# The truth about simulation
## Considerations on the French nuclear tests

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Today we can distinguish three categories of nuclear arsenals: thermonuclear, crude and virtual.

First of all there are the arsenals of the five permanent members of the UN Security Council: the United States, Russia, Great Britain, France and China. These countries enjoy a privilege recognised under international law: the possession of nuclear arms. Legally, this status is derived from the fact that these five countries had carried out nuclear tests before 1967, that is to say before the date fixed by the nuclear arms Non-Proliferation Treaty (NPT).

We can qualify the arsenals of the recognised nuclear powers as thermonuclear, since the most important arms possessed by these countries are hydrogen bombs, the power of which is equivalent to hundreds, or even thousands, of kilotons of TNT. The principal function of these arms is to ensure nuclear deterrence, that is to say to forbid the violation of national territory. This type of deterrence creates a considerable imbalance between States, some of which consider the situation unacceptable. It is for this reason that the NPT gave the nuclear powers only a temporary privileged status and this only in return for their commitment to work towards a rapid and definitive elimination of all nuclear arms.

Within this context, on the occasion of the re-negotiation of the NPT at New York in May 1995, the five nuclear powers undertook to forego definitively any further nuclear test explosions, and to conclude a Comprehensive Test Ban Treaty (CTBT) at the latest by the end of 1996. This test ban treaty is considered to be the main measure undertaken to slow down the nuclear arms race since the coming into effect of the NPT. Its objective is to freeze the technology at its present stage in order to allow the opening of negotiations aimed at the total and definitive elimination of nuclear weapons.

In reality, as has been often stated, by the United States and France in particular, the five great powers have no intention whatever of giving up their nuclear capacity. On the contrary, everything points towards these powers having already ensured, or being in the process of ensuring, the permanence of their thermonuclear arsenals. Thus, they can at present forego full scale nuclear testing without loss.

Neither do other countries such as Israel, India or Pakistan intend to give up nuclear deterrence. Even though these countries do not possess thermonuclear arms, they nonetheless have an arsenal of first generation atomic bombs. It is important to stress that, as opposed to hydrogen bombs, the development of this type of armament, sometimes designated as "crude", does not call for nuclear tests. In demonstration of this, it is possible to point out that all the early

atomic bombs, and in particular that which exploded over Hiroshima, worked first time.

Today the proliferation of nuclear weapons still constitutes one of the greatest dangers for humanity. This danger arises from the ease with which crude nuclear weapons, the power of which can be measured in kilotons or even tens of kilotons, can be developed and used. To get rid of this threat definitively, research and development of nuclear energy should be renounced, the spread of technology monitored, the advance of scientific research controlled and, above all, nuclear deterrence eliminated.

If we wish to effectively eliminate nuclear deterrence, we must also take into account the "virtual" nuclear arsenals. This concept refers to countries such as Sweden or Switzerland, which worked for many years on the development of an indigenous atom bomb, or those like South Africa that have even made them. These countries finally gave up the idea after signing the NPT. However, they still have the know-how and the equipment which would allow them, should they decide upon it, to build up a crude nuclear arsenal over a relatively short period of time.

But the virtual arsenals above all concern the technologically developed countries such as Germany and Japan. With their industrial base and their highly developed scientific resources, notably in the nuclear field, they could easily and rapidly build a crude, or even thermonuclear, atomic arsenal. What is more, these countries have at their disposal the most advanced computers and scientific research tools, with capabilities very close to the so-called "simulation" resources used by the great powers to maintain and improve their thermonuclear arsenals.

Now that the negotiations for the CTBT have been resumed in Geneva, the crucial fact is that today the five great powers no longer need full scale nuclear tests. This has, moreover, be enadmitted by a consultant to the American government, whose judgement on this question is not to bedoubted, in an article recently published in "La Recherche", entitled "Nuclear Tests Are No Longer Necessary". In such circumstances what sense is there in a treaty banning tests?

In order to answer this question, it should be understood that the rapid evolution in the field of nuclear arms control that we have witnessed during these last few years is not simply the result of radical political changes, such as the collapse of the USSR. Technical reasons are just as important. Thus, the reduction by almost half of the number of arms in the thermonuclear arsenals is mainly the result of the decomissioning of obsolete weapons, the elimination of weapons designed for outdated or doubtful military objectives, and the enormous problems associated with the ageing of production facilities and the upkeep of nuclear weapons.

Technical reasons are even more important for the qualitative evolution of nuclear weapons:

- On the one hand, the mastery of a technology based upon more than fifty years of research and hundreds of tests is today at such a level, that it is known that we cannot expect any further major improvement insofar as A and H bombs are concerned.

- On the other hand, this mastery enables the development of new types of nuclear weapons that are very much more satisfactory from the military and political point of view. Certain faults in today's weapons will be eliminated, which opens the way to nuclear arms with a military use, with power and effect that can be adjusted with precision and above all with reduced radioactive side-effects (fall-out, ground activation). It will be very much more difficult for

the small countries to design and manufacture these new weapons than the A or H bombs: the privileged status of the great powers will thus be even greater.

It is therefore obvious that the five thermonuclear powers have little or nothing to gain, at the technological level, from continuing with full scale tests. However, the powers that base their deterrence on a limited number of crude atom bombs have much to lose. Because of the means of verification that will be set up for the CTBT, it will be substancially more difficult for them to carryout a test at a time when they might wish to experiment in order to develop an H bomb. This outcome is certainly desirable insofar as it will check the vertical proliferation among these countries. But the effectiveness of the ban is doubtful, insofar as the technical progress that leads to virtual nuclear arsenals is just as significant in these countries as in the major industrialised countries.

As has been already stated, these techniques are those known today as "simulation". What exactly is simulation?

For the military applications division of the CEA (French atomic energy authority), its main purpose is to ensure the continuation of deterrence. The CEA thus wants to have resources equivalent to full scale testing, in the form of super-computers and various high performance experimental installations.

In fact, the term "modelling" would be more appropriate than "simulation", since it has less to do with simulating nuclear explosions than developing mathematical and physical models that describe the phenomena occuring in an explosion. In effect, the theoretical representation of certain phenomena that occur within H bombs is still incomplete, despite fifty years of nuclear experiments and despite a total of two thousand explosions. In any case, the continuation of full scale experiments would probably never have changed this situation, given the great number of complex phenomena that occur simultaneously within the fraction of a micro-second of the explosion of an H bomb.

In order to better understand these phenomena, plans are afoot to resort to thermonuclear microexplosions in the laboratory, which will fall outside the jurisdiction of the CTBT. In France, these micro-explosions will be carried out with the help of the giant laser whose construction is planned at the CEA-Cesta centre near Bordeaux.

Up to now the development and maintenance of thermonuclear weapons had an empirical basis, derived from a great number of full scale tests. Laboratory tests and simulation will allow these operations to enter a phase where they will have a rigorous scientific  basis. This progression is in double contradiction with the objectives of the CTBT. Firstly, a better understanding of the physics of thermonuclear explosions will impede the desired progressive disintegration of the thermonuclear arsenals. Secondly, it will encourage the development of new types of nuclear weapons.

This is a contradictory evolution because it is not a response to a threat and still less to a need. The threat, if it existed, could only come from the ex-USSR or China. But today neither of these countries possess a significant laser installation; and, for the present, neither has any concrete project comparable to the Bordeaux "Megajoule Laser", nor an installation equivalent to the "National Ignition Facility" planned for Livermore in the United States. Insofar as the need is concerned ( i.e. the need to re-construct weapons identical to those that are ageing when they will have to be replaced) western experts, as well as those of Russia, consider this to be possible without such equipment as the Megajoule Laser.

France attaches great deal of importance to simulation. Thus, the CEA considers the results of the present Mururoa tests indispensable for calibrating simulation. On the other hand, President Chirac has taken a considerable political risk in deciding to resume nuclear testing shortly after the New York NPT conference.

We now have to understand the possibilities offered by the simulation laboratories for the creation of new types of nuclear weapons. But first of all it must be pointed out that the United States, like France, have formally undertaken not to develop new nuclear weapons. As the American representative at the Geneva disarmament conference reminded us at the end of January, the United States have definitively abandoned the development of third generation nuclear weapons, that is to say miniature thermonuclear arms, or those with enhanced effect, as well as the directed energy weapons activated by atomic bombs.

However, the present legal definition of atomic weapons does not explicitly cover anything but devices based upon nuclear fission. Similarly, the CTBT, as presently formulated, will only forbid fission explosions. Therefore, this ban will only affect tests meant for the development of A bombs, or the development of detonators used to trigger H bombs, or again the development of third generation nuclear weapons.

On the other hand, the CTBT does not allow for the restriction of experiments concerning thermonuclear fusion, or other nuclear processes such as matter-antimatter annihilation. As a result there is still the possibility of creating a fourth generation of nuclear weapons, of which one of the essential particularities will be the advent of militarily usable nuclear weapons which confound the qualitative distinction between the present nuclear arms (for deterrence purposes) and conventional arms (for combat purposes).

Let us look at two examples of developments which lead towards such weapons and which both have a direct link with nuclear weapons development technologies such as the Megajoule Laser.

First example, antimatter. Antimatter atoms were fabricated for the first time a few months ago. This has been much talked of in the press over the last few weeks, and in a way that indicated acontinued interest on behalf of the military. In fact, present research on antimatter shows that realistic military applications would call for the use of tiny quantities of antimatter, in the order of a microgram. Such a quantity would be enough to set off an H bomb, which would mean the ability to forego plutonium and create a "clean" nuclear weapon, that is to say, without residual radioactivity.

However, the present processes used for manufacturing even a tiny quantity of antimatter are still largely inefficient. This is where the Megajoule Laser has its uses: it will allow the testing of theoretically much more efficient methods of producing antimatter.

Second example, metallic hydrogen. Everybody knows that ordinary hydrogen is an inflammable gas of very low density. However, if hydrogen is very highly compressed, theory predicts that it will become a metal, and that, in its metallic phase, it might be stable at normal temperatures. In fact, just like antimatter, metallic hydrogen has been, for some considerable time, an important subject of research within military laboratories. One of the concrete reasons for this interest lies in the fact that metallic hydrogen is probably the most powerful chemical explosive possible to conceive of.

Up to now the synthesis of metallic hydrogen has yet to be achieved. All the same, theory indicates that such a synthesis will be possible with equipment such as the Megajoule Laser.

The Megajoule Laser has other predictable military applications. For example, the simulation of the effects of nuclear weapons, the creation of an X-ray laser, the production of very high power electromagnetic pulses, etc.

The official justification for the construction of the Bordeaux laser is, therefore, highly questionable. Everything suggests that the reconstruction of ageing nuclear weapons, even in a distant future, will still be possible without the Megajoule Laser, on condition that suitable measures are taken to preserve the technology that allows the bombs to be built. Again, one of the explicit objectives of the present series of tests is to test a "rugged" design, that is to say, a type of weapon which should pose no problems in case of future rebuilding.

It is essential to understand that behind the last series of tests carried out at Mururoa there lurks an even greater danger: the construction at Bordeaux of a laser that will allow the creation of thermonuclear micro-explosions. In the light of its military potential, the simple implementation of this laboratory will cancel any hope that existed for a slowdown of the nuclear arms race.

If the nuclear arms race is thus given a fresh boost, it must be realised that, as a result, there will be a considerable follow-on effect within other countries. Japan and, to a lesser extent, Germany already possess microexplosion fusion equipment of comparable quality to that of France or the United States. These countries will certainly increase the power of their lasers (*), which will have the effect of strengthening their virtual nuclear arsenals. India and Israel are close behind. The world runs the risk that certain countries will equip themselves with fourth generation nuclear weapons, by-passing the creation of the preceding generations of weapons.

In conclusion, so that the CTBT becomes truly effective with a view to a definitive elimination of nuclear weapons, it is essential that its scope be extended. It should, in particular, forbid any pure or applied research, that deals with nuclear fission or thermonuclear fusion reactions, at any level of explosive power whatsoever. Given such conditions, the Megajoule Laser planned for Bordeaux or its American equivalent at Livermore should not be built.

This extension of the CTBT presupposes a formulation that encompasses both civil and military aspects of nuclear research. This would necessitate action at the highest level of science policy, international law and diplomacy. At this level the United States and France have a special responsibility, because they are today by far the most advanced regarding the quality of their nuclear armament.

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(*) The power of microexplosion fusion installations can be expressed as the energy that the lasers are capable of delivering to the target at the highest frequency. At present, the most powerful laser energy attains approximately 30 kJ for the United States, 10 kJ for Japan, 6 kJ for France, 3 kJ for Russia and China and about 1 kJ for Germany and the UK. The nominal energy of the Megajoule Laser at Bordeaux will, in principle, be the same as that of the new laser being built in the United States, i.e. 1,800 kJ, which corresponds to an energy of the order of 600 kJ at the highest frequency.