

**FAS-NRDC  
DISCUSSIONS IN PARIS  
REGARDING THE NECESSITY OF NUCLEAR TESTS  
FOR MAINTAINING A RELIABLE FRENCH NUCLEAR FORCE  
UNDER A COMPREHENSIVE TEST BAN**

by

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We thank our interlocutors in Paris and hope that they will find their views presented fairly in this report.

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## READER'S NOTE

The discussions reported on below were held in Paris from November 2 - 7, 1994. On November 8, a major shift occurred in the political environment in the United States that may seriously affect the prospects for achieving a CTB, so the views outlined in this report should be read in that light. It appears to us that much of the evolving willingness of French nuclear officials and politicians to entertain the prospect of a CTB derives from the perception that many other states -- the United States in particular -- are committed to achieving this objective, and that France not be perceived as the spoiler in the European community or the world as a whole. Somewhat to our surprise, we discovered that the French nuclear weapons community was coming to accept the political inevitability of a test ban, and that a technical consensus was emerging on what needed to be accomplished in a short test program at Mururoa prior to France's entry into a CTB by late 1996.

The impact of the Republican conservative sweep in the U.S. elections on U.S. policy toward a CTB is unlikely to be positive, and the perception of a weakening U.S. commitment could foster a strategy of delay on the part of France. In any case, we were told that French CTB policy will not be clarified until after the May 1995 presidential elections. But a hint of what the U.S. political shift might mean came from René Galy-Dejean, the Rapporteur of the Assemblée Nationale defense committee report on future French nuclear test simulation capabilities: "In things that are essential to national security, national egoism always wins out. We don't know who the future U.S. president will be. But it is my duty as a French responsible leader to consider our own notion of security, as well as to advance nonproliferation and the banning of nuclear weapons....France is seeking its own position."

## ***Introduction***

In mid-August 1994, Christopher Paine of NRDC and Richard Garwin of FAS began to explore whether it would be productive to schedule an FAS-NRDC trip to improve our understanding and perhaps that of French officials in regard to the necessity or lack thereof of nuclear testing for maintaining a reliable stockpile under a Comprehensive Test Ban Treaty.

Both parties had obtained in early 1994 the very interesting Rapport d'information No. 847 of December 1993 from the Assemblée Nationale, "La simulation des essais nucléaires" with René Galy-Dejean as Rapporteur, with co-authors Jacques Baumel, Jean-Michel Boucheron, Daniel Colin, Pierre Favre, and Pierre Lellouche, all Députés of the Assemblée Nationale. The Rapport emphasizes "the system of simulation known as PALEN-- Préparation à la limitation des Essais Nucléaires."<sup>1</sup>

FAS and NRDC have cosponsored six international workshops on CTB and nuclear weapon elimination in conjunction with the Academy of Sciences, Ministry of Atomic Energy, the Moscow Physical-Technical Institute (MPTI), and other Russian entities. We have also collaborated on other enterprises, such as a June 1993 trip to Beijing for discussions with Chinese officials regarding nuclear and hydronuclear testing.

Garwin called upon some of his friends and colleagues in Paris to learn the names of those who would be informed and influential on nuclear testing issues, and who would have a spectrum of views. Chief among these colleagues is Dr. Venance Journé, of the Centre International de Recherche Sur l'Environnement et le Développement (CIRED) who now works in energy and environment but until recently was a high-energy (particle) physicist.

Dr. Journé was indispensable in serving as a local point of contact in dovetailing various potential engagements and in following up to obtain responses to the letters requesting appointments. The Appendix (pages A1-A2) contains an example of the letters, from Garwin to Jean-Michel Boucheron.

When we began, we were flexible about the size of the FAS-NRDC contingent and the format of discussions, not knowing whether it would be possible to meet with a substantial group of officials in a workshop format. It soon became evident that we would be able to arrange effective meetings in Paris with only one or two officials at a time, given the difficulty of coordinating schedules for a larger meeting. The meetings followed a prescribed format, with Garwin introducing himself, Kidder, Paine and (where present) Journé, by referring to the letter requesting the meeting, and also presenting a two-page paper (Appendix pages A3-A4) as an aide-memoire.

We expressed our concern that the Assemblée Nationale report, although extremely interesting and substantive, drew the wrong conclusions because it appeared to be premised on the mistaken belief that the United States has already developed, and intends to rely upon, a comprehensive "simulation system" to replace the nuclear tests that will be banned under a CTB. The report concludes that France requires a similar simulation capability that would

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<sup>1</sup> Preparation for limitations on nuclear testing.

require calibration by an unknown number of nuclear explosive tests before France could be confident of maintaining its nuclear deterrent under a CTB.

Christopher Paine then typically took up both the political aspects and some of the technical points that needed to be reinforced, and Ray Kidder lent expertise and authority in his discussions of hydronuclear experiments, the role of nuclear versus non-nuclear testing in stockpile maintenance, laser-driven fusion explosions, and reusable containments for low-yield tests.

We emphasized that the design of nuclear weapons has always been based primarily on computations, and subsequently computer "simulations." These simulations are based on the known laws of physics and properties of matter, but also make use of simplified physical models and numerical approximations to describe processes too complex to allow precise description on first-principles alone. These models contain adjustable parameters, so adjusted to provide a best-fit between computed and observed results in nuclear, hydronuclear, and hydrodynamic tests. These computer simulations are therefore partly "first-principle," and partly empirical.

If nuclear explosive tests could no longer be conducted under a CTB, hydrodynamic (and perhaps hydronuclear) studies of the implosion phase of the primary could still be done, and the information obtained used to possibly extend and improve the computer simulation of primary<sup>2</sup> implosions. However, the experimental study of the boosting process, the primary explosion, energy transfer to the secondary, the secondary implosion, and secondary explosion could not be done. Experiments with NIF (the National Ignition Facility) would have only marginal -- and possibly zero value if ignition is not achieved -- in improving the computer simulation of these aspects of thermonuclear weapons.

We emphasized that France can avail itself of experimental and test facilities comparable to those planned in the U.S., if it wishes to do so, including even facilities on the scale of the \$1.2 billion National Ignition Facility, and we cited the cooperative Livermore - Limeil program in laser fusion as an example. However, we noted that French decisionmakers should understand that such large, expensive new facilities are not technically required to maintain the French nuclear weapon stockpile, but rather may serve, along with more directly relevant computational efforts, to maintain the interest and skills of a scientific cadre whom France might call upon at some future date to resume the testing of thermonuclear weapons, if future strategic developments, such as the deployment of Russian ABM defenses, should prompt a French withdrawal from the CTB.

***11/02/94 1600 Meeting with a member of the Commission du Livre blanc***  
 ("Livre blanc<sup>3</sup> sur la défense 1994")

In France there are only about six or seven people with access to the full range of scientific data regarding nuclear weapons testing and stockpile maintenance that is needed to have an

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<sup>2</sup> The French term for primary is "l'amorce."

<sup>3</sup> (White paper on defense), March 1994, with prefaces by Prime Minister Édouard BALLADUR and Defense Minister François LÉOTARD

informed technical opinion. All of them mix technical knowledge with their views of what is required to support deterrence. For instance, Roger Baléras, the former director of the CEA/DAM. You ask them, "Can we keep the present stockpile reliable without testing?" and the answer is "No, because of the absolute necessity to adapt or modify French deterrent systems."

For example, in some circles nuclear deterrence of the "weak-to-the strong" (e.g. offsetting the Warsaw Pact's numerical conventional superiority with tactical nuclear weapons) is becoming deterrence of "strong to the weak" (e.g. low-yield "micronukes" to deter future Iraqs-- Baumel is one of the exponents of this view).

Since Mitterrand could not ascertain what, if any technical adjustments to existing weapons were needed to be made prior to ending testing, he decided to make the decision purely on political grounds -- chiefly, the need to strengthen the nonproliferation regime. The Chief of Staff of the Armed Forces did not know in advance about the moratorium initiative of April 1992, nor did the Minister of Defense. Once the President had decided on the moratorium without consulting the Chief-of-Staff, the testing issue bounced back to the politicians. No one really focused on the issue until the Chinese resumed testing in October 1993. The RPR (Party), especially Chirac, is challenging Mitterrand, and they argued that testing should resume immediately.

The French Assemblée Nationale does not have the oversight power that the U.S. Congress does. There is a very narrow technical community, all insiders. In the view of most politicians, nuclear affairs are a matter for national consensus, not to be probed too deeply. "Those who know don't speak, and those who speak don't know."

Regarding the Livre Blanc ("White Paper") on defense, 25% of the people involved in its preparation say "No test ban; we will sometime need to test for low-yield nuclear weapons to counter proliferation." And 25% want to counter proliferation by a CTB, in order to get an NPT.

The remaining 50% in the middle reflect serious people who believe that:

1. We can maintain technical credibility of deterrence without testing; and
2. We require testing if we are to develop new weapons. Until last year the nuclear forces were: Force Océanique Stratégique (FOST), Force Aérienne Stratégique (FAS), Force Aérienne Tactique (FAT), and Pluton; but now Pluton is scrapped, and will not be replaced by Hadès. In fact, Pluton was "pré-stratégique." All this happened pre-White Paper.
3. The U.S. is clearly ahead in readiness for a test ban-- because weapon designers in France do not yet have a comparable simulation capability. So it is more difficult for us (France) to have a CTB. So the question becomes, when can we sign, for how long, and how many tests will we need before we can sign?

GARWIN, KIDDER, and PAINE made the following comments:

The stated requirement for PALEN is for "simulation," not merely experimental facilities to maintain the interest and expertise of nuclear weapon designers. The Assemblée report talked about a "simulation system."

It was unclear to us why the October 5, 1993 Chinese test should influence any French decision to resume testing. The issues of confidence in current nuclear weapon designs, and possible future requirements for new designs, were both matters for French national decision, and the Chinese nuclear deterrent clearly is not aimed at France.

In the end there should and likely would be a supreme national interest clause in the CTB treaty, rather than the JCS/DoD-inspired U.S. position favoring review and possible early withdrawal after 10 years without invoking supreme national interest.

To make progress in the talks in the context of the current arrangements for coordination among the Perm 5, French cooperation was needed, but the French delegation in Geneva appeared to have no instructions other than to delay resolution of the outstanding issues.

How about a compromise position -- a few tests? The PALEN requirement is not at all helpful in this regard.

The member of the Commission remarked that if a Gaullist is elected President, and there is huge pressure, he won't be able to sign a test ban. But they (the Gaullists) could say initially "in ten years, and that might go to seven, six, five years... "

(The balance of this meeting was spent in a helpful survey of the political landscape and the general stance of important personages on nuclear weapons issues, and will not be summarized here).

***11/02/94 1730 Amiral Jean BÉTERMIER (Ret.)***

(He is an ex-carrier pilot and former commander of the aircraft carrier Clémenceau, and had four years in charge of nuclear planning for the Joint Chiefs in the late 1970s. He volunteered that he was not responsible for adjectives or adverbs in the AN report, although he had been technical advisor to Baumel.)

BÉTERMIER asked if we had met with Roger Baléras, formerly head of DAM (Direction des Applications Militaires) at CEA until August 1994, the job now held by Jacques Bouchard. Baléras had been in charge of weapon development as well as testing, and we were told by Admiral BÉTERMIER that Baléras was also a substantive expert in plutonium metallurgy, etc.

BÉTERMIER quoted Baléras as saying that the difference between the French view and the American view arises from technical differences, and the level of integration in the nuclear weapons.

BÉTERMIER quoted Baléras as saying that the French needed a new family of weapons that would be less "sensitive" (presumably to aging effects and small deviations from production specifications).

KIDDER: When the United States tests for reliability, we pick a weapon from the stockpile that has the minimum amount of plutonium, and with the greatest age of boost gas, in order to maximize the probability of failure. So when they don't fail, we are confident that the average weapon will work.

GARWIN: We do not have in the United States a simulation capacity that would enable us to certify a weapon of new design without test. Everybody agrees that one could design a robust non-boosted weapon without test. But there is no interest in doing that, because our high-performance systems are adequately robust, and I, personally, would not favor putting such new weapons into the stockpile.

PAINE: The U.S. has not constructed a "nuclear test simulation system."

BÉTERMIER: The PALEN concept was tabled before the 1992 Mitterrand decision -- even during the Carter Administration (which also sought to negotiate a CTB.) The original purpose was to expand measurements, to increase the amount of information obtained per test. But because of the budget, we had no additional tests beyond the program already decided.

PALEN was initially designed to reduce the number of tests required to develop new weapons and therefore to reduce the cost.

Now the French are looking at PALEN as a means to develop more robust weapons, and the simulation capabilities for these weapons. But the purpose is to ensure the reliability not of the stockpile but of the remanufacturing capability. We are considering injectable liquid or slurry explosive.

Also, we don't have the same flexibility in the new strategic environment; we don't have the same flexibility that the U.S. has in view of the greater number of U.S. weapons.

We also need variable-yield designs, including one with much lower yield.

In the year 2010, we will field the M5 -- much longer range than the current missile, and we will need to change the warhead to protect against the greater thermal stress. By the year 2010, the ASMP will become the long-range ASLP. ("Medium-range" will become "long-range").

The M5 was scheduled pre-moratorium for the year 2005, but the moratorium delayed it five years.

The ABM Treaty was rather convenient for us; we did not need to increase the numbers of submarines, weapons, and penetration aids. When Reagan in 1983 began the SDIO, Mitterrand was very much against it.

Now more people are thinking that some kind of defense should not be dismissed (Conze-Bétermier paper).

ATBM is a sensitive issue. An ATBM defense line in the South of France would mean that the Maghreb would be considered as our potential enemy, or maybe the ATBM would simply be regarded as demonstrating a desire to attack them.



BÉTERMIER once again said that we ought to talk with Roger Baléras, and that he would be seeing Baléras and would ask whether Baléras could meet with us.

We left Bétermier at about 1900, and at 2000, he called Garwin at the hotel to say that Baléras had agreed to meet with us the next day, Thursday 11/03/94 at Les Invalides. In fact, he called Thursday morning to change the appointment to early Friday morning at CEA, the location being Baléras' choice.

***11/03/94 0900 Jean-Michel BOUCHERON***

(Socialist member of the Defense Committee, at l'Assemblée Nationale, accompanied by Dr. Venance Journé)

BOUCHERON: Our objective is non-proliferation. Physicists say it is much more difficult to design weapons by computer than by computer plus tests; the more difficult it is to make weapons by computer, the more we want a test ban.

Regarding new types of weapons, they are not useful. 500-600 warheads are amply sufficient. 1000 are enough for U.S. security. We are counting on pure deterrence and not a war-fighting weapon. A political weapon. The weapons will be targeted on cities, not against weapons. A major attack on France could kill all 60 million French people; we just want to make sure that there would be more dead people in a country making such an attack, which we consider as "deterrence of the weak to the strong."

This is very simple, but very effective. Especially because we live on the European continent. The United States has a vast ocean on each side. Fifty years ago, people rang the doorbell to take families to the concentration camps in France, and we all remember that, and that is why we have nuclear weapons.

Now we have the Russians instead of the Soviet Union, but they are like the Chicago of the 1930s. The Russians never knew democracy. Also there is tremendous Islamic pressure from the South.

It is not of interest to have new, small nuclear weapons.

The AN report is not important. There is a group who want to test. Thus, 5000 military go to the Pacific; 5500 very good researchers in CEA work on nuclear weapons; there is a whole industry of nuclear testing, a "culture of nuclear tests."

Every time there is a test, France is saying to the world "We have the nuclear weapons." It is important that not only the leaders, but that the public opinion know we have nuclear weapons. But this small advantage must be weighted against the good of the CTB.

There is a small but powerful lobby. This government has inherited De Gaulle's nuclear policy, but De Gaulle was fighting against flexible response.

Really no one has said "I am against the political decision, and if elected I will resume tests."

PAINE: Except Léotard.

BOUCHERON: I have spoken with him about this. He was wanting to please his lobbies. In fact, he said it is the new President who will decide.

The government could make a nuclear test, but they say that it depends on the President. Not so. Constitutionally the use of a nuclear weapon is the power of the President. However, the (center right) government shelters behind the President by saying that the President himself must authorize tests; this is not true.

PAINE: It seems that the political people should have more confidence in the ability to maintain the stockpile.

BOUCHERON: We have confidence in our physicists. We can simulate some things and not others. It is important that the U.S. and France cooperate because we are (1) friendly countries; and (2) otherwise France will be jealous.

PAINE: The U.S. does not have a global ability to simulate nuclear explosions.

BOUCHERON: "Why sell a Cray-2 to the Chinese (supposedly for weather research)? With that they will be able to predict the weather 200 years ahead!"

"We have decided to invest (in PALEN) over five years, ten billion francs (\$2 B), with \$200 M the first year."

PAINE: There is a political question regarding the negotiations -- right now the French delegation has no instructions.

BOUCHERON: The government will sign nothing before June of 1995. The President's delegate wants to go very fast, but the government won't sign.

There is a fight for political reasons between the government and Mitterrand, but it will be different after the elections.

PAINE: Will a Gaullist sign?

BOUCHERON: The next President will be Jacques Delors.

PAINE: Should the rest of the world proceed to a test ban without France?

BOUCHERON: If the French negotiators are slowing the negotiations, evidence of this needs to appear in a national circulation newspaper. The Prime Minister could then be asked on TV to change the negotiators or the instructions. But such an article should appear before December in a big newspaper.

PAINE: There are two other political issues:

1. The need to show progress on a CTB before the NPT conference opens April 1995,

2. The U.S. government is coming under increasing pressure to support a South Pacific NFZ. But we are not giving our support publicly, in order to accommodate France.

BOUCHERON: If the South Pacific were declared a nuclear free zone, we would the next day explode a bomb.

At this point, Boucheron had to leave, as he had warned us he would.

Discussion continued with J.P. MAULNY Secrétaire général, of the Institut de Relations Internationales et Stratégiques - IRIS.

PAINE: France has recently signed the NPT and the concept of national nuclear deterrents forever is not compatible with the NPT.

Either there needs to be:

1. A transition phase, during which nuclear deterrent forces in some states are conditionally acceptable pending elimination of nuclear weapon stockpiles, or
2. A cooperative security system, with a possible small UN nuclear deterrent force and conventional peacekeeping forces.

MAULNY:: Bary(?) Longchamps(?) ... say France should give security guarantees to non-nuclear countries, if France wishes the NPT to continue indefinitely.

PAINE: Yeltsin has proposed further five-power negotiations. What is the French view?

MAULNY: We will probably say -- let's see START-I and START-II results first. We have already reduced our nuclear weapons systems. There is such a disparity that for France to join such reductions now would be unfavorable for France.

PAINE: In a recent meeting, Chinese nuclear weapon scientists also indicated that START-I and START-II were "not of interest" to China because they have no view of what happens after the weapons are taken off the launchers. They are seeking further guarantees regarding the actual disposition of U.S.-Soviet weapons (before joining a nuclear arms control regime)

MAULNY: We are too dependent on the CEA. The position of the right is the position of Roger Baléras.

"Maybe there are one or two independent scientists-- Kastler<sup>4</sup> and Curien<sup>5</sup>" who can provide advice on nuclear weapons issues.

GARWIN: Is there fear of prosecution that prevents knowledgeable people from discussing such matters publicly?

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<sup>4</sup> Deceased

<sup>5</sup> Formerly Minister of Research and Higher Education.

JOURNÉ: There is no legal bar to people talking about unclassified matters.

KIDDER: The President could pick for private consultations a few scientists whom he can trust.

*11/03/94 1230 René GALY-DEJEAN*

(Député RPR; Rapporteur of the Assemblée Nationale report on simulation and nuclear testing; Mayor of the XV Arrondissement, where we met, together with Venance Journé, for lunch in the mayor's private dining room)

Venance Journé accompanied us, because Galy-Dejean had explained that in order to be precise, he would speak French.

Galy-Dejean was accompanied by a colleague, who was essentially silent.

We met for five minutes or so in his office in the Mairie, before going downstairs to a fine lunch in a side room on the first floor. Galy-Dejean spoke of "the ten U.S. nuclear explosions to prepare directly for modeling weapons under a CTB."

GALY-DEJEAN: ... state-to-state relations are not such that one can place complete trust ... The U.S. is not a strategic rival; the word is not there (in the report), nor is the idea.

(Galy-Dejean was responding to Paine's criticism of the section of the report which stated that France was "somewhat paralyzed, allowing the Americans to maintain an undeniable technical advantage and a dominant position in the area of nuclear weapons, with all the risks that this might entail for our country in terms of national independence.")

"Yes, national independence is different from strategic rivalry.

"Right now, we believe that we have the best weapons possible.

"Why do you have a problem with France's acquiring a scientific capability? And if some tests are required to calibrate? The moment that ...,<sup>6</sup> France will reconsider ..."

PAINE: There are discussions at an official level, but France has declined to specify the number of tests, or to say how the U.S. could help. It is important to make a statement before the NPT conference.

GALY-DEJEAN: There is a problem of the calendar (for the negotiations) and the election. The response will be given in the six months after the election.

PAINE: You are suggesting there is a difference between France and the other nuclear weapon states. Are you suggesting that a Gaullist President would not accept a consensus of the other nuclear weapon states (to end testing)?

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<sup>6</sup> Our notes are lacking this important definition of the "moment".

GALY-DEJEAN: ... the British don't have a program of their own; they are totally dependent on the Americans; the Chinese are testing ... we don't know for how long; Russia can't test because of all of the confusion. France wants to keep its freedom of action.

One question -- our scientists believe the U.S. is capable of exploding up to one kiloton without detection. O'Leary has revealed 200 plus previously undisclosed nuclear tests.

PAINE: But (Russian Atomic Energy Minister) Mikhailov not only knew of all these, but pointed out additional tests that were missing from the "complete" list when it was first revealed!<sup>7</sup>

GALY-DEJEAN: I have confidence in the total good faith of my interlocutors. But you didn't convince me. In things that are essential to national security, national égoïsme always wins out.

"We don't know who will be the future U.S. President. But it is my duty as a French responsible leader to consider our own notion of security as well as to advance nonproliferation and the banning of nuclear weapons (tests?) ..."

***11/03/94 1530 Col MAXIMOV and Capitaine de Vaisseau D'ARBONNEAU***

(Military Staff of the Prime Minister, meeting at the Hotel Matignon)

Garwin led off with a summary presentation of stockpile stewardship without reliance on nuclear explosive tests, and Paine presented a critique of the AN simulation report. Unfortunately, almost no notes exist from this meeting. These gentlemen expressed the view that some additional number of tests were needed to ensure confidence in France's nuclear arsenal and to assess "aging of thermonuclear components."

They noted that there were two schools of thought. One, exemplified by Baléras and others, was that long term confidence issues involved both the primary and thermonuclear secondary components, and thus a resumption of full scale nuclear testing was required. The other, reportedly exemplified by Général Quesnot, agreed with our view that reliability concerns focused on proper performance of the primary, and that if this could be checked over time through non-nuclear hydrodynamic testing, and the condition of the secondary monitored by disassembly and inspection, one could have confidence in the performance of the overall weapon.

***11/03/94 1730 Général de Corps d'Armée QUESNOT and Col Bertrand DUMONT***

(Général QUESNOT is Chef de l'Etat-Major Particulier du Président de la République-- Chief of Staff to the President of France)

(Meeting at Palais l'Elysée)

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<sup>7</sup> Mikhailov turned out to be right, when DOE revealed additional tests six months later as being part of so called "string-of-pearls" events involving multiple device explosions.

At 1730 on 11/03/94, Garwin, Kidder, and Paine met with Général Quesnot, this time with Colonel Bertrand Dumont.<sup>8</sup> They are in the office of the President, and we met at the Elysee Palace. The discussion was in English.

QUESNOT: "For new-development weapons under a CTBT, how important is it that every weapon work?"

"If the primary works, then we are not sure the entire secondary will work, but surely a portion of it."

PAINE: Are you saying "French weapons are unreliable," or are you saying "we are not satisfied with the weapons we have?"

QUESNOT: What can cause the present force to be insufficient? For instance, it could encounter defenses -- ABM.

PAINE: France can stipulate that it is approving the CTB on the assumption that there will be no strategic defense and that the development of strategic defenses would be cause for withdrawal.

QUESNOT: We have no problem about the reliability of the weapons that are in the stockpile. Scientists working in the field are always trying to persuade political leaders that they need more tests.

KIDDER: If this were a serious concern, France could design new weapons and even build prototypes for future testing under a CTBT, thereby reducing by years the response time to deployment of an ABM system.

***11/04/94 0900 Roger BALÉRAS***

(Counseiller du Gouvernement)

(Consultant to the Government; formerly Director, Division of Military Application/CEA)

At 0900 Friday 11/04/94, Garwin, Kidder, and Paine arrived for their appointment at CEA, 31 rue de la Fédération. Accompanying Roger Baléras, was Christian Combettes, Assistant to the Director of DAM CEA, who works for Jacques Bouchard and knows both the subject and English very well.

We made our, by now, usual introductory remarks.

According to Baléras, the current French plan is to maintain their weapons by hydro-nuclear test (HNT) of 100-200 tons yield, in order to begin to test boosting. Baléras commented that the U.S. had conducted a lot more tests for weapon physics in Nevada, and so the U.S. could

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<sup>8</sup> When Mike May and Garwin met with QUESNOT in May 1994, he was accompanied by Général Bastier, who has now moved on to a command position.

afford on the basis of that experience to have a CTB and to maintain our nuclear weapons by non-nuclear inspection and remanufacture.

BALÉRAS: There have been French problems with "bonding" and "pollution..." (the French term for mixing of metal with boost gas), and with plutonium metallurgy.

BALÉRAS: We had not predicted the brutal advent of a CTB, beginning with the shock of the Mitterrand announcement of a moratorium April 1992. Testing is necessary to maintain the credibility of nuclear weapons. We were not asked to build robust weapons, although we could have done it.

It would take 10-20 tests in order to obtain weapons that would be acceptable under a CTB.

A lot of effort went into miniaturization to reduce the size and cost of the missiles and of the submarine that carry them. As a result, the French weapons are "more sensitive" than the American weapons.

Baléras indicated that there was so little space in the French SLBM reentry vehicle, that the secondary was toward the front of the RV and the primary at the rear, "contrary to U.S. practice."<sup>9</sup> He indicated that the small space around the secondary was a special problem for the design.

KIDDER: We don't understand this requirement for continued testing for reliability of a stockpile in which one has initial confidence. When we take a weapon out of stockpile and observe some problems which cause doubt about the continued performance of weapons supposed to be in the enduring stockpile, we have sometimes fired one in a nuclear explosion in Nevada. But when we did, we chose another weapon of that type, and selected the weapon in the stockpile with the minimum amount of plutonium and with end-of-life boost gas, in order to give it the greatest opportunity to fail. We would fire one nuclear explosion, and do a lot of cold hydrodynamic testing on the problem. And for the most part these weapons (intentionally as marginal as possible) worked, giving us great confidence in the average such weapon in the stockpile.

BALÉRAS: We don't get as much information from our nuclear tests as do the Americans, because our (diagnostic) canister is only 150-cm in diameter, and it has thick steel walls in order to survive the hydrostatic pressure of the water in the Mururoa lagoon. Furthermore, we have "difficulties with the signal cables".

COMBETTES: We are limited to about a 1 meter useful diameter inside the canister.

BALERAS: Our weapons have not been planned for long stockpile life. Even if the lifetime of the weapon system was 20 years, we have built shorter life nuclear weapons; then instead of testing the old one, we have replaced it with a more modern, but not very different one.

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<sup>9</sup> This could not be confirmed from open sources.

GARWIN: But when you say that "10-20 nuclear explosions are required to prepare for a CTB" do you mean that you would make one test and then have to think and design on the basis of that test before conducting another test? How long would the series take?"

BALÉRAS: We would prepare in advance "un rafale" (a "squall" or a "flurry"). We could be finished in 1-2 years.

(Baléras is saying very specifically that only a single test series is required, and the design, preparation, and completion of the tests could be over in as short as one year, but surely by two years.)<sup>10</sup> We replied that personally we could appreciate the rationale for such a program, limited in both time and the number of tests. We noted that Chinese nuclear weapon experts had told us in June 1993 that they needed a number of additional tests, but the Chinese government has stated officially it will be ready to sign the CTB in 1996, if such is signed by the other nations at the time, and there are no further tests by other nations. So we recounted this to Baléras and indicated that it would be important in announcing any test series that the French government state its purpose was not to improve the performance or broaden the range of effectiveness of its nuclear weapons, but simply to modify them so that confidence in their performance and eventual remanufacture could be sustained without nuclear explosive testing.

COMBETTES said that he had read our report on the China trip and that it was a very good report<sup>11</sup>.

Baléras agreed regarding the statement of the desirability of the NPT, but he had questions about the direct impact of the CTB in denying additional nations nuclear weapons. He felt that the first nuclear weapons could be acquired by a nation without testing.

PAINE: The CTB has the technical benefit of keeping India, Pakistan, maybe Israel, and possibly other countries in the future from proceeding to thermonuclear weapons and improved yield-to-weight devices (for missile warheads). And it has the political benefit of limiting the nuclear weapon states and thus encouraging non-nuclear states to join and remain within the NPT.

GARWIN: And with these two benefits, it would then give the nuclear weapon states the moral position to move against one or a very few states that did not sign the NPT.

Paine added that the fissile material cutoff would also help.

Baléras observed that the fissile material cutoff had a problem, in that we don't really know how much Pu there is; for instance, see the statement and corrections by Secretary of Energy Hazel O'Leary.

At this point we discussed the desirability to have declarations, the proposal for the U.S. and Russia to move all weapon-usable material not in agreed nuclear weapons to safeguarded civil stockpiles, mentioning also the role of "societal verification" (i.e. internalizing treaty constraints

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<sup>10</sup> In principle, a string of tests could be done in a single hole, and detonated almost at the same time; but this is unlikely, given the limitations on canister volume and cabling noted by Baléras.

<sup>11</sup> Garwin believes he had sent or given a copy to Dautray, High Commissioner of the CEA.



in both domestic criminal codes, regulations, and codes of professional ethics) and encrypted systems for reporting violations and exchanging sensitive data.

Regarding "simulation," we brought up the technical point that in the United States we do not use simulation of nuclear explosions, and we regard the emphasis on simulation in the Assemblée Nationale report to be a dangerous misconception. Dangerous because the recommendations of that report, if followed, would commit the French to many years of nuclear testing to calibrate a "simulation system" which could not possibly do what is expected of it.

Baléras stated clearly that from their perspective, "simulation" means a program for maintaining competence in key areas: laser-driven implosion is a way for weapon program scientists to continue working with fusion; hydro tests give experience with diagnostics and chemical explosives, and computer modeling needs to make use of new technology. The purpose of these experiments is to maintain skills and to create interest, not actually to "simulate" nuclear weapons.

Baléras specifically agreed that the AN report greatly overstated the case for simulation and that the French technical community had the same view about simulation that we expressed.

Baléras closed with an observation about "the policy man in France ..." which was not recorded in our notes.

So we came away from this meeting with two very important answers and one unanswered question from Baléras:

1. The CEA (or Baléras personally) would be satisfied with a single test series of 10-20 explosions, conducted within one or two years, which would provide them the information needed to transform their stockpile into a robust stockpile (not very different from the present one) which would not require nuclear tests for maintenance.
2. "Simulation" is an unwarranted term and whatever the reasons for obtaining such experimental facilities, they were not actually to simulate nuclear explosions, and that nuclear tests were not required to calibrate such facilities.
3. Would France continue to insist on a threshold for permitted tests at 100-200 tons?

***11/04/94 1115 Xavier de VILLEPIN***

(Senator and Head of the Defense Committee of the Senate)  
(Meeting at the Senate)

At 1115 on 11/04/94, Garwin, Kidder, and Paine met with Xavier de Villepin in the Senate. As with Baléras, we introduced ourselves with the two-page paper, but went briefly through the recommendations. We then referred to the document by Paine, but noted that following our productive discussion with Baléras, we would not go into detail with these criticisms of the report of the Assemblée Nationale, but rather quoted Baléras in his rejection of the concept of direct simulation of nuclear tests.

We described our concept for U.S. stockpile maintenance and particularly the difficulty that we had with the mistaken perception in the Assemblée Nationale report of the U.S. use of simulation.

We then presented precisely the answers of Roger Baléras, and we noted (as we did with Baléras) that personally we would not be critical of such a limited test program. We noted that the Chinese had told us in June 1993 that they needed a number of additional tests, but the Chinese government has stated officially it will be ready to sign the CTB in 1996, if such is signed by the other nations at the time and if there are no further tests by other nations. So we recounted this to de Villepin and indicated that it would be important in announcing any test series that the French government state its purpose-- that it was not to improve the performance or broaden the range of effectiveness of its nuclear weapons, but simply to modify them slightly so that they could be maintained and remanufactured without nuclear testing.

With de Villepin, we spoke English, and he spoke French (Garwin interpreting), which seemed to work well.

De Villepin is head of the Defense Commission of the Senate of France. He speaks very precisely and he repeated exactly the position that we were taking, which he understood and seemed to find quite acceptable. We left after 30 minutes, feeling that we and he had a full meeting of minds, and that everything that could be expected to be accomplished from the meeting had been achieved.

***11/04/94 1600 Laurent BARTHÉLÉMY and Bernard SITT***

(Meeting at the Délégation aux Affaires Stratégiques (DAS) in the Ministry of Defense, 14 rue Saint-Dominique, 00450 ARMÉES)

At 1600 on 11/04/94, Garwin, Kidder, and Paine met with Deputy Director Laurent Barthélémy, Chief Engineer for Armaments, who was joined by Bernard Sitt (whom Garwin had met with Mike May 05/06/94 in discussion of the weapon plutonium problem). Jean-Claude MALLET, Directeur chargé des Affaires Stratégiques (in the ministry of defense) had asked that Barthélémy receive us at the Delegation aux Affaires Stratégiques (DAS).

We gave our usual introduction, and Barthélémy and Sitt were quite willing to respond.

BARTHÉLÉMY: Regarding the report of the Assemblée Nationale, "pieces of the puzzle are quite correct, but we do not agree with the conclusions." Instead of "simulation" we might call it "modeling." But it is wrong to suggest that simulation could "replace tests".

There is an asymmetry between the U.S. and France:

1. Smaller experience with existing weapons, which are newer.
2. Less experience with extrapolating from low yield to high yield.

3. France and maybe the Chinese are in a different position from the other nuclear weapon states. France has the M5 in development and no selection yet of the required yield. U.S. and U.K. have Trident-II; the Russians have the SSN-24, so they don't need a new weapon.

PAINE: Are you talking about a new missile or a new warhead?

SITT: A new missile. The warheads would not be a new nuclear weapon, but in a known family of weapons, a modernization or modification.

4. Verification and detection. Our testing is totally transparent at Mururoa, and probably tests below one ton could be detected there.

PAINE: One ton is certainly a nuclear explosion. Four pounds of nuclear yield is typically small compared with the amount of high explosive needed for the implosive assembly.

(Unfortunately, some discussion with Barthélémy has gone unrecorded here.)

BARTHÉLÉMY: Regarding the question of remanufacturing, even with the same specifications one may have bad surprises. For instance, there are hidden parameters that may change in uncontrollable ways-- explosives, adhesives, welding ...

KIDDER: "Uncontrollable" is not "unobservable."

We then discussed that, even though one built to the same specifications, one should not accomplish this by different techniques. For instance, instead of using "net-shape casting" of plutonium, we should continue to cast and machine plutonium in order better to avoid changing these "hidden parameters."

BARTHÉLÉMY: If we have problems in the stockpile, we would want to (1) either test the nuclear weapon, or (2) find the problem and modify the nuclear weapon. We have not decided our needs for future weapons. The M5 missile will have an IOC of the year 2010. For the first time, as a result of budget problems, there is less overlap between the warhead program and the missile program. So the warhead will be defined and ready first, and the missile and the submarine later.

"Our main objective is not to develop variable yield warheads or a low-yield warhead, but simply to replace with more robust weapons."

Barthélémy and Sitt were very reasonable, but we did not fully get them to recognize a logical inconsistency between their apparently adequate confidence in the reliability of their current force, and their lack of confidence that a remanufactured force, of any age less than the current force, would be comparably reliable. This "inconsistency" is explicable, however, given their belief in the difficulty of adequately controlling all the (possibly "hidden") remanufacture parameters that could affect weapon performance.

In addition, although with Barthélémy and Sitt, as with some of the others, we used the analogy that when the U.S. put John Glenn into space, it did not modify him but packaged him, there was no enthusiasm for using an existing warhead in an "overpack" that would allow the

warhead to be fired exactly as it is now, while satisfying the more stringent reentry requirements of a longer-range missile.

***11/07/94 0930 Général Eric de la MAISONNEUVE***

(Directeur de la Fondation pour les Études de Défense; Kidder and Paine accompanied by Venance Journée)

Ms. Marie-Hélène LABBÉ, Chargé de Mission FED (who spoke fluent English) was also present and participated in the discussion.

Général de la Maisonneuve apparently helps to anchor the right wing of the French defense debate. He seemed generally opposed to a test ban, and supportive of the development of additional types of French nuclear weapons to deter future proliferants in the Arab world and elsewhere. He exhibited a high degree of skepticism that an enhanced international nuclear nonproliferation regime could prevent further nuclear weapons proliferation.

***11/07/94 1130 Jacques BOUCHARD***

Director CEA/DAM (Meeting at CEA, 31 rue de la Federation); Kidder and Paine.

With minor, but possibly politically significant differences in emphasis, Jacques Bouchard's views on nuclear testing issues tracked closely those of his predecessor, Roger Baléras. Bouchard understands and speaks English well, and was accompanied by the same knowledgeable assistant, Christian Combettes. Kidder and Paine summarize Bouchard's views as follows:

BOUCHARD: The existing stockpile of French nuclear warheads is not sufficiently "robust" (by which we understood him to mean both "insensitive to aging-induced changes" and "capable of reliable performance following remanufacture") to encourage the belief that its reliability can be maintained for a long period of time without nuclear testing.

Confidence in warhead performance over time can be adequately increased without major redesign, but will require sufficient modification so as to require nuclear tests to confirm proper performance.

It is expected that 10-20 tests would be needed to correct the perceived deficiency in warhead robustness. These tests can be completed in 1-2 years.

Preparation for the commencement of these tests have already been made, but tests cannot begin until after the forthcoming French elections in May. Bouchard cautioned us against concluding that a Delors victory would necessarily mean a continuation of the current moratorium. He seemed confident that DAM has a convincing case for a short test program prior to a CTB, and that it would likely be approved by Mitterrand's successor, whoever that may be.

The alternative to France conducting these tests would be to insist on a CTB that would allow tests of at least 100 tons (presumably to allow limited testing of boosted primaries).

(In contrast, Roger Baléras had not so clearly presented the matter as an explicit trade-off between these two approaches.)

Nuclear tests of the nuclear explosive component of the new M5 missile warhead can be completed within this 1-2 year period. Any further warhead changes needed to accommodate increased reentry heat resulting from increased missile range will involve the RV but not the nuclear component, reversing the usual order of making the nuclear component fit the delivery system. (The IOC of the M5 missile is currently scheduled for the year 2010.)

Bouchard did not support the earlier assertion by Admiral Bétermier that "we also need variable-yield designs, one with much lower yield." Also, Betermier's earlier reference to French consideration of the use of injectable liquid or paste explosives (presumably to improve warhead safety) was not mentioned by Bouchard. Kidder notes that unless this development is already nearing completion, it is unlikely that it could be completed within the 1-2 year testing period contemplated by the DAM, and therefore may no longer be under serious consideration.

In the course of explaining French concerns about excessive optimization of their SLBM weapons, Bouchard referred to the W68 warhead of the U.S. Poseidon C3 SLBM as an example of a sophisticated, highly-integrated warhead (as many as 14 could be carried on the C3 missile), suggesting that French warheads might be similar, and also subject to stockpile reliability problems as a result. (The W68 suffered from deterioration of its high explosive, and thus required a complete rebuild of all weapons in the stockpile.)

Bouchard likewise discounted as being ill-informed the report by René Galy-Dejean concerning U.S. nuclear weapon simulation capabilities. He believes that French and U.S. experimental (as opposed to computational) simulation capabilities are generally comparable, and of course, subject to the same natural limitations.

On other matters, Bouchard seemed more interested and informed than Baléras in nonproliferation and safeguards issues. Paine gave him a copy of the NRDC paper on reducing the IAEA's threshold values for "significant quantities" for plutonium and highly enriched uranium. He did not respond directly on this point, but noted that he thought the main technical safeguards issues involved bulk-handling facilities, and that Russian facilities did not even meet the current international standards, much less some higher standard. He also expressed interest in sending a DAM representative to a possible meeting to discuss the technical and operational aspects of safeguards to verify President Yeltsin's proposed five-power nuclear arms control regime.

Bouchard then very kindly provided us a car and driver to take us to Saclay to visit the Laser Isotope Separation program underway at that facility.

***11/07/94 1430 with Monsieur Yves LAPIERRE***

(Chief of Department for Enrichment Processes) and two assistants  
(Meeting at Saclay Research Center, 91191 Gif-sur-Yvette, about 15 km. outside Paris)

We (Kidder and Paine) were given a program briefing and a tour of experimental facilities. Saclay employs about 5000 people in three main directorates, with about 1500-2000 people per directorate. Atomic vapor laser isotope separation (AVLIS or "SILVA" in French) is carried out in the fuel cycle directorate (Direction du Cycle du Combustible), which in turn is divided into four "Département," two of which concern SILVA -- the Département Des Procèdes D'Enrichissement (which we visited) and the Département de Technologie de L'Enrichissement, based at Pierrelatte in the southern Rhone valley. The former is in charge of understanding the physics of the SILVA process and of its optimization using 1/10 to 1/4 scale demonstration facilities, while the latter is in charge of developing and testing pilot production scale facilities.

The Enrichment Processes Department at Saclay currently employs 250 people. We were told the SILVA process is to be used solely for uranium enrichment -- there is no parallel plutonium program. They too are interested in separating an isotope of gadolinium (for use as a burnable poison in nuclear power and naval reactors), but believe that ion cyclotron resonance provides a better method of separation for this particular application (the AVLIS process is being explored for this purpose at Livermore).

In contrast to the Livermore-Limeil cooperation in developing the National Ignition Facility (NIF) and "Le Projet Laser Megajoule," the Saclay researchers do not share AVLIS design data with their U.S. counterparts, but only basic physics data (spectroscopic data and the like). Competition rather than cooperation is the rule in what they hope will be a commercially significant area of research. However, despite such competition, Lapierre noted that French researchers were extremely glad to hear that the quasi-private U.S. Enrichment Corp. had elected to assume funding of AVLIS work at Livermore, as this helped to reinforce the commitment of French authorities to push ahead with the French program, which won't enter an industrial phase until 2005 at the earliest.

They are projecting a minimum 10-fold reduction in electricity costs for a production scale SILVA plant compared with the existing EURODIF gaseous diffusion plant at Tricastin. It seemed to us that the relevant competitive cost comparison is between AVLIS/SILVA and current or next generation centrifuge plants, but we were provided no data on this. And even if SILVA used zero electrical power, its capital investment would still need to be taken into account in an economic choice.

The existing "Andromède" separator and HFRA laser have carried out about 110 runs lasting from 2 to 20 hours each, producing enriched quantities of 1 to 10 grams/hr. and enrichment up to 5.5%. A larger separator ("Aldebaran") and CVL/dye-laser combination ("Aster") is under construction at Saclay, while an even larger 2.5 meter diameter separator ("Maeva") has been constructed at Pierrelatte for evaluating the erosion of separator pod components at liquid uranium temperature.

In sum, we were impressed with the French commitment to SILVA (reportedly about \$80 million per year) and the advanced research facilities, but the long time scale for development and difficult technical hurdles on the path toward industrial deployment mean that the program is high risk, and remains vulnerable to budgetary pressures and changes in the economics of the uranium market.

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October 4, 1994  
(Via FAX to 9-011 (33) 9978-1092)

M. Jean Michel Boucheron

Dear M. Boucheron:

Please forgive my writing you without having a proper address or title, and also without having been introduced. I do enclose a brief biography so that you will know some of my background and interests.

I visited Paris in May, as a member of the National Academy of Sciences' Committee on International Security and Arms Control (CISAC), and my meetings were largely addressed to the question of the disposition of excess U.S. and Russian weapon plutonium.

Naturally, there are many other topics of mutual interest, and also of interest to a wider group. I am Chairman of the FAS Fund, the research and policy arm of the Federation of American Scientists, and also Vice Chairman of the FAS. In this role I sometimes work closely with the Natural Resources Defense Council (NRDC) but very largely on nuclear weapon matters. You are probably familiar with the "Nuclear Weapons Databook" series of the NRDC, which has been a massive, and I believe constructive effort. Indeed, there is now a Volume V "British, French, and Chinese Nuclear Weapons" (1994) which might be of interest to you.

My closest colleagues at NRDC are Christopher E. Paine, Thomas B. Cochran, and R. Stanley Norris. In fact, in June 1993 the four of us spent several days in Beijing (accompanied by Ray Kidder of the Lawrence Livermore National Laboratory) for detailed discussions with Chinese nuclear weapons technologists at the Institute of Applied Physics and Computational Mathematics (IAPCM). We were trying to present our understanding of the place of hydronuclear experiments under a Comprehensive Test Ban Treaty, and also trying to understand the Chinese need for nuclear weapon tests until the Comprehensive Test Ban Treaty enters into force in 1996, as we hope.

Of course, the Chinese maintained that they do need more tests, but that they would be ready to join a CTBT in 1996.

As the negotiations proceed toward a CTB, there has been a good deal of discussion of the role of hydronuclear experiments, the definition of a threshold in the CTB, etc. And, of course,



there was the report from the Assemblée Nationale on the role of simulation in a CTB era. We would like to talk with the nuclear weapons experts in CEA about some of these questions, as well as with the relevant people in the Assemblée Nationale. We believe we can help in understanding the situation in the United States.

For instance, Christopher Paine had a major role in drafting the "CTB Readiness Program" mandated by the Congress for the U.S. Department of Energy laboratories, but he knows well that these requirements were not in fact followed.

In any case, we are visiting Paris to discuss these matters, and I believe we will be able to have appointments within CEA.

In the United States, of course, not only the DOE but also the Department of Defense expresses views about such matters, and it would be useful for us to have further discussions with the Ministry of Defense, to follow up on some informal discussions Mike May and I pursued during our visit in May 1994.

I hope that it will be possible to meet with you and to have frank and detailed discussions about these matters. I apologize for not having your full title and address, which lack I hope you will remedy by return FAX.

I plan to arrive in Paris Wednesday morning, November 2 and plan tentatively to leave Monday night, November 7.

Please put aside some time to meet with us during this period.

Very best regards.

Sincerely yours,

Richard L. Garwin

Encl:

04/06/94 Brief Biography of R.L. Garwin. (040694BIOG)

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EXCHANGE OF VIEWS ON INTERNATIONAL SECURITY  
AND  
NUCLEAR WEAPONS MAINTENANCE AND TESTING.

Richard L. GARWIN: Physicist. Consultant to Los Alamos National Laboratory 1950-1993 on matters of nuclear weapons and testing. IBM corporation 1952-1993. Former member, President's Science Advisory Committee and other involvements in international security. Member, National Academy of Sciences and National Academy of Engineering.

Ray E. KIDDER: Physicist. Recently retired after 35 years at LLNL working on nuclear weapons physics, reliability, and safety; inertial confinement fusion; laser isotope separation, and directed energy weapons. Consultant to members of Congress on maintaining nuclear weapons reliability and safety under a comprehensive test ban. Winner of the 1993 Leo Szilard Award of the American Physical Society.

Christopher E. PAINE: Senior Research Associate, Natural Resources Defense Council. Arms control and nuclear nonproliferation analyst; Congressional staff specialist on nuclear weapons testing and production, 1985-1991; co-author of Congressional legislation restricting U.S. nuclear tests.

REFERENCES: Assemblée Nationale "La simulation des essais nucléaires" (XII 1993); "Livre blanc sur la défense 1994" (II 1994); Speech by President François Mitterrand, 5 Mai 1994. U.S. discussions regarding Science-Based Stewardship, NIF, hydronuclear experiments, etc.

Garwin's published advice regarding U.S. nuclear weapons, taking into account NPT and Comprehensive Test Ban (CTB):

1. Build laboratory-based manufacturing and remanufacturing capabilities for a normal rate of 300 nuclear warheads per year, of precisely the existing models. "Science-based stewardship" should be used to ensure high confidence in a stockpile of existing weapon types-- not low confidence in more "advanced" weapons.
2. Place confidence in reduction to 3500 total U.S. warheads by the year 2003-- ten times fewer than previously. By the year 2010, have in place tritium production capability adequate to sustain these warheads (less than 1000 gram per year).
3. Do not develop or manufacture nuclear warheads different from existing ones. Atoms do not age; we can use obsolete materials and techniques.
4. Maintain stockpile by inspecting for corrosion or deterioration, non-nuclear testing including pin shots, radiography of implosion of inert cores. If in doubt, remanufacture to existing specifications.
5. Hydronuclear experiments (HNE), little relevant because one can't test the real system with "boost gas". Either one needs to replace the fissile material or one needs to put a lot of inert gas in the pit to greatly hamper the implosion.

6. Computation is useful, but it is irresponsible to place a sophisticated weapon into stockpile without a real nuclear test.

7. What is experimental "simulation"? The National Ignition Facility (NIF) is to provide megajoule implosion of tiny D-T pellets. It can provide understanding, but in my way will it contribute specifically to the design of thermonuclear weapons.

In the chain of events--

- implosive assembly of the primary charge, explosion of primary (pre-boost), thermonuclear boost;
- nuclear explosive disassembly of primary,
- assembly of secondary,
- ignition,
- burn of secondary,
- thermonuclear explosive disassembly of secondary,

the builder has direct control of the implosive assembly, and that can be tested well with flash radiography.

8. NIF (megajoule short-pulse laser implosion) will drive a tiny "capsule" with the pressure of x rays in a Hohlraum. It is a fine research facility and a useful step toward potential civil energy release from inertial confinement fusion, and it will probably be operated as an unclassified facility. French nuclear weapons scientists are already very active with NIF's predecessor, NOVA.

9. The truly relevant simulation is by computer to maintain skills and (optionally) to design weapons that might be built in case of collapse of the arms control regime.

THIS SECTION STANDS IN FOR A 6-PAGE DOCUMENT FROM CHRIS PAINE THAT WE LEFT WITH PEOPLE IN PARIS.

THIS SECTION STANDS IN FOR A 13-PAGE RAY KIDDER DOCUMENT ON  
HYDRONUCLEAR EXPERIMENTS THAT WE LEFT WITH SOME PEOPLE IN PARIS.