique development on OMEGA to time four shocks and the timing campaign on the NIF in FY2010 and in subsequent years. This work includes development of platforms to time the first three shocks using velocity interferometry and x-ray radiography to time the fourth shock. LLE will also lead the hohlraum energetics campaign with beam smoothing on OMEGA. In particular, LLE will purchase 42 x-ray drive phase plates for use on OMEGA to assess the predicted increase in radiation temperature with cocktail hohlraums. LLE will be an active participant in the development of diagnostics for the NIF. LLE will provide the Protex (yield), Neutron time of flight (ion temperature), and activation (primary and tertiary yield) diagnostics. In addition, LLE will support diagnostic development on OMEGA by fielding the Magnetic Recoil Spectrometer, providing dedicated diagnostic development and calibration shots, and maintaining the calibration of the Full Aperture Backscattering Station and Near Backscattering Imaging diagnostics. Additionally, OMEGA will support experiments from all NIC participants.

LLE will also leverage its cryogenic target experience in support of the NIC by providing engineering support for the NIC and developing the infrastructure to provide multi-axis viewing of cryogenic targets in hohlraums with x-ray phase contrast imaging and studying the layering physics.