The Scientific and Technological Readiness
of the
National Ignition Facility
for Construction

by
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Presented
to the
National Research Council's
Committee for the Review of the
DOE's Inertial Confinement Fusion Program

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My name is Thomas B. Cochran. I am a physicist and director of the Nuclear Program of the Natural Resources Defense Council (NRDC). I was invited to give you my views regarding the National Ignition Facility (NIF), a Department of Energy (DOE) funded project at the Lawrence Livermore Laboratory (LLNL); and I am pleased to do so.

As you of course are well aware, the charge to this committee during its first year is to conduct an initial review to (1) determine the scientific and technological readiness of the NIF project; (2) assess the entire Inertial Confinement Fusion (ICF) program (including program scope, balance, and priorities; facility operation; experimental theory, etc.) and make recommendations to facilitate the achievement of the scientific goal, which is ignition, and (3) evaluate the capabilities of the ICF program (in conjunction with NIF) to support Science Based Stockpile Stewardship (SBSS). I wish to speak to the first issue—the scientific and technological readiness of the NIF project.

The charge to this committee does not specify what is meant by "readiness of the NIF project." However, as agreed by David Crandell, Director of the ICF/NIF Office at DOE, "readiness of the NIF project" means in this instance readiness to proceed to Critical Decision 3 (CD3), Start Construction.[1] Dr. Crandell has noted in comments to you that the National Research Council's (NRC's) ICF Committee is the last firewall; if the committee certifies the scientific and technological readiness of the NIF project, then construction will go forward. Under DOE's current scheduled CD3 will be made in March 1997. Also, Robin Staffin, Deputy Assistant Secretary for R&D, DP, indicated to this committee that with respect to "Determining Scientific and Technological Readiness for NIF," DOE "Need[s the committee's] report (at least interim) prior to March 1977 for Critical Decision 3 - physical construction of NIF."[2]

I submit NIF is not ready for construction, because: a) there are important remaining physics uncertainties that should be resolved, i.e., there is not now high confidence that ignition can be achieved with the present baseline designs of NIF and the NIF target; b) there are several clearly identified experiments that can and should be performed and evaluated to better resolve these uncertainties; and c) there is no urgency in pressing ahead with NIF construction before these experiments are completed, carefully analyzed, and the analyses peer reviewed.

I begin by setting forth my understanding of salient aspects of the history of the NIF project, beginning in 1989. At that time DOE's ICF Program plan called for the construction at of a Laboratory Microfusion Facility (LMF), defined loosely as a facility with gains greater than about 10 and fusion yields greater than about 30 megajoules (MJ). The National Academy of

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[1] When the Department of Energy's Inertial Confinement Fusion Advisory Committee (ICFAC) was given a similar charge in 1994, it meant "... to assess the technical readiness of the ICF program to proceed to Key Decision 1 (KD1) in the acquisition process for the National Ignition Facility."; Venkatesh Narayanamurti, Chair, ICFAC, letter to Dr. Victor H. Reis, Assistant Secretary for Defense Programs, August 8, 1994. KD1 is "Approval of New Start," i.e., approval to proceed with engineering design, now called Critical Decision 2 (CD2).

[2] Robin Staffin, Deputy Assistant Secretary for Research and Development, Defense Programs, DOE, "What to expect - DOE & NAS, NAS/NRC Review of Inertial Fusion," August 1, 1996, viewgraph.

Sciences' (NAS') Committee for the Review of the Department of Energy's Inertial Confinement Fusion Program, in its January 1990 Interim Report, recommended, ***"As a necessary preliminary to a decision to construct an** LMF*, we recommend a concerted national effort to resolve the most important remaining physics uncertainties about laboratory ignition."[3] (emphasis added)

As noted by DOE, "The NAS Committee recommendations significantly altered the direction of the ICF program, essentially rendering the DOE's previous five-year plan obsolete....[T]he NAS Committee judged the LMF to be too ambitious a step... Accordingly, the NAS Committee recommended a more modest goal, the 'expeditious demonstration of ignition and gain in the laboratory.'"[4] In its Final Report of September 1990, the NAS Committee reiterated its earlier statement, "In target physics, there must be a concerted national effort ***to resolve the most important remaining uncertainties about laboratory ignition***."[5] (emphasis added) Before an ignition demonstration in "NOVA Upgrade," the newly proposed scaled down ICF replacement of LMF, the NAS Committee called for the completion of a "Target Physics Technical Contract," a set of target physics milestones that were set forth in an appendix of the committee's final report. ***These milestones have not been met for the current target design being proposed for NIF.***

At least as early as 1992, Stephen E. Bodner, Head of the Laser Plasma Branch at the Naval Research Laboratory (NRL), was calling attention to the controversy over whether ignition could be achieved with the then proposed NOVA Upgrade. In a June 30, 1992 letter to Dr. Marshall Sluyter, Acting Director of DOE's ICF Office, Bodner made the following observations:

> "**There is a controversy among the ICF labs whether LLNL currently has a working point design[1] for an ignition target.**" (footnote excluded)
>
> "**Experimental studies of asymmetry in Nova hohlraums are in fundamental disagreement with computer simulations.**"
>
> "My recent analyses of P_2 asymmetry in hohlraums suggest that **sufficient hohlraum symmetry can be achieved for an ignition pellet - but only if the laser energy on target is increased to at least 5-10 MJ.**"

In its first meeting of December 1992, DOE's newly formed Inertial Confinement Fusion Advisory Committee (ICFAC) addressed the following issues identified by Bodner: that "time dependent hohlraum asymmetries [is] a critical problem for indirect drive ICF" and that "no

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[3] NAS, "Review of Department of Energy's Inertial Confinement Fusion Program Interim Report" (Washington, D.C.: National Academy Press, January 1990), p. 5.

[4] DOE, "Inertial Confinement Fusion Five Year Program Plan FY 1994 - FY 1998," April 20, 1994, p. ix.

[5] NAS, "Review of the Department of Energy's Inertial Confinement Fusion Program Final Report," (Washington, D.C.: National Academy Press, September 1990), p.10.

satisfactory solution has been found." In its report of the meeting ICFAC said, "In the judgment of ICFAC the issues raised by NRL, while challenging and not yet fully resolved, are being adequately addressed by the ongoing NOVA program and technical contract as specified by the NAS report cited earlier."[6] ICFAC went on to recommend that DOE begin the conceptual design of NIF. On the strength of the ICFSC recommendation, on January 15, 1993, the Secretary of Energy approved the mission need for NIF (Key Decision Zero, or KD0, now called CD1).

The NIF laser, at 1.8 MJ and 500 TW, was designed with a margin to cover uncertainties in the baseline ignition targets.[7] In terms of incident energy the margin was thought to be roughly a factor of two, as ignition had been predicted as low as 900 kJ of laser energy for some targets, while the NIF was designed to put 1.8 MJ on target.[8] A factor of two may appear sound comfortable, however, the margin is vary sensitive to other design parameters.[9] In 1972, LLNL was projecting that targets driven by lasers as small as 1 kJ possibly could achieve ignition—a thousand times less than LLNL's current projection.[10]

In early 1993, the NIF target design was a gold hohlraum with a plastic liner. In the summer of 1993, Los Alamos National Laboratory (LANL) predicted that the plastic lined hohlraum proposed for NIF would not work due to pressure jets resulting from convergence of the liner material along the hohlraum axis. Consequently, ***in the fall of 1993, LLNL changed the NIF baseline target design to the present helium/hydrogen gas-filled hohlraum***.

May 18-20, 1994, ICFAC held a meeting to assess the technical readiness of the ICF program to proceed to the engineering design and the acquisition phase of NIF (Key Decision 1, or KD1). The committee reviewed the NIF conceptual design, the progress in target physics experiments and theory, and the status of integrated calculations of the performance of specific proposed NIF targets. At this meeting LLNL claimed that its experiments with gold hohlraums and large gas bags showed that there was high confidence that the new NIF target design would achieve ignition. LLNL claimed that at "technical contract" radiation temperatures the stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS) were within NIF requirements, there was no evidence of filamentation, and beam bending within the hohlraum was within acceptable levels. ***None of these results were based on experiments with gas-filled hohlraum targets.*** Nevertheless, on the strength of the LLNL presentation 13 members of ICFAC, including Drs. Koonin, Rosenbluth and Kerman of this committee, recommended

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[6] Venkatesh Narayanamurti, Chair, ICFAC, letter to Richard A. Claytor, Assistant Secretary for Defense Programs, December 30, 1992.

[7] John Lindl, *Phys. Plasmas,* **2** (11), November 1995, pp. 3933 and 4014.

[8] B.J. MacGowan, et al., "Laser Plasma Interactions in Ignition-Scale Hohlraum Plasmas," LLNL, February 7, 1996.

[9] See John Lindl, *Phys. Plasmas,* **2** (11), November 1995, 4014.

[10] Ibid., p. 3941.

proceeding to KD1.[11] One ICFAC member, Dr. Timothy Coffey of the Naval Research Laboratory (NRL), felt that the technical uncertainties were still too formidable to proceed to KD1, and opposed the recommendation. The ICFAC transmittal letter begins:

> The Inertial Confinement Fusion Advisory Committee(ICFAC) believes that the Inertial Confinement Fusion (IFC) research and development program has a key role in "science-based stewardship" of the Department of Energy's Defense Program (DOE/DP). ***An essential ingredient in this role will be the achievement of ignition of a fusion capsule in the laboratory.***

On the strength of the ICFAC recommendation, in October 1994 DOE approved KD1, initiating funding of the NIF project, including preliminary design, safety analysis, cost and schedule validation, and preparation of an Environmental Impact Statement (EIS).

Almost immediately after the NIF KD1 Decision, LLNL and LANL began identifying problems with the NIF baseline target in experiments in gas-filled hohlraums and gas bags. These experiments revealed lower than expected peak hohlraum radiation temperatures, larger than anticipated laser-plasma instabilities, evidence of filamentation and large beam bending within the hohlraum. ***None of these gas-filled hohlraum experiments met the "Target Physics Technical Contract" requirements, which had been established when the baseline target was a plastic-lined gold hohlraum.*** Some of the problems encountered had been predicted by Stephen Bodner, at NRL.

Earlier this year (1996) the ICFAC was abolished by DOE, in anticipation that a newly created NRC Committee (your committee) would be established. In its final report of February 21, 1996 to Dr. Victor H. Reis, Assistant Secretary for Defense Programs—reporting on its final meeting held on November 14-15, 1995--ICFAC had this to say about NIF:

> The overall impression of the committee on target physics is that there has been remarkable progress in the last six months. During the three years of ICFAC reviews of ICF, the ICF target physics program for ignition has identified and resolved many potential target physics issues. The peer review and collaboration between the two nuclear weapon laboratories has been largely responsible for the rate of progress in addressing Nova Technical Contract goals. Without major roles for both laboratories in target physics the credibility of reaching ignition will be significantly reduced. There is a much larger base of attractive designs than at the time of KD1 and the case for achieving ignition on NIF has been significantly strengthened since that decision. The program has developed a broader set of tools. In all of the critical areas—cryogenic layer production, hohlraum laser plasmas, and implosions—there is now a substantial data base supporting a good margin of confidence of attaining ignition. **Most committee members believe**

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[11] Venkatesh Narayanamurti, Chair, et al., letter to Victor H. Reis, Assistant Secretary for Defense Programs, DOE, May 20, 1994.

that the probability of ignition has increased above 50%, and some believe that is well above this level. As one committee member put it, the situation has changed from risk reduction to confidence increasing. Although new problems may appear, the committee has seen a high level of ingenuity in the personnel in the program and has confidence that solutions will be found.

The committee recommends that as far as ignition is concerned there is sufficient confidence that **the program is ready to proceed to the next step in the ICF project, that is to go to the final design phase in FY 1997.** (emphasis supplied)

ICFAC stopped short of recommending construction of NIF. Once again, I have been told, some on the committee felt that there was still time to resolve the outstanding target issues before beginning to spend "real money" on construction. There would be another decision point, KD2 (now called CD3), prior to construction. Now we face that decision point in time.

NRL and LANL have made presentations to your committee that identify potential technical "show stoppers" with regard to achieving ignition with the current baseline NIF facility and target. Stephen Bodner, of NRL, argued that despite having made important progress in some areas, the ICF community is not able to accurately model nonlocal thermodynamic equilibrium (non-LTE) atomic physics for high-Z materials, and therefore cannot accurately model the energy balance within the NIF baseline hohlraum target. Despite all the progress that has been made the bottom line has not changed since 1992. If you accept Bodner's argument, the logical conclusion is that ***one must rely much more heavily upon experimental results from Nova, using NIF-like targets with a minimum of scaling and extrapolation, rather than on LASNEX-type modeling, to predict whether NIF will achieve ignition***.[12] In his presentation to your committee, Bodner noted that while LLNL has done wall motion experiments for low-Z plasmas at electron densities outside the range expected for the NIF baseline hohlraum, LLNL has not published, or even presented, data for electron densities expected for the NIF baseline hohlraum.[13] Here, I am referring to the LLNL experiments designed to evaluate energy balance by measuring the motion of the gold/gas interface cited by Bodner. Bodner notes that these experiments should be repeated with CH_4 rather than C_5H_{12} to better simulate a NIF hohlraum.

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[12] It is perhaps worth noting that the physics of thermonuclear weapons can be modeled with greater confidence than the physics of ICF hohlraum targets, in part because of the larger scales involved, and greater reliance on the more exact LTE atomic physics. Nevertheless, the DOE is embarked on an Accelerated Strategic Computing Initiative, a $7 billion program over seven years to upgrade the nuclear weapon modeling capability at LLNL, LANL and Sandia Laboratories. See attached charts.

[13] According to the LLNL viewgraph reproduced by Bodner in his November 4, 1996 presentation to the NRC ICF Committee, LLNL conducted its wall motion experiments using a "Low-Z plasma ($n_e = 0.1\ n_c$). The baseline hohlraum is filled with a 50-50 (atomic) mixture of hydrogen-helium gas at a density of 0.83-1.25 mg/cm^3. Fully ionized, the gas is 3%-4.4% of critical electron density.; William J. Krauser, et al., "Ignition Target Design and Robustness Studies for the National Ignition Facility," *Phys. Plasmas*, **3** (5), May 1996, 2085.

To gain control of SRS and SBS, LLNL is proposing to use spatial beam smoothing using random phase plates on the laser beams, a variant of ideas proposed previously by Osaka University, NRL and Rochester University. LLNL has done this for one of the Nova beams and is in the process of smoothing all ten Nova beams. LANL and LLNL differ on their confidence as to whether the proposed beam smoothing will resolve SRS and BRS backscattering of the laser light. While LLNL is confident that this will resolve the SBS, SRS and filamentation problems, LANL has been far more cautious. In its presentation to this Committee, LANL claimed, "Until we understand dependence on plasma parameters we cannot make quantitative conclusions for SBS and SRS on NIF." Therefore one must rely on the experimental results of the ten Nova beam smoothing experiments to determine whether the SBS, SRS and beam bending due to filamentation are resolvable for NIF baseline targets through laser beam smoothing. ***These ten beam smoothing experimental runs are yet to be performed and analyzed, and the conclusions have not been peer reviewed.*** According to Bodner, even if these results are positive, this still leaves open the question of "spraying" of the laser beams at high electron temperatures. This issue, according to Bodner's presentation to you, may be resolved through additional analysis at NRL and LLNL.

Bodner indicated in his statement to your committee that in gas-filled hohlraums, the laser beams bend in time with swings up to 12 degrees. The laser aiming tolerance is ±0.5 degrees for the inner laser beams and ±3 degrees for the outer beams. LLNL's strategy is to rely upon beam smoothing to reduce the amount of beam bending, and further argues that the cause of the beam bending is understood, the amount of bending is predictable, and therefore any residual bending can be corrected by re-aiming the beams. LANL has been much more cautious in its judgment with regard to the extent to which beam smoothing will reduce the beam deflection and make it reproducible. In its viewgraph LANL was only willing to state that "Random phase plates ***may reduce*** beam deflection in gas hohlraums."[14] (emphasis added) This is not a positive statement in terms of the probability of achieving ignition with gas-filled hohlraums at NIF. Bodner also argues, "The bending may not be fixed by retuning, because of possible time dependence, and because there are two beams that cross each other at the entrance hole."[15] This is another case where a commitment to construction should await the analysis of the results of the ten Nova beam smoothing experiments.

Next, there is the question of whether NIF ignition will be thwarted by the combined effect of various perturbations involving the target capsule, including non-uniformity of the inside of the DT ice shell. While I was not present at the NEC ICF Committee meeting of September 20, 1996, where this issue was discussed, I have been told by someone attending the meeting that there a significant disagreement between LANL and LLNL scientists over LASNEX calculations modeling the effect of the inside surface non-uniformity on ignition. The differences were said to be due to differences in the choice of zones/nodes in the modeling.

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[14] LANL viewgraph, which was also used by Bodner in his presentation to the NRC ICF Committee, November 4, 1996.

[15] Stephen E. Bodner, LRL, viewgraph presented to the NRC's ICF Committee, November 4, 1996.

William Krauser, a member of the LANL team that has been conducting target design and robustness studies[16] and who presented the LANL results at the NRC ICF Committee's September 20, 1996 meeting, has informed me that there was no real disagreement between LASL and LLNL, and that this is not a "show stopper." Having to rely on conflicting memories of scientists attending an NRC committee meeting, I am unable to ascertain whether this is an important unresolved issue.

Finally, there is the issue raised by Bodner with regard to whether there is adequate diagnostics to analyze the time-dependent asymmetries in NIF targets. Bodner raised this issue in his paper, "Time-Dependent Asymmetries in Laser-Fusion Hohlraums," *Comments on Plasma Physics and Controlled Fusion*, Vol. 16, 1995, pp. 351-374. LLNL claims they have a radiographic technique whereby a foam sphere is used in place of the capsule. This and a complementary technique are described by John Lindl in "Time-Dependent Asymmetries in Laser-Fusion Hohlraums: A Response," LLNL, UCRL-JC-122654, November 1995, pp. 25-27. Bodner claims that the two most recent LLNL papers on this issue, by Amendt, et al.,[17] contain errors and prove nothing.

These outstanding physics issues which bear on whether ignition can be achieved with NIF, should be resolved—at least the differences should be greatly narrowed—before committing to NIF construction. Your own deliberations are not the appropriate mechanism for resolving these issues. These issues cannot be waved aside, as some might suggest as "typical of uncertainties that are always present in large-scale undertakings of this kind." It is incumbent upon this committee to reach beyond such sweeping generalities and address the specific unresolved physics issues on a case by case basis:

- Does the committee have confidence that wall motion and x-ray conversion in gas-filled hohlraums are understood? Shouldn't the proposed CH_4 experiments at high laser intensity be conducted and analyzed, and the analyses subjected to peer review prior to commencing construction of NIF?

- Does the committee have confidence that the effects of laser plasma instabilities due to SBS and SRS can be adequately controlled through beam smoothing and lowering the laser intensity? Shouldn't the ten beam smoothing experiments be completed, analyzed, and the analyses subjected to peer review prior to commencing construction of NIF? Should further gas bag experiments be performed to understand remaining uncertainties in SRS and SBS scaling before commencing construction of NIF?

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[16] William J. Krauser, et al., "Ignition Target Design and Robustness Studies for the National Ignition Facility," *Phys. Plasmas*, 3 (5), May 1996.

[17] Peter Amendt, et al., "Witness Foam-Ball Diagnostic for Nova Hohlraum Time-Dependent Drive Asymmetry," *Rev. Sci. Instrum.*, 66 (1), January 1995, 785-787. The second paper is a preprint; Stephen Bodner, private communication.

• Is forward beam spraying sufficiently well understood? Is it a problem of uncertain significance? Should it be better understood before commencing construction? Shouldn't the ten beam smoothing experiments be completed, analyzed, and the analyses subjected to peer review prior to commencing construction of NIF?

• Is beam bending adequately understood? Shouldn't the ten beam smoothing experiments be completed, analyzed, and the analyses subjected to peer review prior to commencing construction of NIF?

• Is there a working diagnostic for time-dependent asymmetries? Are there serious errors in the papers by Amendt, et al.? Shouldn't this issue be resolved prior to commencing construction of NIF?

• Are there important unresolved issues related to capsule performance assuming expected inside and outside surface perturbations, and lacking resolution of any of the above issues?

I also wish to add that I am appalled by the heavy reliance on viewgraph presentations to this committee, rather than reliance on carefully documented reports that have undergone thorough peer review, particular given the importance of the NIF construction decision and the controversy surrounding whether ignition can be achieved with NIF. Demonstration that these physics issues have been resolved, and a clear demonstration that the "Target Physics Technical Contract" has been met for the current baseline NIF target, should have been provided to this committee in the form of one or more peer reviewed technical documents. In this regard, as I indicated in my November 1, 1996, letter to Chairman Koonin, Stephen Bodner published his critique of NIF in "Time-Dependent Asymmetries in Laser-Fusion Hohlraums," *Comments on Plasma Physics and Controlled Fusion*, Vol. 16, 1995, pp. 351-374. John Lindl provided a response in "Time-Dependent Asymmetries in Laser-Fusion Hohlraums: A Response," LLNL, UCRL-JC-122654, November 1995; and has published the first part of this response: "Time-Dependent Asymmetries in Laser-Fusion Hohlraums, A Response (Part 1)" *Comments on Plasma Physics and Controlled Fusion*, Vol. 17, 1996, pp. 221-247. Bodner has not submitted for publication a response to Lindl's Part 1. This may be due to the time constraint, or because he is waiting for Lindl's Part 2. Presentations by Bodner and others before your committee are evidence that these physics and diagnostic issues are still unresolved and the case for having confidence that NIF can achieve ignition is not adequately documented and peer reviewed. Bodner still maintains that Lindl's analysis is wrong.

Since the initial appeal for funding of NIF, the Congress and the public have been told that its purpose--its *raison d'être*--was to demonstrate ignition of fusion energy on the laboratory. For example, the DOE's FY 1997 OMB Budget Submission states:[18]

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[18] DOE FY 1997 OMB Budget Submission, at Project No. 96-D-111; reproduced in DOE, "National Ignition Facility Project Execution Plan," April 1996.

> The project provides for the design, procurement, and construction of the National Ignition Facility (NIF), an experimental inertial confinement fusion facility ***intended to achieve controlled thermonuclear fusion in the laboratory*** by imploding a small capsule containing a mixture of hydrogen isotopes, deuterium, and tritium. (emphasis added)

And DOE's *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, September 1996 [hereafter, "SSM PEIS"] states,

> NIF would contain the world's largest solid-state laser system, which ***would be used to achieve ignition of nuclear fusion in the laboratory for the first time.*** NIF would perform fusion, high-energy-density, and radiation-effects experiments in support of the stewardship of the Nation's stockpile of nuclear weapons and other basic and applied science objectives.[19] (emphasis added)

The prerequisite to a decision to construct NIF was established by the NAS Committee in 1990—to resolve the most important remaining physics uncertainties about laboratory ignition. This requirement was endorsed by ICFAC, the predecessor to this committee. "Scientific and technological readiness of the NIF project" for construction means a finding by this committee that the most important remaining physics uncertainties about laboratory ignition have been resolved. It does not mean "good progress has been made," of "ignition is not essential to stockpile stewardship," are several other formulations. The goal post has been established. This committee can decide whether these most important remaining physics uncertainties have been resolved—and clearly they have not—or this committee can attempt to move the goal post. If the committee choose the latter course, it will open itself to potential public ridicule.

A number of arguments have surfaced for dismissing the concern over ignition—for moving the goal post: "LLNL is making progress, they are bright people, and there are many variables with which to work, so do not break the program momentum;" "ignition is not important to stockpile stewardship;" and perhaps most important to some, but never publicly articulated, "take the money while it is available." The last argument is not worthy of a response. With respect to the "momentum" argument, I simply note that this is a very difficult problem. LLNL, and their ICF colleagues in other institutions, have spent the last four years trying to resolve these issues, but they have not done so. They need and deserve more time.

With respect to the stewardship issue, I first, remind this committee of ICFAC's statement cited above, namely, that ICF research and development has a key role to play in DOE's science-based stewardship program, and "an essential ingredient in this role will be the achievement of ignition of a fusion capsule in the laboratory." I also submit that there is absolutely no urgency to construct NIF before resolving at least those outstanding scientific and technical issues that can be resolved. NIF's primary stewardship role is to "preserve a core of intellectual and technical competencies of the weapon laboratories." As evidenced by the attached charts, prepared by my colleague Christopher Paine, the weapon labs have numerous

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[19] SSM PEIS, Vol. III, p. I-3.

other facilities that that will serve this same purpose while this program goes forward. There are ample other facilities for conducting high energy density physics for stewardship.

If the NIF construction decision, CD3, had been scheduled for March 1998, instead of March 1997, would it have been detrimental to stewardship? Not in the least. It would be disappointing to some, but not detrimental to the nation, or to the program. The right way is for the construction decision to be driven by—determined by—the physics.

The NIF stewardship role can and should begin now, rather than waiting for construction of NIF to be completed. Resolving the most important remaining physics uncertainties about laboratory ignition, and demonstrating with high confidence that NIF can achieve ignition, are worthy and challenging goals that can be pursued now as part of Science-Based Stockpile Stewardship. And if the nuclear weapons stewardship program is to serve the country well, we should instill in the stewards a work ethic that encourages them to be conservative and cautious--dotting all the "i"s and crossing all the "t"s--when reaching critical decisions. Surely, you would not want our stewards drawn form a cadre of people who would make important decisions, such as building a billion dollar fusion machine, before carefully demonstrating and documenting that their decisions are technically sound? It would be ironic indeed if the SBSS Program met its first big challenge by, in essence, rolling the dice and hoping for the best, while sucking up billions of dollars of the taxpayers money.

Stockpile "Stewardship" Tasks

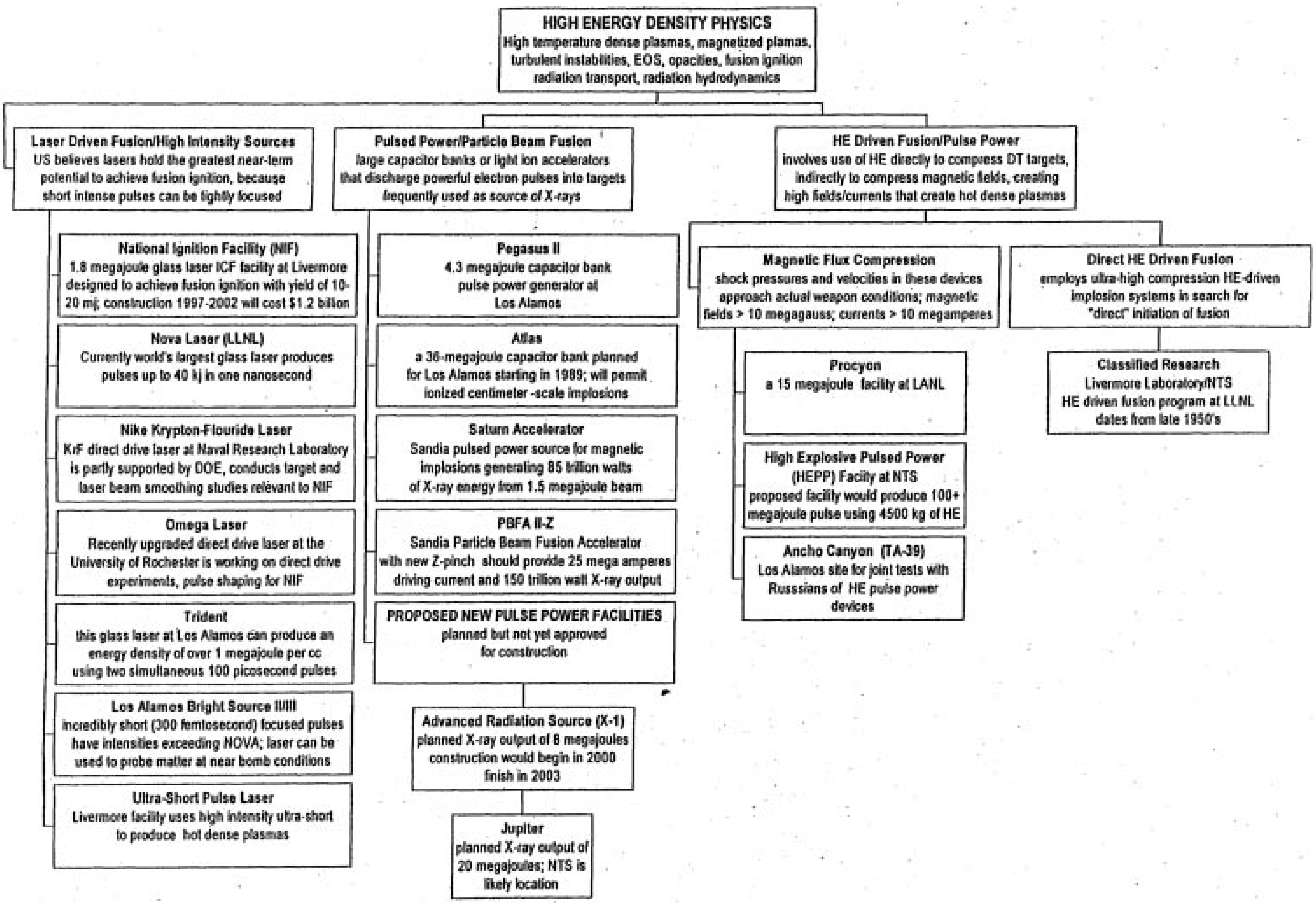
Science Based Stockpile Stewardship

COMPUTER MODELING
hydrodynamic codes
neutronic codes
radiation transport, etc.

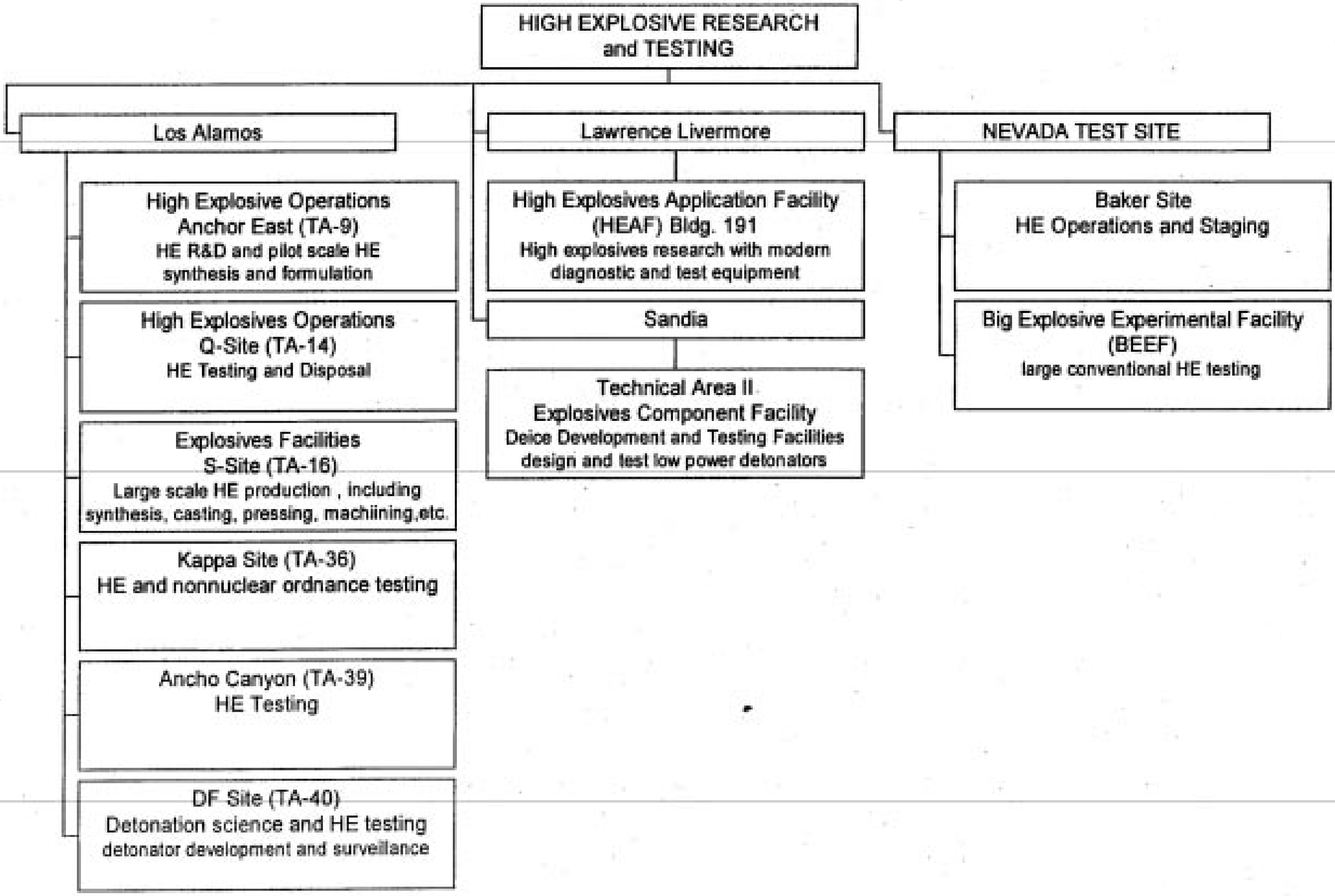
HIGH EXPLOSIVES R&D
HE synthesis and formulation
low power detonators
initiators and timers

LOW ENERGY IMPLOSION PHYSICS
radiographic hydrotesting
fast critical assemblies
subcritical experiments

HIGH ENERGY DENSITY PHYSICS
EOS at high temperatures, opacities
radiative transport, radiation-driven
hydrodynamics, DT ignition

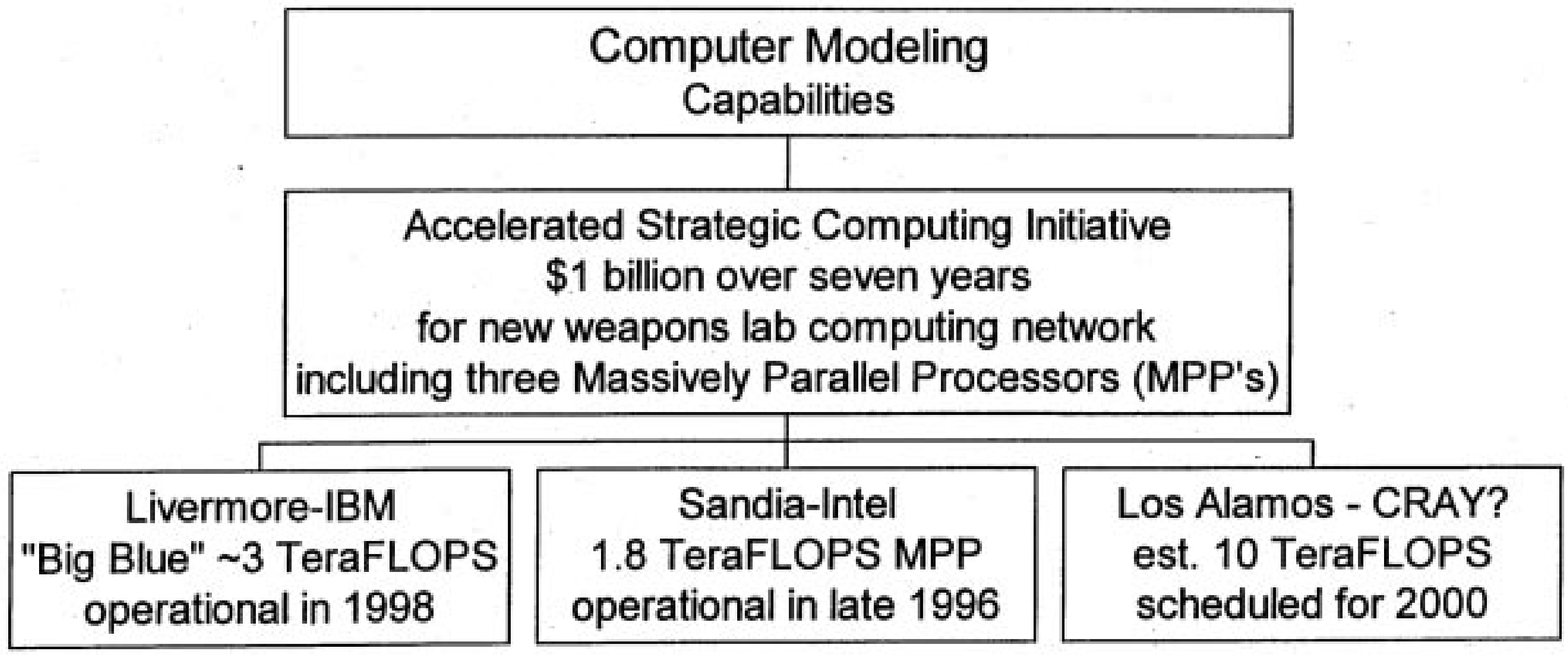


Christopher Paine, NRDC, 11/21/96

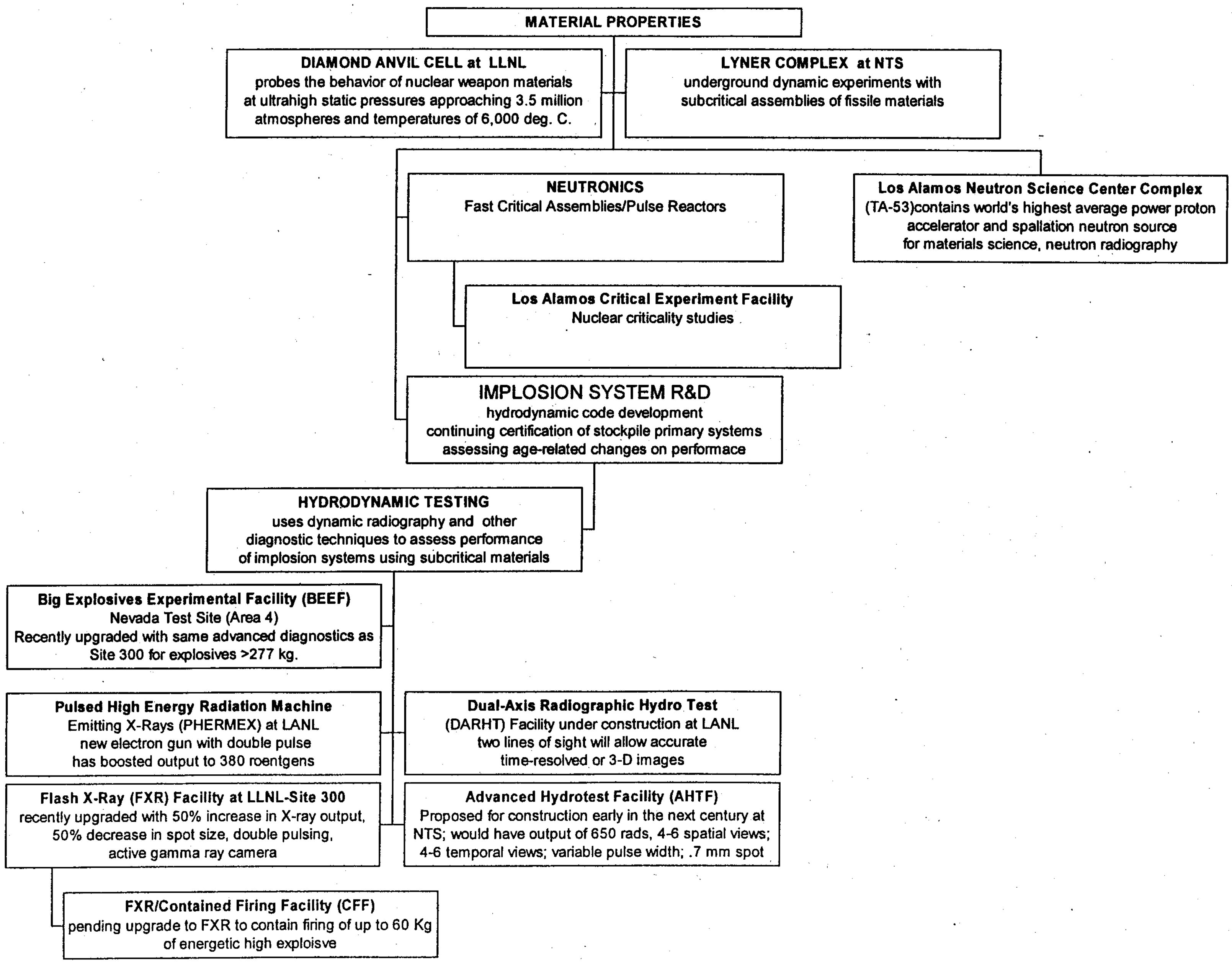


Christopher Paine, NRDC, 11/21/96

Accelerated Strategic Computing Initiative (ASCII)



Christopher Paine, NRDC, 11/21/96



Christopher Paine, NRDC, 11/21/96