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Nuclear Stockpile Management: A Technical and Political Assessment

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EXECUTIVE SUMMARY

Managing the nuclear arsenals (whether strategic or non strategic ones) belonging to States that possess nuclear weapons is quintessentially based on the objective of maintaining security, safety and the reliability of their weapons. Since the early stages of military nuclear armaments, it has hinged on an approach that has been altogether scientific, technical and industrial, where nuclear tests have played a key role in acquiring and checking knowledge, while advancing the research and development of new weapons. It has experienced important evolutions, particularly linked to the interruption of nuclear tests since the early 1990s, and to the gradual multilateral evolution towards the total banning of such tests, enforced thanks to moratorium agreements and later by the rounds of talks leading to the Comprehensive Test Ban Treaty (CTBT), its adoption and opening for signature in September 1996.

The situation of *de facto* nuclear states is a different one, in that their strategic posture and the development of their arsenals are placed in specific regional contexts; yet, compared with the five nuclear weapons States according to the definition of the Non-Proliferation Treaty (NPT), their objectives in terms of reliability, safety and security are, of necessity, of the same nature, even though the technological capabilities placed at their disposal to meet their goals may vary considerably from one country to the next.

One determining context is the ban on nuclear weapon tests. As decades went by, four successive treaties were signed: PTBT (1963), TTBT (1974), PNET (1976), CTBT (1996). Even though a complete, legally binding test ban still remains to be fully implemented, for more than ten years, there has existed a political norm of renunciation of testing, and a quasi universal one too. Indeed the CTBT has had, and will continue to have, more remarkable results than the previous treaties, and it is bound to impose further serious constraints on the Stockpile Stewardship strategies. In fact, its effective implementation has resulted in the

actual freezing of nuclear States' capacities, while allowing for somewhat different situations in Nuclear Weapon States and *de facto* nuclear States.

The second structuring element of nuclear stockpile management is the ban on the production of fissile materials for nuclear weapons (FMCT), which has been on the agenda of the international community for fourteen years. But its negotiation at the Conference on Disarmament still has not managed to get started because the CD is still in a stalemate even today after the adoption of its program of work last May.

The Stockpile Stewardship concept emerged rather belatedly in the history of nuclear arsenals, since it was introduced by the USA in 1992, as well as by other nuclear powers. The concept itself gradually evolved, until 1995 when the US Science Based Stockpile Stewardship policy and the French one in particular found their full expression: managing potential problems due to aging stockpiles, refurbishing weapons and components as required, maintaining the science and the engineering agencies supporting the national deterrent.

As a matter of fact, the maintenance in operational condition of nuclear weapons presents, contrary to classical weapon systems, specific and increased challenges, owing to the sophistication of the technologies involved and because of the aging processes of nuclear and other materials in the weapons.

We then try to review briefly in this paper the Stockpile Stewardship and Simulation context and policies in the Nuclear Weapon States and in three other *de facto* nuclear States considered as such, although very little is known in certain cases.

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Managing the nuclear arsenals (whether strategic or non strategic ones) belonging to States that possess nuclear weapons is quintessentially based on the objective of maintaining security, safety and the reliability of their weapons. Since the early stages of military nuclear armaments, it has hinged on an approach that has been altogether scientific, technical and industrial, where nuclear tests have played a key role in acquiring and checking knowledge, while advancing the research and development of new weapons. It has experienced important evolutions, particularly linked to the interruption of nuclear tests since the early 1990s, and to the gradual multilateral evolution towards the total banning of such tests, enforced thanks to moratorium agreements and later by the rounds of talks leading to the Comprehensive Test Ban Treaty (CTBT), its adoption and opening for signature in September 1996, in the United Nations General Assembly.

The situation of *de facto* nuclear states is a different one, in that their strategic posture and the development of their arsenal are placed in specific regional contexts. Yet, as compared with the five nuclear weapons States, according to the definition of the Non-Proliferation Treaty (NPT), their objectives in terms of reliability, safety and security are, of necessity, of the same nature, even though the technological capabilities placed at their disposal to meet their goals may vary considerably from one country to the next.

One determining context: the ban on nuclear weapon tests

Apart from the recurring issue of nuclear disarmament, the test ban is central to one of the most mooted controversies related to nuclear weapons. Since Nehru proposed, in April 1954, to adopt a "standstill agreement", besides the proposals put forward by Eisenhower (in 1958) and Kennedy (in 1963), this is a matter that has been constantly on the international community agenda and, as decades went by, four successive treaties were signed:

- The Partial Test Ban Treaty (PTBT) was signed in August 1963 and entered into force in October the same year; it prohibits tests in the atmosphere, in outer space, and underwater;
- The Threshold Test Ban Treaty (TTBT) imposed a 150 kiloton limit on underground tests; signed in July 1974 by the United States and the USSR, it entered into force only in December 1990, on account of the problems met during the bilateral negotiations on an efficient verification protocol for that threshold. For all that, both great nuclear powers committed themselves to abide by the 150kt limit, pending its implementation, and the United Kingdom as well as France followed suit;
- The 1976 Peaceful Nuclear Explosion Treaty (PNET), the twin agreement to the TTBT, provided that peaceful nuclear explosions carried out by the USA and the USSR should be subject to a specific regime, designed to make it impossible for such blasts to be used for military purposes; however, that treaty has been obsolete since the late 1980s;
- The Comprehensive Test Ban Treaty (CTBT)[1,2] – the ultimate objective aimed at for the past forty or so years of talks – was formally negotiated in Geneva from 1994 onwards and was opened for signature in September 1996; to this day, it has been signed by 181 States and ratified by 149 of them, but has yet to enter into force;

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[1] *A New Look at the Comprehensive Nuclear-Test-Ban Treaty*, International Group on Global Security (IGGS), Clingendael Security Paper No. 6, September 2008

[2] *Nuclear Test Ban – Converting Political Visions to Reality*, O. Dahlman, S. Mikkelveit, H. Haak, Springer Ed., 2009

> indeed, out of the forty-four States belonging to Annex 2 that are endowed with nuclear civilian or military capabilities and whose ratification is a precondition to its entry into force, nine have failed to ratify it, among which, in particular, two nuclear weapons states (the US and China) and four *de facto* nuclear States (North Korea, Israel, India and Pakistan), and indeed Iran.

Even though a complete and universal, legally binding ban has yet to be implemented, it is possible today to assert that, for more than ten years, there has existed a norm of the political renunciation of tests, and a quasi universal one too, since North Korea has been the only country that infringed it in the 21st century – in October 2006 and May 2009, after India and Pakistan tested in 1998.

It can be said that the gradual extension of the scope of test bans had no great impact, either on the arms race underway from the 1950s to the 1970s, or on the qualitative and quantitative growth of arsenals at that time. The development by nuclear powers of thermonuclear weapons and of megaton charges was carried out without any real constraints. Conversely, the limitation of underground tests to a maximum 150kt yield did impose strenuous technological constraints regarding the measurement, acquisition and recording techniques designed to deal with the experimental data collected during tests. Therefore, nuclear powers have had to develop much more sophisticated methods for the diagnosis of results from experimental devices, along with a proportional increase in the corresponding budgets.

The CTBT has already had, and will continue to have, more remarkable results than the previous treaties, and it is bound to impose serious constraints on the Stockpile Stewardship[3] strategies. The objective it has been assigned, as written in its preamble, is "to take [..] effective measures toward nuclear disarmament and against the proliferation of nuclear weapons in all its aspects" and to contribute to "an effective measure of nuclear disarmament" "by constraining the development and qualitative improvement of nuclear weapons and ending the development of advanced new types of nuclear weapons". In reality, its effective implementation has resulted in the actual freezing of nuclear States' capacities, while allowing for somewhat different situations:

- Without nuclear tests, the five nuclear weapon States according to the terms of the NPT are no longer able to develop new ones, and each of them is stuck at the qualitative development stage that its arsenal had formerly reached, a stage achieved thanks to the tests, very numerous in the case of both great Cold War powers, up to 1996.
- *De facto* nuclear States (India, Pakistan, and North Korea) carried out an extremely small number of tests – in 1974, 1998, 2006 and 2009 – whose contribution to the build-up and the development of safe and reliable arsenals is bound to be limited. Nevertheless, India and Pakistan, probably with the assistance of China as far as the latter is concerned, and based on the (very significant) knowledge that is available nowadays in the non-classified domain, as well as thanks to their high scientific and technological level, have been able to put together an arsenal boasting a few dozen warheads whose reliability and security they regard as satisfactory to meet their needs in terms of deterrence. Yet, just like the historical nuclear powers, they are quite unable to upgrade the design of their existing inventories, let alone design new ones.

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[3] V. Belous, I. Safranchuk, *Stewardship of Test-Free Nuclear Arsenals*, World Security Institute Report, Washington D.C., August 2006

- The case of Israel is quite particular. Apart from the unconfirmed hypothetical atmospheric test alleged to have occurred in 1979 off the coast of South Africa, it is not supposed to have implemented any nuclear test program at all. However, its past cooperation agreements, resting on very extensive scientific and technological capabilities, may have enabled that country to build up its own safe and reliable arsenal.
- The ability of the CTBT to inhibit the development of nuclear arsenals is challenged when it comes to tackling proliferation in an emerging country: it is possible to conduct the first nuclear test successfully without meeting insurmountable technical difficulties, so long as the experimental device has been given a proper size, i.e. allowing for sufficient margins, as was formerly the case until the first test by India in 1974, and as is a fortiori the case at present, due to the technological progress that has been made, and to the fact that knowledge that used to be sensitive has fallen into the public domain.

Therefore, the CTBT is a useful instrument for limiting nuclear weapons capabilities, and promoting disarmament and non proliferation. Yet it is still unable to prevent the emergence of new nuclear powers. It must be satisfied with merely detecting their existence. It does also create extremely significant constraint in terms of stockpile stewardship and further warhead development by eliminating the most obvious tool to check the reliability of a nuclear arsenal or a nuclear design: testing it.

A second structuring element: the ban of the production of fissile materials designed for nuclear weapons

The negotiation of a Fissile Material Cut-Off Treaty (FMCT), relating to the banning of the production of fissile material designed for nuclear weapons and for other explosive nuclear devices, has been on the agenda of the international community for a long time. Such a multilateral, universal and internationally verifiable instrument would introduce a *de facto* ban on the qualitative growth of all nuclear arsenals, given that it would impose a definitive ceiling on the total amount of fissile materials available in the military cycle of countries, providing the latter accepted being bound by such an instrument, which is what the NPT nuclear weapon States have agreed to. Such a commitment by all NPT States Parties stands as one of the three elements (besides negotiation of the CTBT and the continued reduction of nuclear arsenals) that make up the Program of Action provided by Decision N° 2 regarding the Principles and Objectives for the non-proliferation of nuclear weapons and nuclear disarmament, adopted in 1995 along with the extension of the NPT for an indefinite period.

The negotiation of an FMCT, listed since that time as part of the agenda of the Conference on Disarmament, has still not managed to get started for want of a consensus, because it is held hostage to diplomatic scheming that takes advantage of the various interrelated connections that exist between non-proliferation, disarmament and the prevention of the arms race in outer space.

Pending the unlikely break that would unlock the CD, still in a stalemate today even after the adoption of its work program last May, and in the framework of their levels of sufficiency, all three western nuclear powers and Russia have taken the unilateral decision to put an end to fissile material production, whereas China is thought to be maintaining its own production program, and the other nuclear armed States still continue to increase their own stocks – having shown no sign of any political determination to eventually stop.

The Stockpile Stewardship concept and its origins

The Stockpile Stewardship concept emerged rather belatedly in the history of nuclear arsenals, since it was introduced by the USA in 1992, as well as by other nuclear powers. Following the announcement by the USSR and France that they intended to apply a moratorium on their own nuclear tests (in October 1990 and April 1992 respectively), President G.H.W. Bush, under pressure from Congress, signed in September 1992 the Hatfield-Exxon-Mitchell amendment, which provides the following:

- A moratorium on US tests (and it *de facto* applied to the British tests as well, since the United Kingdom was then carrying out its tests at the Nevada Test Site) until 1 July 1993.
- Binding terms regarding the resumption of tests, 15 of which were performed until 1996 and were designed to increase the reliability, safety and security of existing weapons.
- A ban on tests as of September 1996, unless another country carried one out before that date.
- The obligation for the US President to negotiate a CTBT by September 1996.

The Stockpile Stewardship concept itself gradually evolved later. The National Defense Authorization Act, in fiscal year 1994, requested the Energy Secretary to develop a program devised to ensure the preservation of the whole body of US scientific knowledge and techniques in the area of nuclear weapons, whose objective was to guarantee the security, safety and reliability of the arsenal, despite the absence of nuclear tests. More specifically, this program was directed to[4]:

1. Increase the understanding of the enduring stockpile.
2. Manage potential problems due to the aging of the stockpile.
3. Refurbish and remanufacture weapons and components as required.
4. Maintain the science and engineering institutions supporting the nation's nuclear deterrent.

Such an approach explicitly provided for the preservation of national laboratories working on deterrence programs[5], as well as the upkeep of US capability to resume tests, should such a measure proved necessary, which implied the maintenance of the operational capabilities of the Nevada Test Site.

Concerning the resumption of tests, it is worth pointing out that the CTBT includes (according to its article IX) a traditional clause regarding supreme national interests that is in accordance with international law governing treaties: "Each State Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests." In 1995, on the occasion of the Geneva round of talks, all three Western nuclear powers and Russia had formally declared, through their permanent representatives, that the maintenance of the safety,

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[4] *Nuclear Matters: A Practical Guide*, Office of the Deputy Assistant to the Secretary of Defense (Nuclear Matters), The pentagon, Washington, DC ,2008

[5] This means the three National Laboratories, in Livermore, Los Alamos and Sandia

security and reliability of their weapons was part and parcel of their supreme national interests, hence opening a legal means towards resuming tests, if needed in the future, thus preparing a way out in case of serious difficulties in the management of their arsenals.

The US Science Based Stockpile Stewardship policy found its full expression in August 1995, when France and the USA, later joined by the other nuclear powers, almost simultaneously announced their decision in favor of the "zero option" regarding the scope of the CTBT, a choice that amounted to accepting the ban on all nuclear experimentation where chain reactions are triggered, hence more particularly on hydro-nuclear experiments, during which the tests of nuclear devices result in a limited release of nuclear energy, that can range, according to the positions then expressed, from only a few kilos to some tens of TNT equivalent[6,7].

On that occasion, the White House published a communiqué whereby it formulated the conditions required for the US to agree on a CTBT. Since those conditions define in detailed fashion the technical and political framework within which the US Stockpile Stewardship can exist, it is important to recall them here in extenso:

"A Comprehensive Test Ban Treaty (CTBT) is conditioned on:

A. The conduct of a Science Based Stockpile Stewardship program to insure a high level of confidence in the safety and reliability of nuclear weapons in the active stockpile, including the conduct of a broad range of effective and continuing experimental programs.
B. The maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology which will attract, retain, and ensure the continued application of our human scientific resources to those programs on which continued progress in nuclear technology depends.
C. The maintenance of the basic capability to resume nuclear test activities prohibited by the CTBT should the United States cease to be bound to adhere to this treaty.
D. Continuation of a comprehensive research and development program to improve our treaty monitoring capabilities and operations.
E. The continuing development of a broad range of intelligence gathering and analytical capabilities and operations to ensure accurate and comprehensive information on worldwide nuclear arsenals, nuclear weapons development programs, and related nuclear programs.
F. The understanding that if the President of the United States is informed by the Secretary of Defense and the Secretary of Energy (DOE) – advised by the Nuclear

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[6] That interpretation of the scope of the CTBT is shared by all Five, and it does not therefore exclude carrying out so called "subcritical" nuclear experiments, which aim at studying the dynamic behavior of nuclear materials in passive nuclear conditions, as they do not result in nuclear chain reactions. Such experiments have been or are being performed officially by the US and Russia, and they have been or might be carried out currently by the other nuclear States.

[7] It is worth pointing out that hydro-nuclear experiments are hardly detectable by the CTBT verification system, except, possibly, in some Western regions of the Northern hemisphere and, though technically hard to design and carry out, they could be performed by a State that would develop its arsenal clandestinely under the condition that it would enjoy a certain level of technical potential.

> Weapons Council, the Directors of the DOE's nuclear weapons laboratories and the Commander of the U.S. Strategic Command – that a high level of confidence in the safety and reliability of a nuclear weapon type which the two Secretaries consider to be critical to our nuclear deterrent could no longer be certified, the President, in consultation with Congress, would be prepared to withdraw from the CTBT under the standard "supreme national interests" clause in order to conduct whatever testing might be required."

President Clinton reiterated the same safeguards when transmitting the CTBT to the Senate in September 1997, for advice and consent to its ratification. On that occasion, he insisted on the yearly certification procedure by the DOD and the DOE, and proposed to include that procedure within US law. However that attempt was met with determined opposition from the Senate (whose majority was Republican) and ended up in its well-known failure It failed again in 1999.

The Science Based Stockpile Stewardship: the elements of the model

The maintenance in operational condition of nuclear weapons presents, contrary to classical weapon systems, specific and increased challenges, owing to the sophistication of the technologies in question.

The technical credibility of the deterrent power of nuclear weapons makes it particularly necessary to solve a problem that is inherent in the maintenance of a safe and reliable nuclear arsenal without performing nuclear tests, as such absence makes it impossible to validate either existing weaponry or to develop new weapons: it is a real problem since weapons become rapidly obsolete due to the natural evolution of nuclear materials included in their design, an evolution that shortens their lifetime and compels nuclear powers to renew their inventories. The capability of renewing weapons rests both on technical databases constituted from past nuclear tests, and on the scientific and technological capabilities to simulate the functioning of weapons. In principle, such national capabilities pertain to three categories:

- ➢ The mastery of the physics of nuclear weapons, based on physical models that must be both interpretative and predictive as regards the various stages involved in the working of those weapons, as well as on databases about the physical state of fissile nuclear materials (uranium and plutonium) or fusible ones (deuterium and tritium), besides other materials present in those weapons.
- ➢ Capabilities of numerical simulation, i.e. scientific calculation, based on the possession of very powerful computers[8] and on the development of numerical codes able to reproduce as realistically as possible the complexity of the numerous physical phenomena that come into play, as well as their sequences.
- ➢ Capabilities of experimentations in laboratories. This involves having large-sized instruments at their disposal, that enable them to study the extreme behavior found in matter, and particularly to reproduce some physical phenomena occurring in these weapons, besides validating their numerical modeling and simulation.

[8] Today, the power of the most highly performing computers in this field is calculated in teraflops (1 teraflop = one thousand billion elementary arithmetical operations per second).

Stockpile Stewardship in France: Simulation

Regarding Science Based Stockpile Stewardship, the French position follows the general model, and France has contributed considerably to the articulation of its definition, along with the USA.

The “Direction des applications militaires” (DAM—Directorate of Military Applications) of the “Commissariat à l’énergie atomique” (CEA—Atomic Energy Commission), is in charge of the design, manufacturing and maintenance in operational condition, as well as of the dismantling, of the nuclear warheads that equip the submarine launched SLBMs (TN 75) and airborne (TN 81) components of French nuclear forces. The DAM is also responsible for the supply of nuclear materials to meet defense needs, as well as for the design and maintenance of the nuclear reactors ensuring the propulsion of the National Navy ships (submarines and aircraft carriers).

This mission is carried out in the framework of the French commitment, as of 1993, to the negotiation, the success and the entry into force of the CTBT, as well as in the context of the constraints imposed by the 1996 presidential decisions:

- The definitive stop to the production of fissile materials (plutonium and uranium) for military purposes and the dismantling of the associated Marcoule and Pierrelatte production factories.
- Following one last series of nuclear tests between 1995 and 1996, the definitive end and dismantling of the Pacific test site.

The Stockpile Stewardship strategy developed by France since 1995 in that context offers the advantage, compared to other NWS policies, of being extremely explicit. That strategy hinges upon three elements:

- The concept of robust charges, based on their stable functioning and their low sensitivity to technological variations. Those charges were tested during the last 1995-1996 test series.
- The validation of the discrepancies due to the “militarization” of the nuclear charge or of those that are likely to appear during the operational lifespan of the weapon. That validation is carried out thanks to the tools belonging to the simulation program.
- The compulsory certification of the teams in charge of assessing the consequences of such discrepancies on the functioning or the safety of weapons all through their lifespan. Those teams, not familiar with nuclear tests, are being trained thanks to the experiments performed in the simulation program facilities and to the reinterpretation work on past tests, along with an evaluation made by experts experienced in nuclear tests. The handover from one generation to the next was considered crucial for the simulation program to keep to schedule.

As for the simulation program per se, the specific nature of the French program relies on its outstanding scientific calculation capabilities and on the large scale of its laboratory instruments. Regarding the former, the DAM multiplied its calculation power by a factor of

100 in 2001 and of 1000 in 2005, when it acquired the TERA 10[9] machine; the third step will be to reach a factor of 10000 in 2010.

Concerning the large experimental means, two instruments play a major part:

- The AIRIX radiographic machine, operational since 2000, has been designed to permit the validation of models relative to the functioning of a weapon in its non-nuclear working stage. In the experiments that are carried out with it, the non-nuclear materials are replaced with inert ones. The radiographs obtained that way show, with great spatial and temporal resolution, the movements of matter preceding its switch to nuclear behavior.

- The "Laser Mégajoule" (LMJ), whose construction has been ongoing since 2003 at the CEA center of the CESTA, is very similar to the US National Ignition Facility (NIF) and its size has been designed to perform experiments called "inertial confinement fusion experiments", whose applications are dual in nature. Such experiments consist of imploding millimetric targets containing a few tenths of milligrams of a mixture of the two heavy isotopes of hydrogen, deuterium and tritium. They make it possible to meet, in a laboratory, conditions that are similar to the ones found during a thermonuclear test or at the core of a star. Hence, it will be possible to validate both the scientific models and software used in numerical simulation, as well as the skills of the physicists involved in those programs. The first experiments could be carried out as early as 2011.

Stockpile Stewardship in the United Kingdom

The United Kingdom performed its first nuclear test in 1952, and carried out 45 in all. Since 1962, all those tests have been made in Nevada. It had accepted a testing moratorium as of 1991; it signed the CTBT in September 1996, and ratified it along with France in 1998.

Since 1997, the British government has taken a series of decisions aimed at limiting the nuclear arsenal, today reduced merely to its submarine component (submarines of the Vanguard class, which replaced the Polaris from 1994 onward, and their Trident II D5 missiles). It currently fields fewer than 160 operationally available warheads.

The nuclear warhead developed for the Trident system currently in service has a lifespan that enables it to dispense with replacement until the 2020s. That warhead was designed and manufactured at the (British) Atomic Weapons Establishment (AWE), but the United Kingdom has acquired some of its non nuclear components from the US, while insisting on the necessity to maintain a deterrence capability fully independent from the US in operational terms[10].

Regarding Stockpile Stewardship, the British posture has not been publicly presented in detail, but it manifests itself quite unambiguously: "We will continue the program of investment in sustaining the capabilities of the Atomic Weapons Establishment (AWE), both

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[9] It has a power of 10 teraflops (see note 6 above).

[10] *The Future of the United Kingdom's Nuclear Deterrent*, White Paper presented to the Parliament by the Secretary of State for Defense and the Secretary of State for Foreign and Commonwealth Affairs, Cm 6994, December 2006, Section 4.

to ensure we can maintain the existing warhead for as long as necessary and to enable us to develop a replacement warhead, if that is required"[11].

Currently, the activity of the AWE (essentially comprising two major centers in Aldermaston and Burghfield), covers the whole cycle of nuclear weapons, from their initial concept, evaluation and development, as well as the manufacturing of components and their assembly, the production and maintenance of weapons in service, down to their scrapping, dismantlement and the management of the resulting waste. That activity includes having the knowledge required to developing a replacement nuclear warhead, should such a decision have to be taken (see supra). All in all, it aims to ensure the security and reliability of the arsenal.

Carrying out that "support of national security" mission rests on very sophisticated scientific, technological and engineering capabilities, which permit both the warranting of the reliability of arms and at a very challenging security level. As is the case for all other nuclear powers, it has to be performed without any nuclear testing, and despite the small number of tests actually performed by the UK.

Henceforth, in the same way as the US and France, and in cooperation with the former, the United Kingdom has had to develop a Science Based Stockpile Stewardship program dependent on the command of the same key scientific and technological subjects: weapons physics, design methods, metallurgy, systems engineering and manufacturing techniques.

Stockpile Stewardship in Russia

The nuclear posture of the Russian Federation can boast the 715 tests it carried out between 1949 and 1990, whose objectives covered, in the same way as those of the other major powers, the whole range of the classical aims of any nuclear test[12]:

- Weapon design and development,
- Studying the effects of weapons,
- Weapon safety and security studies,
- Technological and fundamental research,
- Industrial development and militarization.

These led to the development of the oversized arsenal that has since become history. The end of the Soviet Union in 1991 resulted in the direct consequence, regarding the testing program, of losing the test sites of Semi-Palatinsk to the benefit of Kazakhstan (which decided to close it down that very same year) and the declaration of a testing moratorium as of October 1991, then extended, as was the case of the other nuclear powers, up to the CTBT negotiation period. In April 1996, Russia announced that it would sign the treaty but that it would also make sure of the reliability and safety of its weapons, as well as of their combat readiness, and that it would reconsider its adhesion should problems arise.

[11] Ibid., Section 5

[12] Russian Strategic Nuclear Forces, ed. by P. Podvig, MIT Press, 2004, Chap. 8

The Russian Federation has succeeded in managing the considerable and difficult transition imposed upon it by history since the early 1990s. Its nuclear complex and arsenal have gradually phased out the gigantism that was typical of it at the end of the Cold war (approximately one hundred and fifty R&D centers, ten of which were so-called "closed cities", which had one million persons on its staff at the time of Minatom in 1989[13]) and, in the new strategic context, it evolved towards a much leaner and profitable infrastructure, whose size was determined by the decrease in strategic arsenals imposed on them by the START I and START II Treaties, as well as by the autumn 1991 Bush-Gorbachev Presidential Nuclear Initiatives concerning, amongst other things, the elimination of the major part of tactical nuclear weapons[14].

Minatom was reorganized in late 2007 into a State corporation, Rosatom, which pools the institutions working on military programs, the research institutes and the nuclear safety agencies, while controlling within that framework the Atomenergoprom holding, responsible for the civilian nuclear cycle. Inside that complex, the federal centers made up of the two historically closed cities of Sarov (VNIIEF, the ex-Arzamas 16) and Snezhinsk (VNIITF, the ex-Chelyabinsk 70) are more especially in charge of the Stockpile Stewardship programs, since they were originally responsible for the nuclear weapons R&D and design programs, as well as the associated nuclear test programs, and also part of their industrial production.

Stockpile Stewardship in China

China has a particular place within the P5. While it has kept away from the arms race between the two major powers, and continually reproaches them for perpetuating it[15], it has been keen to maintain considerable opacity regarding its own nuclear posture and infrastructure, and other countries have very little actual knowledge about them.

China has carried out a relatively small number of nuclear tests to develop its arsenal, namely 45 (20 of which underground or inside galleries)[16], and its first one occurred in 1964. It has never agreed on a moratorium on its tests, arguing that it was exercising "utmost restraint" in this matter. It has not taken part either in the 1991 moratorium accepted by the four other Nuclear Weapon States, and carried out two tests per year until the end of the CTBT negotiations in July 1996. It then officially placed itself under a moratorium. It could be assumed that the last series of eight tests, of quite similar seismic magnitudes, constituted the last campaign carried out at such a sedate pace, and was designed to fine-tune its robust charge design, so as to be able to make do without tests for an indefinite period of time.

According to all available evidence, China has developed an arsenal that is little diversified, mainly composed of one or two sorts of multimegaton warheads designed in the 1970s and '80s, to be fitted to its DF 4 and DF 5A intercontinental missiles, as well as an gravity bomb devised for its bombers. In 1988, it allegedly tested a low-power enhanced neutron radiation tactical weapon. It would seem that, later on, it has focused on the relative miniaturization of its equipment, aiming to improve a smaller (200 to 300kt?) yield warhead designed for the

[13] Ibid., Chap. 3

[14] Including all the nuclear artillery ammunitions, short range missiles and the tactical weapons based at sea.

[15] Wang Zhongchun, "Nuclear Challenges and China Choices", *China Security*, Winter 2007, pp. 52-65.

[16] http://www.fas.org/nuke/guide/china/nuke/tests.htm

new missiles allocated to its ground (DF-31 and DF-31A) and submarine (JL-1 and later JL-2)[17] force components.

In fact, China is currently the only nuclear power in the NPT sense that is pursuing the development and modernization of its nuclear forces, regarding both weapons and vectors. Yet, despite all speculation as to the real size of its arsenal, it claimed in 2004 that, among the P5, it was the one with the smallest arsenal at its disposal, which ranked it behind that of the United Kingdom (although open sources and commentators question the credibility of that statement). For all that, it has never made any more accurate official statement, either about the size of its arsenal or regarding its inventories of fissile materials or the manufacturing rate of its new nuclear warheads, thereby using the quantitative ambiguity surrounding its arsenal to reinforce the credibility of its deterrence.

As for Stockpile Stewardship, China is quite aware of the concept, and it is fully knowledgeable as regards the scientific and technical approaches connected to the Science Based Stockpile Stewardship model, as explained in this paper. The nature and scope of its activities in this domain, however, are as yet unknown. But on account of China's scientific and technological capabilities, as well as its desire to maintain a credible means of deterrence, it might logically be concluded that it must be supporting substantial programs in the area of simulation (non nuclear experiments, powerful scientific calculation software, an interest in inertial confinement fusion studies, performed with high power lasers by the other nuclear powers). Moreover, it is somewhat surprising that no official statement officially exists in China in this respect. In 1994, then US Defense Secretary, William Perry, stated that the US was offering to help China in the area of the numerical simulation of its nuclear tests, thus permitting it to keep up, in the absence of nuclear tests, the reliability and safety of its arsenal, without allowing it to design new weapons[18]. However, Beijing turned down the offer.

As for the matter of the definitive renunciation of nuclear tests, it is worth reminding readers that China, in 1996 and on the first day, signed the CTBT, as it considers it will contribute to the achievement of nuclear disarmament, and that it declared itself time and time again in favor of its ratification, though it has not followed suit so far, probably pending ratification by the US. In coming months, it should be interesting to follow the statements made by China in this respect; most particularly in the context of the April to May 2010 NPT Review Conference, when pressure for the implementation and entry into force of the CTBT is bound to rise.

Stockpile Stewardship in *de facto* nuclear countries

The model of Nuclear Stockpile Management in the absence of nuclear tests, as presented above, imposed itself on the original nuclear powers by force of circumstances, since they wished to ensure the credibility of their deterrent posture, and it brought about the implementation of, at times, large scale scientific and technological programs.

De facto nuclear powers have been, and still are, naturally confronted by the same challenges, owing to the restricted reliability and safety of their weapons. They enjoy very different capacities regarding their various capabilities, and are wary of communicating on the subject,

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[17] R.S. Norris, H.M. Kristensen, *Chinese nuclear forces*, 2008, Bull. Atomic Scientists, Vol. 64, n°3, pp. 42-45 (2008).

[18] *Arms Control Today*, December 1994, p. 28.

or even maintain total opacity in this respect, so as to avoid exposing the possible weaknesses in their arsenal management, whether they concern their available scientific potential, the industrial infrastructure they have developed in favor of the cycle of their nuclear armaments or the budgetary means at their disposal. The qualitative and quantitative ambiguities they have thereby generated enable them to protect the credibility of their own posture, and they resort to a kind of political communication that forces any potential opponent to consider that their arsenal is sufficiently combat ready to ensure effective deterrence.

India certainly stands out as the *de facto* nuclear power whose capabilities are closest to those in medium range nuclear powers. It undoubtedly enjoys the scientific, technical and industrial means to maintain its arsenal at a level of efficiency and safety that matches its official posture regarding minimal deterrence.

India has been a nuclear capable State since its first 1974 test, and has only a limited number of nuclear weapons, quite possibly in the order of several tens of warheads[19]. Its arsenal includes an airborne component and a ballistic one, based on the medium-range (2500 km AGNI II missile). It has been developing both ballistic capabilities of greater range (the AGNI III boasts a range of 3500 km) and, in the longer run, it will enjoy a submarine component, since it is determined to equip itself with a credible minimal deterrence capability. Yet, for the time being, it seems that its nuclear forces are not being maintained in a state of readiness. The five nuclear tests it has performed on the occasion of its two 11 and 13 May 1998 experiments demonstrate, however, its determination to achieve the technical upgrade of its arsenal, even though those experiments do not seem to have been totally successful. It has allegedly aimed to master the design of thermonuclear warheads, and of low yield devices within the sub-kiloton range. It is therefore possible to assume that, in spite of its extensive scientific and technological capabilities, India is unable to entirely control the reliability of its weapons, though it would be hard to formally substantiate such a claim. In any case, India refused to adhere to the CTBT immediately after the June 1996 round of talks, as it deemed that being mentioned in the list of the 44 countries whose ratification is necessary (and sufficient) for the treaty to enter into force constitutes an attack on its sovereignty. Yet, it has declared a moratorium on its nuclear tests, by which it continues to abide, despite the occurrence of at times highly controversial debates within the Indian political and nuclear communities as to the possible resumption of tests to meet its simulation needs.

Paradoxically, Pakistan for its part is credited, according to some sources, with a slightly bigger arsenal, although in the same range of several tens of warheads[20]. Such an arsenal is very likely being constantly increased, in the same way as India's. Yet, very little is known as to Pakistani engineers' know-how in terms of Stockpile Stewardship. That country had announced it had conducted six nuclear experiments on the occasion of its 28 and 30 May 1998 tests, but in view of the seismic data that was recorded on those occasions, a great number of pundits have aired their doubts as to the success of the tests. For the past several years, the physical safety of Pakistani nuclear weapons has raised a great deal of concern, whatever their operational readiness might be, in view of Islamist threats and despite the soothing statements made by the Pakistani authorities. More especially, General Kidwai, the

[19] 30 à 35 according to an assessment by the NRDC (Natural Defenses Research Council) in 2002. See also: http://www.fas.org/nuke/guide/india/nuke/index.html

[20] R.S. Norris, H. Kristensen, *Nuclear Notebook: Pakistani Nuclear Forces*, 2009, Bull. Atomic Scientists, Sept.-Oct. 2009.

managing director of the Strategic Plans Division, declared the following in 2008[21]: "We have institutionalized the structures (overseeing the nuclear arsenal) and introduced modern technology so there are sufficient firewalls, safety and security built into the chain of command, as well as into the weapons and weapon production facilities". The elements for a Stockpile Stewardship do exist, in fact, but it is difficult to assess their technical level.

The case of the Israeli nuclear arsenal, whose reality is an averred fact according to all observers, is a very peculiar one, on account of the total ignorance of other countries in the matter. Assessments of the size of the Israeli arsenal deem it to range from just a few tens of weapons to more than two hundred, according to whether the number of weapons that have possibly been manufactured, or the inventory of the available fissile materials[22]. are taken into account. In the same way, nothing is known regarding their nuclear tests, apart from speculation as to the alleged 1979 test off the coast of South Africa. As for Stockpile Stewardship, in view of the Israeli engineers' scientific level of expertise, one is bound to assume that it is part and parcel of the Israeli operational posture, even though nothing is known as to its nature, organization and effectiveness.

Some conclusions

This brief tour of both the constraints and programs related to stockpile stewardship of nuclear weapons leads to some preliminary conclusions:

- All nuclear weapon states (*de jure* or *de facto*) are engaged in stockpile stewardship activities. In spite of significant differences in terms of financial, scientific and technical means available, they all devote substantial amounts of resources to maintaining a safe and reliable nuclear stockpile.
- Politically, this signals a desire to sustain a credible nuclear deterrent for the foreseeable future and meets a traditional objective of every nuclear weapon complex.
- Technically, the current ban on testing (potentially even stronger when the CTBT comes into force) creates very severe constraints on stockpile stewardship-related activities, and prevents in particular the development of new weapons design, at least in a manner compatible with common criteria on safety and reliability. It also creates additional constraints on the management of aging stockpiles and has led many NWS to develop robust weapon designs in order to achieve their long-term safety and reliability objectives. The moratorium on fissile material production respected by four countries (US, UK, France and Russia) and the potential Fissile Material Cut-off Treaty create additional constraints by inducing a careful management of a finite stock of fissile materials. The combination of the test ban and the fissban has made significant modernization and growth of nuclear arsenals extremely difficult if not impossible.
- Nuclear states have therefore accepted a variety of severe constraints on their activities, ranging from very heavy and legally binding for France, Russia, the UK and the US, to lighter ones when it comes to China and the other four nuclear capable countries.

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[21] F. Bokhari, *Pakistani Official Addresses Nuclear Security concerns*, Jane's Defence Weekly, Feb. 6, 2008, p. 6.

[22] http://www.fas.org/nuke/guide/israel/nuke/index.html

- The degree of transparency regarding stockpile stewardship activities also varies considerably. Primarily for domestic political and bureaucratic reasons, the Western NWS (and Russia to a lesser extent) tend to provide a lot more information than the other nuclear players. Opacity even seems to be a policy when it comes to China, India and Pakistan and of course Israel and the DPRK. This might be a way not to expose weaknesses or a deliberate strategy of secrecy.
- Finally, from a nonproliferation and disarmament perspective, it seems fair to expect of all nuclear armed States a reasonable level of transparency on these activities if only to provide the necessary reassurances that they are focused on safety and reliability and not engaged in a large scale modernization process.