New Technologies and the Arms Race

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Foreword

This volume contains the proceedings of the International Conference on 'Technology, the Arms Race and Arms Control' which took place at Castiglioncello, Rosignano Marittimo, in the Province of Livorno, Italy, from 25 to 30 September 1987. The Conference was organised by the Union of Scientists for Disarmament (Unione Scienziati Per Il Disarmo – USPID), thanks to the decisive contribution of funds and the valuable co-operation of the Town Council of Rosignano Marittimo.

We are glad to express our thanks here to every person who helped to make the initiative a success.

The Accademia Nazionale dei Lincei, the Istituto di Biofisica of CNR in Pisa, the Regione Toscana and the Amministrazione Provinciale di Livorno sponsored the Conference. The President of the Senate and the President of the Chamber of Deputies both supported the Conference.

The President of the Republic, Senator Francesco Cossiga, sent a goodwill message for the opening of the Congress. The keen attention and appreciative esteem he expressed – the full message is reproduced below – greatly encouraged all concerned.

The President of the Senate, Senator Giovanni Spadolini, the President of the Chamber of Deputies, on. Nilde Jotti, and the Minister of Foreign Affairs, on. Giulio Andreotti, sent greetings telegrams expressing their great interest in the work of the Conference.

The objective of the meeting was, on the one hand, to promote discussions and exchanges among experts and, on the other hand, to better inform political circles and, through the Press, public opinion in general, about matters that are all too often handled lightly or used as mere propaganda, depending on ideological standpoints and preconceived opinions. We sincerely hope that this volume will contribute to the international debate – both between the two great blocs and within them – about matters that are of crucial importance to all mankind.

THE SCIENTIFIC COUNCIL OF USPID
(Carlo Bernardini, Bruno Bertotti,
Francesco Calogero, Paolo Cotta-Ramusino,
Michelangelo De Maria, Roberto
Fieschi, Francesco Lenci, Carlo Schaerf)

22 Experimental Nuclear Explosions and the Arms Race

Francesco Lenci

It is highly significant that, ever since the first few years of experimental explosions of thermonuclear devices, the three nuclear powers of the time (the United States, Great Britain and the Soviet Union) have grappled with the problem of suspending their nuclear tests. This awareness of the importance that the discontinuance of programmes to develop military nuclear technology could have for international security and peace led, in the summer of 1958, to the convocation of a conference of experts of the Eastern and Western countries to tackle the technical questions linked with the detection of experimental nuclear explosions. The conclusions of those discussions were that it would be possible to detect and identify nuclear explosions in the atmosphere above the power of 1 kiloton (kt; 1 kt = 1000 tons of TNT), and to detect, with a reliability of approximately 90 per cent, underground nuclear tests of more than 5 kt. The monitoring network necessary for this purpose would have required a system of around 160 to 170 control stations installed on the ground and about ten appropriately-equipped ships.

Also in 1958, the Soviet Union, the United States and Great Britain inaugurated a 'voluntary' moratorium and began negotiations for the ending of all experimental nuclear explosions. On account of the difficulties that these negotiations encountered, the multilateral voluntary moratorium came to an end, and in 1961 first the Soviet Union and then the United States resumed their tests.

On the one hand, the radioactive contamination caused by the nuclear tests in the atmosphere, and, on the other hand, the moments of great tension that characterised the international situation in those years, created a state of alarm and preoccupation in public opinion which, in turn, gave rise to political pressure on the superpowers to reach an agreement banning all nuclear tests.

On 5 August 1963, the United States, the Soviet Union and Great

Britain thus signed the Limited – or Partial – Test Ban Treaty (LTBT or PTBT), which prohibits carrying out nuclear tests in the atmosphere, in outer space and under water. The partial nature of the resulting agreement is clearly recognised in the preamble to the Treaty, in which it is declared that 'seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, [the signatories] determined to continue negotiations'. And, even if intermittently, the negotiations did in fact continue over the years, always with the ultimate goal of drawing up a Comprehensive Test Ban Treaty (CTBT). However after 1963 the Soviet Union, the United States and Great Britain pursued their test programmes by carrying out nuclear explosions underground. The LTBT, by allowing underground tests to be conducted, sets no limit to the development of nuclear technologies for the acquisition of new weapons; it merely seeks to prevent contamination from radioactive fall-out due to tests in the atmosphere. (France and the People's Republic of China, not having adhered to the LTBT, conducted numerous tests in the atmosphere up to 1974 and 1980, respectively.)

However, thanks to this commitment by the United States, the Soviet Union and Great Britain to strive for agreement on the CTBT, over the years following 1963 various other treaties were negotiated and completed, both with the aim of greatly limiting the areas in which nuclear arms could be installed or tested (the Treaty on Outer Space and that of Tlatelolco relating to Latin America in 1967, the Sea Bed Treaty in 1972 and the Treaty of Rarotonga relating to the Pacific Ocean in 1986) and in order to try to avoid the horizontal proliferation of nuclear weapons (the Non-Proliferation Treaty in 1970). Also in the Non-Proliferation Treaty, the signatory states undertake to 'pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament' (Article VI).

In 1974, returning to the commitments of the LTBT of 1963, the United States and the Soviet Union, in order to continue to negotiate a CTBT and with the intention of facilitating the attainment of this objective, signed a treaty prohibiting underground nuclear tests of more than 150 kt, namely the Threshold Test Ban Treaty (TTBT). To allow satisfactory reciprocal verification of respect for the Treaty by National Technical Means (NTM), the Treaty and the Protocol to the Treaty provided that the United States and the Soviet Union exchange precise information on the geological and geophysical

characteristics of the ground in which the tests were carried out (such as density, seismic velocity, degree of humidity and porosity). It was also stipulated that the two parties should exchange detailed, complete data on two tests to be used for the preliminary calibrations. The TTBT was never ratified, but it has been substantially respected by both parties since 1976. The reciprocal accusations of violation of the Treaty, mainly directed against the Soviet Union by the Ronald Reagan Administration, have always been contested as unwarranted, not only by the Soviets but also by numerous American experts and by organisations such as the Swedish National Institute for Defence Research.[1]

In 1977 the trilateral negotiations for a CTBT between the United States, the Soviet Union and Great Britain seemed to be headed towards the final stage. The Soviet Union seemed willing to accept voluntary on-site inspections and the United States appeared to agree on the 'non-obligatoriness' of such inspections. An accord had also been reached on the number of national seismic stations to be installed on the territory of the other party, and it had been established that between 10 and 15 of these stations would be supplied with cryptological systems that would guarantee the data were transmitted without interruption and could not be altered or modified. It seems that the negotiations were so promising as to induce the Jimmy Carter Administration not to bother with the ratification of the TTBT, which had already been approved by the Senate Foreign Relations Committee in 1977. However various external factors slowed the course of the negotiations in a way that later proved to be disastrous: unforeseen difficulties in the second phase of the Strategic Arms Limitation Talks II (SALT II) , the kidnapping of the American hostages in Iran, and the Soviet intervention in Afghanistan.[2]

The negotiations to reach agreement on the CTBT were broken off immediately after the election of Reagan as President of the United States, and were resumed only in September 1987. Quite an important contribution to the resumption of the negotiations on the CTBT came from the unilateral initiative of the Soviets to suspend their nuclear test programme from 6 August 1985, the fortieth anniversary of the dropping of the atomic bomb on Hiroshima, to 1 January 1987, despite the United States's continuing to conduct nuclear tests. The Reagan Administration justified the non-adherence of the United States to the moratorium by claiming that the Soviets' initiative was merely propagandistic and that in reality the Soviets had brought their test programme to a conclusion with a long series of nuclear

explosions in 1984 and the first half of 1985. Consequently the United States, according to the official declarations, would take the possibility of a moratorium into consideration only after having completed its own test programme.

In reality this unilateral initiative had the great value of constituting concrete proof of the Soviets' 'new way of thinking', and appreciable results were seen immediately. First, in May 1986 the Academy of Sciences of the Soviet Union agreed on collaboration with the Natural Resources Defense Council (NRDC), an American environmental protection organisation, in the installation of seismic detection stations, run jointly by Soviet and American scientists, in the area of Semipalatinsk and in the desert of Nevada, where the nuclear tests of the Soviet Union and the United States are carried out. This collaboration is unequivocal proof that it is possible to find adequate solutions to the technical problems connected with the verification of a CTBT provided there is the political determination to consider international agreements for the control, limitation and reduction of armaments to be the decisive instrument for mutual security and peace.[3] Secondly, in July 1986 an International Forum of Scientists was held in Moscow to analyse the problems linked with the verification and control of a complete ban on nuclear tests and to assess the reliability of the possible technical solutions. On that occasion the first results obtained by the US–Soviet 'Verification Team' in the detection stations installed in the Semipalatinsk area were made public. The final document of the Forum also reaffirmed the technical feasibility of adequately verifying a CTBT and clearly evidenced the contribution that a CTBT, by preventing the development of new weapons systems, could make to stopping, or at least slowing, the arms race. Finally, on 7 August 1986, the group of the six countries that constitute the 'Initiative of the Five Continents' (Argentina, Greece, India, Mexico, Sweden and Tanzania) made a public appeal for the CTBT in which, among other things, the six countries declare themselves to be 'prepared to participate in co-operative efforts together with the USA and the USSR and also to take certain steps on our own to facilitate the achievement of adequate verification arrangements'.

At the end of February 1987, however, the Soviet Union too began conducting experimental nuclear explosions again, although stating its willingness to suspend them as soon as the United States did the same. The Soviet Union justified this decision with the usual arguments regarding the necessity of safeguarding its security and not

finding itself in a position of strategic and military inferiority vis-à-vis the United States. In reality this decision to resume conducting nuclear tests could be interpreted as a concession to those Soviet military and political sectors that consider the 'new way of thinking' of the Soviet leadership a continual, unjustified backing down and a declaration of weakness towards the Reagan Administration.

Substantially, underground nuclear tests must be detected by means of techniques of the seismological type, whose sensitivity is a crucial factor. A significant part of the energy released by a nuclear explosion which takes place underground is in fact transmitted to the earth (approximately: 0·01 per cent if the explosion occurs in cavity, 0·1 per cent if it takes place in dry alluvial soil and 1 per cent in the case of granitic rocks), thus generating seismic waves.

One of the most delicate problems in monitoring underground experimental nuclear explosions is discriminating them from natural seismic phenomena: repeated 'false alarms' due to earthquakes would lead to rapid deterioration of the reliability of the verification system and therefore of the credibility of the treaty itself. Today agreement among experts is nearly unanimous that the technologies now available can permit detection of weak seismic signals produced by underground nuclear tests of a power of around 1·0 kt, even in the event that the explosion is 'decoupled'.[4] Putting adequate verifiability into doubt thus appears to be a pretext so as to avoid arriving at an agreement on a total ban on nuclear tests. Finally, it should be kept in mind that the nuclear tests of less than two kilotons are a decidedly small fraction of the total number of tests, since tests of such low power have little significance or demonstrative worth if it is desired to design and develop new nuclear weapons. Indeed, tests of new arms must have explosive powers of at least half or a third that of the weapon one wants to produce.

The questionable utility of low-power tests for the development of new nuclear weapons has led some to suggest the advisability of negotiating very rapidly a ban on tests of a power above a quite low level, namely a Low Threshold Test Ban Treaty. The strongest arguments against this alternative solution to the CTBT may be, on the one hand, the possibility of perfecting new weapons systems anyway, and on the other hand, the plethora of allegations and accusations of having carried out 'above-threshold' tests that the parties might make against each other.

In the middle of the month of September 1987, the Soviet Union and the United States decided to start a negotiating process that

gradually, beginning with the ratification of the TTBT of 1974 and through intermediate limitations on the number and power of the nuclear tests, could lead to the achievement of the ultimate goal of banning all nuclear tests. The verification measurements during this negotiation will probably be performed by means of on-site controls using both seismological techniques as well as those of the 'CORRTEX' type (Continuous Reflectometry for Radius vs. Time Experiment).

Experimental nuclear explosions have basically three aims: a study of the effects of nuclear weapons; the development of new nuclear weapons; and control of the efficiency and security of nuclear weapons. As far as the effects of nuclear weapons are concerned, they have been the subject of much in-depth study, and can be easily simulated.

It is a widely held opinion, however, that the greatest obstacles to agreement on a CTBT are created by the determination to pursue development programmes for new nuclear weapons. And this is precisely the reason why a total ban on nuclear tests, although certainly not in itself a panacea, would bring nuclear weapons technology at least partially under control and make a decisive contribution to avoiding the modernisation of already existing arms systems and the development of new ones, thus significantly slowing down the arms race.

New and ever more deadly nuclear weapons can certainly be designed and acquired. One such possibility is the N-bomb, foreseen as usable as an 'anti-man' bomb on the battlefield. In it the fraction of energy emitted in the form of fast neutrons is as high as possible, while the power of the atomic triggering bomb and the quantity of fusionable material are reduced to the minimum. Another is the high Electromagnetic Pulse (EMP) production bomb. The elecromagnetic pulse generated by the asymmetric distribution of positive and negative charges is formed because of air ionisation produced by gamma rays; to maximise the pulse, asymmetric shielding could be used to make the emission of gamma radiation anisotropic.

Among the weapons systems that require nuclear tests in order to be perfected, the best known is perhaps the x-ray laser (the Excalibur Program), one of the components of the arsenal planned for the US Strategic Defense Initiative (SDI). This laser would be 'pumped' by

the energy emitted in the first few microseconds following a thermonuclear explosion, consisting, to about 70 per cent, of x-radiation. The x-rays could be collimated by thin metallic bars from which x-rays would then be emitted in phase in beams directed against the missiles to be shot down. It is estimated that another 10 to 15 nuclear tests are necessary to validate the technical feasibility of the Excalibur Program, while at least 100 to 200 additional experimental explosions would be needed to allow development of the weapon.[5]

In order to make it easier to destroy hardened objectives, such as missile silos, a warhead is being studied at the Lawrence Livermore National Laboratory which, installed on intercontinental missiles and bombers, would be able to penetrate into the earth and explode underground, thus damaging the target much more effectively. These Earth Penetrating Warheads would considerably increase the probability of success of a counterforce attack and therefore would make the enemy's nuclear weapons more vulnerable, with a decidedly destabilising effect.

One of the most important goals sought in all new arms projects seems to be that of directional channelling of the energy released by a nuclear explosion in order to concentrate it on selected objectives.[6] Weapons that emit microwaves (wavelength between 3 cm and 1m) in a relatively narrow angle could much more efficiently damage electrical installations and electronic systems, such as communications and data transmission networks, for instance. According to an estimate reported by Theodore Taylor, if 5 per cent of the energy released by a 1-kt blast could be converted into microwaves, energy fluxes of some 800 J/m^2 could be achieved (enough to seriously damage many kinds of electronic equipment) over an area of approximately 250 km^2, assuming that the explosion took place at a distance of some 30 000 kilometres from the earth (for example, by detonating, at the desired moment, a device installed on a satellite place in a geosynchronous orbit).[7] The energy flux would rise to something like 5 000 000 J/m^2 if the explosion occurred 400 kilometres away from the earth.

For the reliability and the security of nuclear weapons, the United States Department of Defense specifies the principal military characteristics that must be controlled in nuclear warheads (for example, those of the MX missile): security against triggering of the nuclear explosive in case of accident; compatibility of the dimensions and weight envisaged for the warhead by the Department of Energy with the characteristics of the launching and warhead transport systems; security from dispersion of plutonium in case of accident; efficiency of

the triggering systems, also with regard to the high-power conventional explosive; real power of the warhead; state of conservation of the nuclear material (plutonium and tritium, for example); and resistance of the warhead.[8]

As far as the security of the warheads is concerned, the entire world community can only hope that this is absolutely guaranteed for all operative nuclear weapons. As for their reliability, the researchers of the Lawrence Livermore National Laboratory report that over a third of the nuclear weapons introduced from 1958 to the present have displayed problems of reliability, 75 per cent of which were solved thanks to nuclear tests. The continuation of the tests would thus be necessary for reasons of national security. Of a decidedly contrary opinion are numerous scientists and nuclear arms experts, who hold that 'continued nuclear testing is not necessary in order to insure the reliability of the nuclear weapons in our stockpile'. 'The best way to confirm reliability,' they continue, 'is to disassemble sample weapons and to subject components to non-nuclear tests'.[9]

Even many of those who today assert that it is necessary to control the reliability of the nuclear arsenals by means of tests concur that a drastic reduction in the number of nuclear weapons is a condition that could facilitate reaching agreement on a CTBT. Actually, in a situation of minimum deterrence, if not subjecting nuclear arms to control tests truly lowered their reliability and created uncertainties as to their functioning, the danger that one of the two parties tried a first strike attack could also be less. Such a first strike would, in fact, be a completely irrational decision, both owing to the uncertainties regarding one's own arsenal and to the necessity of assuming the arsenal of the adversary to be perfectly efficient ('worst case hypothesis'), and hence capable of retaliating with a devastating counter-attack.

Notes

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2. H. F. York, 'U.S.–Soviet Negotiations and the Arms Race', in W. F. Hanreider (ed.), *Technology, Strategy and Arms Control* (Boulder, Colorado, 1985) pp. 1–14.

3. See Thomas B. Cochran, 'The US National Resources Defense Council/Soviet Academy of Sciences Nuclear Test Ban Verification Project', below, pp. 354–62.
4. J. F. Evernden, C. B. Archambeau and E. Cranswick, 'An Evaluation of Seismic Decoupling and Underground Nuclear Test Monitoring Using High Frequency Seismic Data', *Review of Geophysics*, vol. xxiv (1986) pp. 143–215.
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9. H. Bethe, N. Bradbury, R. Garwin, S. M. Keeny Jr, W. Panofsky, G. Rathjens, H. Scoville Jr and P. Warnke, in *Bulletin of the Atomic Scientists* (November 1985) p. 11.