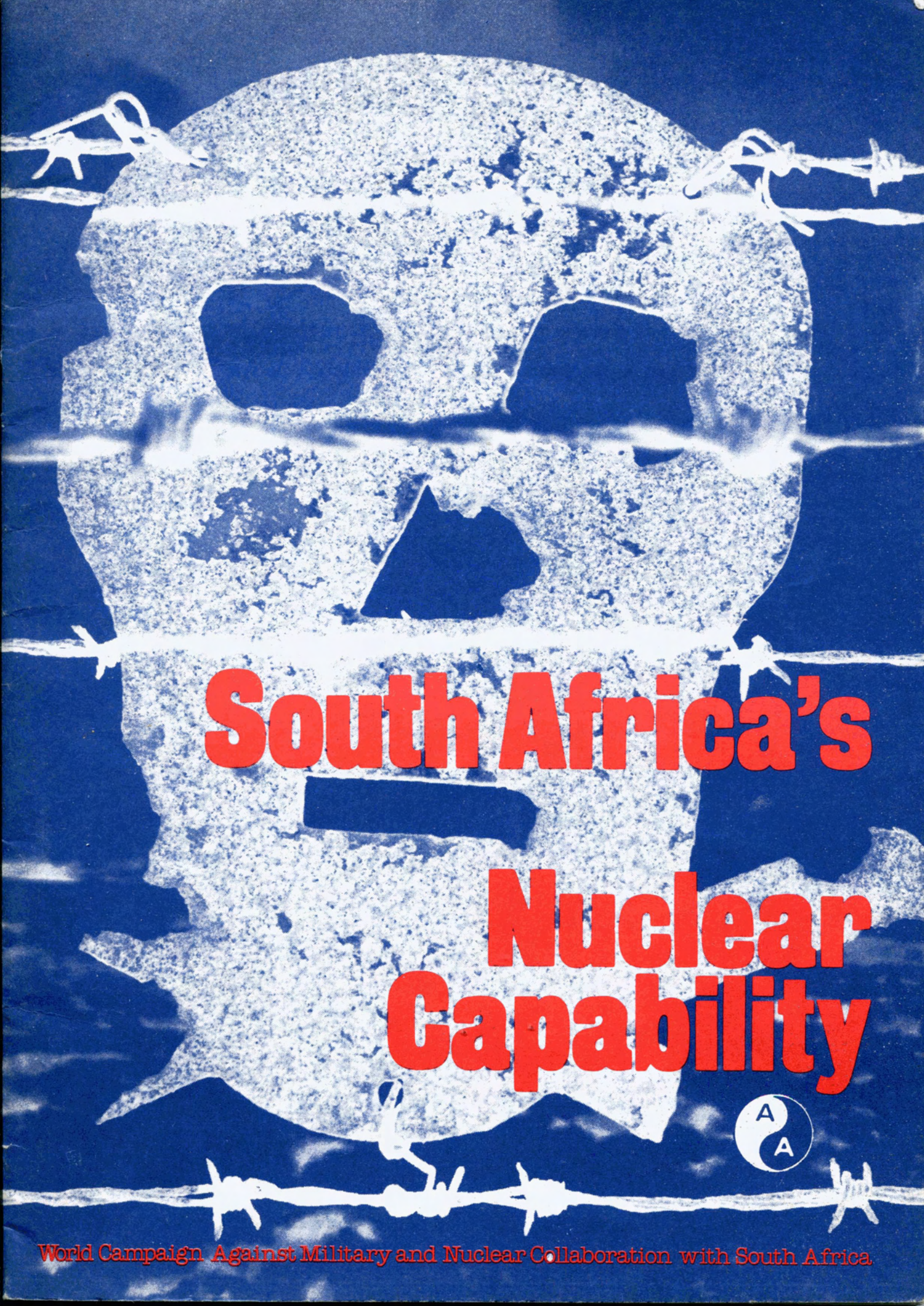

South Africa's Nuclear Capability

World Campaign Against Military and Nuclear Collaboration with South Africa

The World Campaign against Military and Nuclear Collaboration with South Africa wishes to express its appreciation to the author for preparing this paper. The views expressed are the author's and do not necessarily reflect those of the World Campaign against Military and Nuclear Collaboration with South Africa.

WORLD CAMPAIGN AGAINST MILITARY AND NUCLEAR COLLABORATION WITH SOUTH AFRICA

Aims and Objectives

1. To promote the widest awareness by world public opinion of the grave and increasing threat to international peace and security created by the system of apartheid in South Africa
2. To campaign for an end to all forms of military, nuclear and security collaboration with the racist regime in South Africa
3. To work for the effective implementation of the United Nations arms embargo against South Africa and to ensure that it is reinforced to encompass all forms of assistance and cooperation to the racist regime in the maintenance and strengthening of its military and police establishment and in its nuclear programme
4. To make representations to governments concerned on violations of the embargo and about any military, nuclear or security collaboration by them with South Africa.
5. To cooperate with appropriate organs of the United Nations and the Organisation of African Unity on implementation of effective measures against military, nuclear and security collaboration with South Africa
6. To publicise all information concerning military and nuclear plans of the South African regime, its threat to and breaches of international peace and security, and actions by governments and organisations to end all collaboration with that regime.

The World Campaign against Military and Nuclear Collaboration with South Africa was launched in London on 28 March 1979 at the initiative of the Anti-Apartheid Movement

Founding Patrons of the World Campaign: His Excellency President Mwalimu Julius K Nyerere, His Excellency President Sir Seretse Khama, His Excellency President Dr Agonstinho Neto, His Excellency President Dr Kenneth Kaunda and His Excellency Lt-General Olusegun Obasanjo

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Further copies of this pamphlet are available from the Anti-Apartheid Movement, 89 Charlotte Street, London W1P 2DQ, UK

SOUTH AFRICA'S NUCLEAR CAPABILITY

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PREFACE

The frantic efforts of the South African regime to develop its nuclear technology and installations, and to acquire nuclear weapon capability, constitute a menace of alarming proportions and an urgent challenge to the international community.

The regime in South Africa is unique in that it is based on and committed to racism. It has an unparalleled record of defiance of the United Nations and of aggression against neighbouring states. It has not flinched from mass deportations of millions of people and massacres of peaceful demonstrators, including little children, in order to maintain the system of racist domination and exploitation.

There can be no doubt that this regime seeks to acquire and utilise nuclear capability in order to perpetuate that inhuman system, in defiance of world opinion and the norms of international morality, by threatening African states and peoples and all those opposed to apartheid.

The acquisition of nuclear weapons by South Africa undermines the ardent desire of Africa for the denuclearisation of the continent and the efforts of the international community to prevent the proliferation of nuclear weapons as a step towards their abolition.

We have pleaded for 20 years for an end to collaboration with the Pretoria regime and for effective measures to prevent its military and nuclear build-up. But a few powerful states, and a number of transnational corporations and institutions, have recklessly helped that regime in its plans. Though it refused to adhere to the Nuclear Non-Proliferation Treaty, it received more assistance than Parties to that Treaty. Even after it became clear than the Pretoria regime was on the verge of testing a nuclear device, its partners did little more than cajole it to sign the Treaty.

As the elimination of colonialism from this globe draws near and as the continent of Africa looks forward to its total emancipation after centuries of slavery and humiliation, the Pretoria regime and its friends have created the threat of a racist monster wielding nuclear weapons in order to retard and complicate the inevitable outcome.

The international community must urgently take firm action to dissuade the collaborators of South Africa from their dangerous gambles and to avert the menace of nuclear blackmail by the Pretoria regime. There must be an end to all collaboration with that regime – direct or indirect – in the nuclear field. Any moves for an accommodation with that regime, by formulas that facilitate continued nuclear collaboration, are not only irrelevant but are dangerous diversions.

I commend this pamphlet which describes in simple terms the nuclear plans of South Africa and the assistance received by it from other states. It deserves to be disseminated widely all over the world in order to inform the public and encourage all men and women of goodwill to join in the World Campaign against Military and Nuclear Collaboration with South Africa.

B Akporode Clark
Chairman
United Nations Special Committee against Apartheid

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INTRODUCTION

The detection of South African preparations to detonate a nuclear device in the Kalahari Desert in July 1977 and the subsequent warnings and appeals by President Carter and other Western leaders to the Vorster regime not to proceed with its test drew the attention of the world – in a dramatic fashion – to South Africa's advanced nuclear capability and ambitions.

This development led to increased international demands for an end to all forms of nuclear collaboration with the apartheid regime and for effective action to counteract South Africa's dangerous nuclear plans. However, the major Western collaborating governments responded by repeating earlier claims that their nuclear relations with South Africa were essentially commercial in nature and that it did not by itself give the apartheid regime military capability. In addition, it was argued that nuclear collaboration with South Africa should be continued in order to induce the Pretoria regime to adhere to the Nuclear Non-Proliferation Treaty (NPT).

There has been some speculation about whether the proposed nuclear test in the Kalahari Desert was in fact postponed or whether the structures were constructed deliberately to mislead world opinion, but this is not directly relevant to a scientific assessment about South Africa's nuclear capability: all the available evidence has convinced the international scientific community and individual experts that South Africa *does* have a significant military nuclear capability. Indeed, this is also the judgement of the Western powers, even if it is not declared very often.

Over the past decade there have been many reports about South Africa's nuclear weapon capability and these have often been confirmed by Western intelligence sources. Reportedly the US Central Intelligence Agency, in an official assessment prepared in September 1974, stated that South Africa 'could advance with its nuclear weapons programme if seriously threatened'.

Since 1974 the balance of power in Southern Africa has shifted significantly against South Africa, which has been forced to adjust to a new strategic situation. It has done so in the main by increasing internal repression, expanding its military arsenal and unleashing armed attacks against neighbouring African states, both directly and via the illegal Salisbury regime. Meanwhile it has undoubtedly increased its nuclear weapon potential.

The detection by a US Vela satellite of evidence that a low-yield nuclear explosion had taken place in a region around South Africa in September 1979 was kept secret by Washington until the news was revealed a month later by the ABC television network. The State Department added that it had 'no corroborating evidence' to verify the explosion and 'no independent evidence' to link it with South Africa. There was considerable international pressure at the United Nations and elsewhere for further investigations and the US announced that it had appointed a panel of outside experts to determine whether an atomic explosion occurred near South Africa on 22 September.

This panel of seven experts met just before Christmas and, according to *The Washington Post* of 1 January 1980, ruled out almost every other explanation for the event besides an atomic explosion. A White House source is quoted as stating that 'The signal the satellite saw still looks in every way like a nuclear explosion in the atmosphere.' There have since been several apparently revised versions of the panel's findings.

An additional factor is that within the region of the nuclear explosion there is also an area where the radiation belts which surround the earth in fact reach sea-level. Because of dangerous radiation the area is avoided by all shipping and is an ideal place secretly to detonate a nuclear device since its radiation impact on the atmosphere would be difficult to detect from that already prevailing. Moreover, an atmospheric test would avoid any seismic detection and the area is usually deserted.

As we go to press, *The Guardian* of 31 January 1980 carries a report from *The Washington Post* that the CIA has established that on the night of 22 September 1979 a task force of South African warships was conducting a secret exercise at sea and that it was at about the same latitude and longtitude as the nuclear explosion. Also, on the same night scientists operating a radio telescope detected a ripple moving through the ionosphere and coming from the right direction and at the right velocity to have been caused by a nuclear explosion.

Despite South Africa's acknowledged threat to international peace and security and its aggressive behaviour in the region, the major Western powers remain determined to continue collaborating with the Pretoria regime in the nuclear field. This long partnership in developing and enhancing South Africa's nuclear capability is said to involve only 'peaceful nuclear' collaboration. But it is through the transfer of nuclear technology, expertise, equipment and other forms of support that apartheid South Africa has acquired its nuclear weapon capability. In a real sense it is precisely through their partnership in the South African nuclear programme and the information gained therefrom that these powers have convincing evidence about Pretoria's nuclear weapon capability. Without such knowledge it is unlikely that public warnings would have been issued to the Vorster regime in 1977 not to proceed with its proposed Kalahari Desert test.

When one considers the full implications of an apartheid atomic bomb it is possible to see the monstrous gravity of the crime committed by all those outside powers which have helped to create a nuclear Frankenstein in Africa. It is no use pretending that they either made a series of consistent mistakes in encouraging nuclear collaboration with South Africa or were not aware of Pretoria's ambition to acquire nuclear weapon capability: they have been warned repeatedly about the danger by the South African liberation movement, by Africa

and the international anti-apartheid community. They chose to ignore those appeals and warnings, as they choose to ignore all the body of accumulated evidence now – nuclear collaboration with South Africa continues despite *knowing* about the apartheid regime's nuclear weapon capability and ambitions.

When South Africa's nuclear weapon capability is seen in the wider context of that country being recognised by the major Western powers as a major regional power in the southern hemisphere, that danger is increased manifold. Overall Western policy towards Southern Africa is based on giving priority to South African interests in the region and being firmly committed to preserving the stability and security of South Africa, with all 'reforms' being encouraged exclusively *within* the apartheid system.

Furthermore, powerful forces in the Western countries advocate full recognition of South Africa's potential role as a regional power and propose various methods of incorporating it, either formally or informally, into the overall Western defence system. South Africa's nuclear weapon capability can clearly enhance its military role in the southern hemisphere and it can then blackmail and intimidate not only Africa but all the countries within its striking range, as well as the world community, with even more sinister threats.

At the same time the rulers of South Africa and their powerful allies will point to the apartheid regime's considerable military power as a reason for abandoning the African liberation struggle since its prosecution would only lead to increased violence with catastrophic consequences for everybody in the region. However, it is impossible for the oppressed people of South Africa to accept the inhuman system of apartheid irrespective of the physical weaponry in the hands of the enemy.

Thus, in the growing confrontation within South Africa, the apartheid rulers have been heavily armed with modern conventional weapons from the Western countries in order to protect the white power system: now that regime has acquired through years of collaboration a deadly nuclear weapon capability as well.

But as this study explains, although South Africa's nuclear capability is far advanced, it is still at the initial stage of its nuclear weapon programme. In order to develop this programme the Pretoria regime will seek increased external nuclear cooperation.

The international community has the responsibility to ensure not only that effective measures are taken to stop the development of South Africa's nuclear weapon programme but also to require the dismantling of all nuclear installations in that country.

All forms of nuclear collaboration with South Africa must be ended and, if the Pretoria regime persists with its nuclear plans, the United Nations will need to impose mandatory sanctions in order to counteract South Africa's enormous threat to world peace.

The major Western powers are not likely to be persuaded to change their policy of nuclear collaboration with South Africa simply by the presentation of factual information and reason. Nevertheless, it is important for the facts to be known more widely and this study provides much of the vital information needed about South Africa's present nuclear capability.

Informed public opinion must be mobilised to act now: the issue is grave and urgent – and time is short.

Abdul S Minty
February 1980

THE KALAHARI AND THE SOUTH ATLANTIC

In 1977 and again in 1979, important evidence has emerged about South African development of nuclear weapons. In each case, the evidence was provided by satellite surveillance, which in 1977 discovered a site for nuclear testing in the Kalahari Desert, and in 1979 discovered what appears to have been an actual nuclear explosion. In this paper, we shall see how South Africa has arrived at a position in which it is widely agreed to have at least the *potential* to manufacture nuclear weapons. First, we can consider these two pieces of evidence suggesting South Africa has *already* done so.

On 6 August 1977, the US president received a message from the government of the USSR informing him that satellite photography revealed South African preparations to detonate a nuclear explosive in the Kalahari Desert.[1] The same information was communicated to the French government on the following day and to the British government on 8 August, when a Tass press release made the information public. On 9 August, the information was officially communicated to the government of the Federal Republic of Germany, which has been particularly accused by the African National Congress of South Africa of aiding the South African regime in technology related to nuclear weapons.[2]

The USSR's evidence came from photographs from a Cosmos satellite which had passed over the area of the test site on successive days from 21 to 25 July.[3] On 11 August, with evidence from photographs taken by one of its Big Bird satellites, the US government confirmed the accuracy of the Soviet information to its own satisfaction; four days later this confirmation was reported to President Brezhnev by the US government.[4]

Reportedly, US intelligence analysts were 99 per cent sure of the finding – as close to certainty as intelligence analysts ever get – although one hypothesis speculated that the structures identified as being preparations for a nuclear test were simply an elaborate sham, calculated to have a political impact through shock when they were inevitably discovered, but not actually intended for detonating a nuclear explosive.[5]

Probably on the basis of information passed on by the US government, on 22 August both the British and French governments stated they agreed South Africa had been preparing for a nuclear test, and communicated their opposition to such an event to the South African regime. On 23 August, President Carter announced that he had two days previously received assurances from John Vorster, the South African prime minister, that no nuclear tests and no development of nuclear weapons would take place in South Africa, and that the structures in the Kalahari Desert were not intended for a nuclear test.[6]

However, in an interview broadcast in the USA by the ABC television network on 23 October 1977, Vorster denied he had given any such assurances, claiming he had merely repeated what he had often said before, that South Africa is interested only in peaceful applications of nuclear technology.[7] The following day, the US government insisted that the assurances had not only been given in August but had been repeated in a letter from Vorster to Carter on 13 October.[8] On 25 October, the South African regime repeated its denial that assurances had been given.[9] Whatever the truth about the assurances, in March 1978 it was reported that continuing US satellite surveillance showed the structures in the Kalahari Desert had still not been dismantled.[10]

Leaving aside for the moment other ramifications of the August 1977 events, two things may be noted. First, at no time did the South African regime offer an explanation for the building of structures which US intelligence was 99 per cent certain could only be preparation for a nuclear test. The only alternative explanation offered was the hypothesis within US government circles that the whole affair was an elaborate sham, a speculation apparently discounted officially.[11] Second, therefore, the discovery of the structures constitutes very strong evidence that, in August 1977, the South African regime either possessed nuclear explosives or expected to possess them shortly.

On 25 October 1979, the US government announced that it had detected signs of a small nuclear explosion occurring in the South Atlantic in the region of South Africa on 22 September.[12] The government was pushed into making this announcement before the State Department wanted to make its suspicions public, because the ABC television network had got hold of the news and was preparing to report it.

These suspicions were based on a double flash of light detected by a Vela satellite, a type specifically designed to spot nuclear explosions occurring in the atmosphere, and one of a variety of means the US has for detecting atmospheric nuclear explosions. The double flash was estimated to have been produced by a nuclear bomb of less than four kilotons.[13] The fact that the explosion, if such it was, was apparently detected only by the Vela satellite, together with three alternative explanations for the double flash, created a considerable degree of ambiguity and doubt.

The fact that evidence of an explosion was provided only by a visual sensor and not by any of the USA's acoustic sensors for detecting atmospheric nuclear explosions, is easily explained: at the time of the apparent explosion, the acoustic system was not functioning.[14] It could be argued that the USA uses more than one type of detection system precisely to guard against the possibility of malfunction, and it could be argued that on this occasion the practice has shown its worth.

In fact, in January 1980, it was announced that US Air Force radar had, on the day the satellite spotted the double flash, picked up signals which could have been radar echoes of the shock waves from an atmospheric nuclear explosion.[15]

This provides some confirmation of the evidence from the Vela satellite, but of rather a tenuous kind: apparently, electrical storms can cause the same kind of radar echoes. By themselves the radar echoes would be insufficient evidence of a nuclear explosion.

Two alternative explanations came from South Africa, where official spokesmen, including Foreign Minister R F Botha and Wynand de Villiers, president of the Atomic Energy Board, vigorously denied that South Africa had conducted a nuclear test.[16] The first explanation was that a Soviet nuclear-powered submarine had exploded; this hypothesis was considered and dismissed by the US government – there was no Soviet submarine in the area.and if it had exploded the flash would have looked completely different.[17] The second offering, from Professor Raul Smit of Durban University, was that a Soviet nuclear-armed missile fired in August 1963 had suddenly exploded after lying dormant for 16 years.[18] This explanation does not have a great deal of merit either: apart from the USSR's denial that it had fired a missile at that date in that area, it does not appear very likely that it would have test-fired an armed missile. Nuclear warheads can be and are tested without putting them on missiles, and for rather obvious reasons when missiles are test-fired they are not armed and there is no need for them to be.

The experts constituted into a special panel to consider the evidence for the US government found another possibility more attractive as an alternative explanation – that what the satellite saw was some kind of natural phenomenon. Possibilities here included a combination of a massive streak of lightning with a meteor burning up in the earth's atmosphere, and a lightning 'superbolt', to which more attention was paid. A 'superbolt' is a lightning flash so powerful that it can release as much energy as a small nuclear weapon. It contains 100 times more energy than a normal bolt of lightning and occurs only under particular conditions (when cold polar air moves into warmer, moist oceanic air, without small storms occurring to relieve the build-up of electric charge). Until the satellite age, 'superbolts' had not been recognised; now, several dozen have been detected by the same kind of satellite that spotted the flash in the South Atlantic in September 1979. The problem for this explanation is that 'superbolts' show only a single flash; it is the double flash which is the tell-tale sign of a nuclear explosion. Nothing daunted, two possibilities have been offered: either 'superbolts' have always had a double flash but the first flash had not previously been seen, or this particular one had a double flash even though they usually only have single flashes.[19]

This explanation could seem reasonable for a single reason – the absence of other evidence to corroborate the evidence from the Vela satellite. But, as we have seen, the USA's acoustic detection system was not functioning and there is some supporting evidence from radar signals. Moreover, before 22 September 1979 Vela satellites had detected 41 double flashes in 15 years, all of which were confirmed as atmospheric nuclear explosions (detonated by China and France). The instruments on the satellite which saw the 42nd double flash had been checked the week before.[20] On the evidence available there is no reason to suppose that the satellite did not simply carry out the function for which it was launched – to spot any atmospheric nuclear explosion. Of the three alternative explanations, one can be ruled out (the exploding Soviet submarine) and the other two involve more assumptions than rational weighing of the evidence (the Soviet missile and the 'superbolt').

Therefore, on the evidence, the most likely case is that a nuclear explosion occurred. Apart from the South African regime itself, nobody has suggested that any state apart from South Africa might have been responsible.

One point must be noted here: both the discovery of a test site in the Kalahari in 1977 and the detection of a nuclear explosion in 1979 constitute strong evidence that South Africa, at least by 1979 if not earlier, possessed nuclear explosives. Neither event, nor both taken together, can be said definitively to prove it. The conclusions – that in 1977 South Africa was indeed preparing a nuclear test and that in 1979 it did indeed conduct one – are strong, but there must remain an element of ambiguity and uncertainty. This does not mean that action to prevent South Africa proceeding further in nuclear weapons technology ought not be taken; indeed, it means the opposite, that action should be taken before the last remaining gramme of uncertainty is removed by official South African confirmation that it has nuclear weapons. From the point of view of trying to assess the situation as accurately as possible, it is important to be aware of what parts of the assessment are hard fact and what parts are deduction on the basis of necessarily incomplete evidence.

This overall uncertainty is but one element of the multiple uncertainty surrounding the events of August 1977 and October 1979 and, indeed, surrounding the whole question of South Africa and nuclear technology.

On receiving the Soviet information about the Kalahari test site in August 1977, the US government appears to have acted promptly and responsibly, firstly in confirming the evidence for itself and then in confronting the South African regime with it. Yet it is strange that the US government had to wait for the USSR to provide information before it took action. The US State Department denies it had any previous knowledge of the Kalahari test site, but it has been reported that an American Big Bird satellite traversed the area of the site on a north-south track (the opposite direction to the Soviet Cosmos satellite) at least three times in July 1977 and again on 2 and 6 August.[21]

One explanation might be that US analysts failed to spot the site simply because they were not looking for it. The path of those orbits also traversed the area in Zaire which was leased by Otrag, a West German firm, for missile testing, an area in which US intelligence was doubtless extremely interested. But potential South African possession of nuclear weapons has long been a concern of US intelligence. In 1974, a secret CIA report stated that South Africa was in a position to proceed to the development of nuclear weapons.[22] In February 1977, there were reports of a US intelligence estimate that South Africa could make a nuclear weapon by 1981, or within a few months if it initiated a crash programme.[23] So one might have expected US intelligence to devote considerable effort to the problem, almost inevitably including analysis of satellite photography for evidence of nuclear testing – and if possible areas for test sites are sought, the Kalahari Desert must immediately come to mind.

Over the years, there has been a great deal of concern and speculation about South African intentions with regard to nuclear weapons, fuelled by hints and statements from leading South African figures. Dr Abraham Roux, long-time president of the Atomic Energy Board, has repeatedly expressed interest in nuclear weapons since the early 1960s.[24] In 1965, as he

officially inaugurated South Africa's first nuclear reactor, Prime Minister Verwoerd said in his address to an international audience: 'It is the duty of South Africa not only to consider the military uses of the material but also to do all in its power to direct its uses for peaceful purposes'[25] – a form of phrasing which seems to give priority to research into military uses. Hints and claims about South Africa's ability to make and readiness to use nuclear weapons have continued through the 1970s. Thus, in 1977 Connie Mulder, the now-disgraced Minister of Information, said: 'If we are attacked, no rules apply at all if it comes to a question of our existence.'[26] And Owen Horwood, the Finance Minister, addressing a political rally on 30 August 1977 in the wake of the international expressions of concern about the Kalahari test site, stated: 'If we wish to do things with our nuclear potential, we will jolly well do so according to our own decisions and our own judgement. America cannot pressure us. We will not allow it.'[27]

For all these statements, however, South Africa's white regime has never formally acknowledged that it has nuclear weapons or that it has undertaken a programme to develop and produce them, or that it intends to initiate such a programme at some future date. Yet the regime has always held back from firmly denying that it might obtain nuclear weapons. Thus, Vorster, so Carter stated, gave repeated assurances that South Africa would never develop nuclear weapons; then he denied giving those assurances, but added that South Africa is only interested in peaceful uses of nuclear technology.

It would appear that this is a deliberate political use of uncertainty. Hints that South Africa will or could manufacture nuclear weapons are taken seriously because it has the material basis to turn the hints into reality; the denials are also taken seriously because of the lack of absolutely firm evidence. The aim of fostering uncertainty would seem to be to place implicit pressure on Western governments, warning them that should they abandon the white regime it will take the drastic step of making and even using nuclear weapons.

The success of this political strategy depends on the lack of firm resolve on the part of key Western states, who neither want to see South Africa develop nuclear weapons nor are prepared to make a decisive break from supporting South Africa. In August 1977 it was the clear and official view of the US government, and of other Western governments, that South Africa had been preparing to conduct a nuclear weapons test. In September 1979 the US government came to suspect that South Africa had actually tested a nuclear device. Between those two dates no firm action was taken to prevent South Africa getting nuclear weapons if it chose to. The most that happened was an offer by a US envoy, Gerard Smith, that if South Africa undertook never to develop nuclear weapons the US would continue to provide aid in developing civil nuclear technology.[28] Yet, in continuing to aid South African civil nuclear technology, the US would simply be helping lay the foundations on which a future military programme could be built. If there is to be a break with the South African politics of uncertainty, there must be decisive action by the Western governments and certain crucial changes in policy.

In the end, whatever the uncertainties and ambiguities, whatever the South African political strategy or the position of Western governments, two pieces of evidence strongly suggest that South Africa has been able to develop a nuclear explosive. And, as we shall see, it has the materials, technologies and facilities needed to make nuclear weapons and the capacity to deliver them to selected targets if it chooses to.

Just as this work was about to go to press, further information became available in the US about the suspected nuclear test in the South Atlantic in September 1979. *

First, on the night of 22 September 1979, when the American satellite spotted the double flash that is evidence a test took place, a South African naval task force was conducting an exercise in the vicinity of the site of the explosion (if such it was).

Second, on that night, scientists operating the world's largest radio telescope detected a 'ripple' moving through the ionosphere a few hours after the satellite saw the double flash. Reportedly, it appeared to be coming from the right direction and at the right velocity for it to have been caused by a nuclear explosion near South Africa. Though this piece of evidence does not by itself prove an explosion took place, it provides further confirmation of the evidence from the satellite.

Third, on the Vela satellite in question, the double flash was also spooted by a back-up visual system.

Fourth, the committee of experts convened by the White House has now discounted the suggestion that what the satellite saw was a lightning superbolt or a freak streak of lightning at the same time as a meteor began to burn up. The committee now says that the satellite could have malfunctioned, even though its instruments had only recently been checked (see main text), or that it may have spotted a double glint of sunlight off another satellite or a meteor.

As evidence that, in fact, a test did take place, there are now the readings from two visual sensors on the Vela satellite, radar echoes detected by the US Air Force, and the 'ripple' in the ionosphere. If a test did not occur, then an extraordinary series of coincidences did.

* *The Guardian*, 31 January 1980

THE DEVELOPMENT OF SOUTH AFRICA'S NUCLEAR TECHNOLOGY

1. The current position

South Africa currently has two small operational nuclear research reactors: Safari 1, of American design and construction, which went critical (ie its nuclear reaction started) in 1965; and Safari 2, of South African design and construction, which went critical in 1967.[29] 'Safari' is the acronym from 'South African Fundamental Atomic Research reactor'.

Both reactors are situated at Pelindaba, near Pretoria. A more recent addition to the site is a plant for manufacturing uranium hexafluoride (UF_6). Often simply known as 'hex', uranium hexafluoride is a gaseous form of uranium, required in the process of turning raw uranium into fuel for reactors or material for nuclear explosives. The plant was commissioned in 1975 and started operating in 1978.[30] Right next to Pelindaba is Valindaba,[31] where there is a pilot plant for enriching uranium, to prepare it for use as a nuclear fuel or explosive. The plant started operating in 1975 and is relatively small, able to produce about 50 tons of commercial grade uranium a year.

In addition, South Africa has access to large reserves of uranium, in South Africa and in Namibia – about 300,000 tons of known and exploitable uranium reserves.[32]

South Africa also has several plants for manufacturing uranium oxide (U_3O_8), the first stage of the process which transforms raw uranium into nuclear fuel or explosive. There have been many references to South African possession of a small plant capable of chemically reprocessing the plutonium which is produced as a by-product in nuclear reactors, but there is no firm evidence.[33]

Further development of nuclear technology is planned on an ambitious scale. The Valindaba enrichment plant is to be expanded so that it is able to produce 200-300 tons of commercial grade uranium by about 1981-2,[34] and two large nuclear reactors for generating electricity are to be sited at Koeberg, near Cape Town. The first Koeberg reactor is due to start operation in 1982, and the second in the following year.[35]

Judging from the available information, if South Africa has manufactured nuclear explosives, the material for them could have been produced at the Valindaba enrichment plant. In the future, material for nuclear weapons could be produced at the expanded Valindaba plant or, if a chemical reprocessing plant were available, by using the plutonium which will be produced by the Koeberg reactors once they start operating.

Compared with many countries, South African nuclear technological capacity is fairly modest. But the regime is moving steadily towards an impressively rounded capacity, especially in the field of the treatment of uranium.

There are several stages in the preparation of uranium for use in nuclear reactors: it must be mined; then it must be made into uranium oxide from which uranium hexafluoride must be produced; this must then be enriched so that one isotope, Uranium-23, which constitutes 0.7 per cent of natural uranium, constitutes a greater proportion (with the exception of some reactor designs which use unenriched uranium); the enriched uranium must then be incorporated in the fuel rods which will be placed in the core of the reactor. In this process it is only the last stage – fuel fabrication – that South Africa lacks (and this would not be a barrier to producing nuclear explosives from uranium).

At every stage in its progress to this position, South Africa has needed and received aid and cooperation from foreign states, parastatal agencies and corporations.

2. Uranium mining

Uranium reserves in Namibia and South Africa amount to nearly 300,000 tons, about 17 per cent of the world total. South Africa thus has access to the second largest uranium reserves in the capitalist world economy and accounts for about 13 per cent of its annual uranium output. It has embarked on a programme to boost its annual output so that by the mid-1980s it could be the second largest producer among capitalist countries.[36] This is an important source of wealth and foreign exchange, but perhaps more importantly these large uranium reserves are the basis of South Africa's nuclear technological capacity.

Uranium mining in South Africa first developed as an offshoot of gold mining.[37] The fact that the mines were being worked to recover gold, together with the cheapness of labour, made uranium mining an attractive financial prospect. In the late 1940s Britain and the US formed the Combined Development Agency to prospect for and exploit uranium in South Africa. In 1949 the South African Atomic Energy Institute was formed and in 1950 it concluded an agreement with the Combined Development Agency to initiate uranium production in four mines.[38] Through the 1950s British finance played a major role in facilitating the opening of a total of 27 mines and, in the same period, was equally instrumental in the construction of 17 uranium oxide plants and nine plants for producing the sulphuric acid needed in the uranium oxide plants.[39] The first uranium oxide plant was opened in 1952.[40]

From 1953 until 1971 the US government imported 43,260 tons of South African uranium oxide[41] (no figures are available for British imports). Since 1971 the US government has not imported South African uranium oxide, but American corporations have continued to import it. In 1978 a total of 2,800 tons was imported into the US, of which 20 per cent came from South Africa. Private companies importing this material are expected to play an increasingly important role in maintaining US stocks of uranium for military use, as the government has been running down its own stocks over the

past several years.

Although the US government has discontinued imports of South African uranium, the British government still imports it, relying on South African and Namibian uranium for about half its annual use of uranium (about 5,000 tons a year).[43] South Africa also exports uranium to France, the Federal Republic of Germany (FRG), Japan and Switzerland; Belgium will shortly join the list, and the Netherlands too.[44]

In 1963, in a departure from the usual practice of recovering uranium from mines already being worked for gold, uranium mining was begun at the Palabora copper mine by two companies from the FRG, Degussa and Norddeutsche Affinerie. This mine is now run by Rio Tinto Zinc, a British-based multinational corporation, together with Newmont Mining of the USA and South African interests.[45]

The largest single mine in the South African uranium mining industry is not in South Africa itself but in Namibia, over which South Africa illegally retains control. The mine is at Rossing and is financed and run by an international consortium; there, uranium is produced in its own right, not as an offshoot of gold or copper mining.[46] The mine started production in 1976 and is intended to reach an output of about 4,900 tons a year, more than a third of South Africa's planned total uranium production in the mid-1980s.[47]

Fifty per cent of the original shareholdings in the Rossing operation were held by South African state and private interests. Of foreign shareholders, the largest is the British-based Rio Tinto Zinc, together with Rio Algo, its Canadian subsidiary; smaller shareholders were Minatome of France and Urangesellschaft of the FRG, both supported by state finance. In 1972, Urangesellschaft's shareholding was withdrawn.[48]

Britain is similarly the largest foreign purchaser of uranium from Rossing. An agreement signed in 1970 by British Nuclear Fuels Ltd, a parastatal body, covers the purchase of 7,500 tons of uranium oxide from the mine from 1977 to 1982;[49] this probably amounts to about 25 per cent of the mine's output in those years and makes it the major source of supply for Britain's domestic nuclear programme. Other major purchasers include the state-owned French company, Total Compagnie Miniere et Nucleaire, which is also part of the Minatome consortium; Urangesellschaft has retained an option to purchase 10 per cent of Rossing's output; the uranium is also to be bought by several Japanese companies, including Kansai.[50] From 1980 the Netherlands will also use uranium from Rossing, through its partnership in the British-Dutch-German consortium of Urenco, established by inter-governmental agreement in 1970 for the purpose of enriching uranium. At present Urenco has two enrichment plants – one at Capenhurst in Britain, the other at Almelo in the Netherlands.[51] Currently uranium oxide from Rossing is air-freighted to France, where some is delivered to the uranium hexafluoride plant at Pierrelatte and the rest is exported to the similar plant at Springfield, Britain.[52] Consumption of the rest of Rossing's output is accounted for by South African use.

Concern about the future supply of energy, emphasised to the point of alarmism by the increase in oil prices since 1974, means that uranium is a matter of great interest for all states. If the growth and spread of the nuclear industry continues, uranium will remain a great source of profit. With large reserves of uranium well able to sustain a major increase in annual output, and with a political system which, among other things, keeps labour costs low, South Africa is well placed to benefit from this situation and Western corporations investing in South African uranium mining look set to get their share in the benefit.

SHAREHOLDERS AT ROSSING

South African Industrial Development Corporation (state-owned)	25%
General Mining (South African company)	25%
Rio Tinto Zinc and Rio Algo (British multinational and Canadian subsidiary)	25%
Urangesellschaft (FRG consortium in which: one-third Veba, state-owned, and one-third STEAG, effectively state-controlled; shareholding now withdrawn)	10-15%
Minatome (French group formed by state-owned Total Compagnie Miniere et Nucleaire, Compagnie Francaise des Petroles and PUK)	10%

FOREIGN URANIUM PROSPECTORS IN NAMIBIA AND SOUTH AFRICA

Union Carbide and Utah Mining in Cape Province since 1973
(US companies)

Exxon in Cape Province since 1975
(US)

Newmont Mining and US Steel reported seeking concessions in 1975
(US companies)

Societe Nationale des Petroles in Namibia since at least 1977
(French, state-owned)

Falconbridge in Namibia since at least 1977
(Canadian)

O'Kiep in Namibia
(US, subsidiary of Newmont Mining)

So there is no reason to expect that Western interest and participation in South African uranium mining will wither away. Western financial investment, especially British and American, in South African mines of all kinds has always been heavy and shows no sign of declining, although its relative weight may be declining.[53] American companies in particular have been involved in independent prospecting for uranium in Namibia and South Africa (see box above) though few details are known. A French parastatal body, Compagnie General des Matieres Nucleaires, was reported in July 1977 to have provided finance for a major gold and uranium mining venture by Randfontein Estates: in return for an interest-free loan, it appears that the French company, and thus the French nuclear programme, will receive 900 tons of uranium oxide a year for 10 years.[54]

3. The research reactors

Through the 1950s American and British assistance was crucial in South African development of the uranium mining industry. But there came a point when the regime wanted to move beyond being a source of material for the nuclear programmes of other states and have its own nuclear programme. It could not have done this alone: outside help was needed, and was received, primarily from the US.

In 1957 the South African Atomic Energy Board (AEB)

was formed, replacing the Atomic Energy Institute formed eight years previously. In the same year the US and South Africa signed an agreement covering nuclear aid from the US and nuclear cooperation.[55]

On the American side the agreement was part of the 'Atoms for Peace' programme, under which the US concluded a number of agreements providing assistance to other states in the civil development of nuclear technology. In the 1970s the inherent connections between civil and military nuclear technology came to be more widely and clearly understood. It is the proliferation of nuclear technological capabilities around the world which provides the basis for the possible proliferation of nuclear weapons. The aid South Africa has received under the 'Atoms for Peace' programme has had a central role in its development of a military nuclear potential.

The 1957 agreement has been amended three times – in 1962, 1967 and 1974 – to extend its scope and its duration; the agreement now covers the period up to 2007.[56]

In 1961, under the agreement, the US licensed the export of a Light Water Reactor using highly enriched uranium; the reactor was constructed by the Allis Chalmers Corporation and became known as Safari 1.[57] Sited at Pelindaba, it went critical in 1965 and has a capacity of 20 Megawatts (thermal rating)[58] – this is a small reactor, unsuited to the commercial production of energy but important for research and the development of technological expertise.

In the development of plans for Safari 1 a number of research bodies in the US were involved: the National Laboratories at Argonne, Brookhaven and Oak Ridge; Reno Research Center; Massachusetts Institute of Technology; the University of Illinois; and New York University.[59]

In 1962, in the first amendment to the 1957 agreement, the US undertook to supply the enriched uranium needed to run Safari 1; it was agreed to supply 104 kg of the material.[60] Precise figures exist for shipments from February 1965 until August 1975 (by which time 95.32 kg had been shipped).[61] Most of the uranium was fabricated into fuel elements and shipped by the British Atomic Energy Authority – in 18 shipments from 1967 to 1974 it sent 71.5 kg of uranium to Safari 1; two shipments totalling 7.76 kg in 1965 were sent by the American company Babcock & Wilcox; and 16.06 kg were sent in four shipments by US Nuclear Inc in 1974 and 1975. Thus the British AEA fabricated into fuel elements and shipped some 75 per cent of the uranium sent to Safari 1 in its first 10 years of operation, while Babcock & Wilcox sent 8 per cent and US Nuclear Inc sent 17 per cent. Of the total (95.32 kg), 86.29 kg were the isotope Uranium-235 – which means that on average the uranium used by Safari 1 was enriched to 90.5 per cent.

By 1976 the full 104 kg had been shipped to South Africa but an agreement to ship a further 104 kg was held up by the Carter administration in 1977.[62] The uranium sent for Safari 1 seems to have been adequately accounted for: in 1976 it was reported by the US government that South Africa still had 23 kg of unused fuel; of the remainder, 22 kg had been returned to the US and 18 kg to Britain; 21 kg had been burned up during the operation of the reactor, while 5 kg were still in the reactor core and 20 kg were in irradiated fuel elements in the cooling tanks.[63]

Some French firms and Krupp and BBC of the FRG also aided in the construction of Safari 1 by supplying equipment.[64]

South Africa's second nuclear reactor, Safari 2, went critical in 1967.[65] It is a small research reactor using low-enriched uranium – about 2 per cent – which is supplied by the US and reportedly fabricated into fuel elements and shipped by Britain.[66] Heavy water for Safari 2 comes from the US,[67] but, apart from this and the fuel, there is no clear evidence about participation by foreign states, companies or parastatal bodies. The design appears to have been South African and it seems to have been an exercise in independent construction and operation of a nuclear reactor.[68]

The crucial point about Safari 1 and 2 has been their role in establishing a technological infrastructure for nuclear development in South Africa. The experience gained in operating the reactors has been an essential element in providing scientists and technologists with practical knowledge, in building up a large body of trained and experienced people without whom South African nuclear development plans could never be more than pipedreams.

But simply having the research reactors would not of itself have been enough. To begin with, training and practical assistance had to come from outside.

Since the 1957 cooperation agreement between the US and South Africa there have been exchanges of personnel on a large scale; this, indeed, was a central part of the agreement. By mid-1977 more than 155 American nuclear technologists and scientists had visited South Africa to provide assistance and training, and 90 South Africans had visited the US to receive training and practical experience.[69] This has been perhaps the most important foreign source of expertise for South Africa, without which it is hard to see how South Africa could have had a nuclear technological capacity of its present dimensions. In addition to assistance and supplies of equipment and material already mentioned, American companies have, with the approval of the US government in the form of export licences, exported special nuclear materials to South Africa – plutonium, iron-55, cadmium, thorium, depleted uranium, cobalt-60, carbon-14, cesium-137, chlorine-36 and strontium-90.[70] American scientists have also been recruited by the South African AEB on a long-term basis.[71]

URANIUM ENRICHMENT

In its natural state, uranium consists 99.3 per cent of the isotope Uranium-238 and only 0.7 per cent of the less stable isotope Uranium-235. It is the instability of U-235 which is utilised for the nuclear chain reaction, whether in reactors or bombs. With the exception of some designs of reactor (such as the Canadian CANDU type), the proportion of U-235 in the total mass of uranium has to be increased. Typically nuclear reactors for the commercial generation of electricity require about three per cent U-235; the reactors in nuclear-powered submarines may require 30 per cent U-235; and nuclear explosives require at least 70 per cent, and ideally over 90 per cent. Different designs for reactors and explosives can, however, use widely different proportions of U-235. The process of increasing the proportion of U-235 is known as enrichment, for which there is a variety of techniques (described further on in this paper). The basic principle of all techniques is to exploit the different properties of the two isotopes in treating the uranium, so that U-238 is discarded.

With Britain, South Africa has enjoyed a series of exchanges and high level contacts since the mid-1950s.[72] Thus, among those present at the formal inauguration of Safari 1, when Prime Minister Verwoerd unmistakeably declared South Africa's interest in military uses of nuclear technology, was the then chairman of the British Atomic Energy Authority, Sir William Penney. His successor in that post, Sir John Hill, exchanged visits with Abraham Roux, president of the South African AEB, in 1970 and 1972. And in late 1974 two South African scientists visited the British nuclear plant at Risley. In the controversy which arose when this visit was discovered, the Labour government revealed the existence of a commercial agreement between Britain and South Africa in nuclear matters, confirming what Roux had claimed in 1972. Britain has also been an important source of recruitment of scientists and technologists for the South African nuclear programme, probably more important than the US.[73] In 1979 the South African Electricity Supply Commission (ESCOM) advertised in the British press for staff to run the Koeberg power station.[74] At the same time ESCOM was advertising for engineers to take a course in Nuclear Reactor Science and Engineering, with fees paid by ESCOM, at Imperial College, London.[75]

At least twice South African scientists have been able to develop their understanding of nuclear weapons and their effects with American and British cooperation. In 1958 American nuclear tests in the South Atlantic were monitored by a joint team from South Africa and the US; in 1967 it was reported in the South African press that South African scientists were collaborating closely with British scientists from the Harwell Atomic Research Institute in monitoring French nuclear tests in the Pacific Ocean.[76]

France has itself been an important source of this kind of aid for South Africa, sending technologists and training South African technologists since 1966.[77] Since 1969 the FRG has also helped with training in the development of techniques for uranium enrichment (see below).

4. Uranium enrichment at Valindaba

For nuclear weapons and for most designs of nuclear reactor, it is necessary to enrich uranium in order to have the material in which an atomic chain reaction can occur. Equipped with large natural resources of uranium and with plans to develop an independent nuclear technological capacity, it is not surprising that there was early interest in South Africa in uranium enrichment. In 1960 Dr W L Grant, a senior scientist in the South African AEB, was instructed by Dr Roux, the AEB's president, to initiate a secret programme of research into enrichment techniques.[78] It seems that through the 1960s this work proceeded without positive results; it was only when South Africa was able to hitch into research and development work in the FRG that there were positive results.

In 1959 work had begun in the FRG to develop an enrichment technique invented by Dr Erwin Becker of the Gesellschaft fur Kernforschung (GfK) in Karlsruhe.[79] GfK is a state-owned and state-run agency. In fact the technique, known as the jet-nozzle technique, appears to be less an original invention and more an adaptation of the gas centrifuge technique which was originally developed by German scientists in World War II. Development of the jet-nozzle proceeded fairly slowly and it was not until the end of the 1960s that a commercially viable technique emerged. In March 1970, an agreement between GfK and STEAG, which is effectively state-run through the provision of finance, provided the latter with the world rights for the commercial exploitation of jet-nozzle enrichment.[80]

By then nuclear cooperation between South Africa and the FRG had already commenced. A 1962 cultural agreement between the two states included the promotion of scientific exchanges, of which there were many during the 1960s in the nuclear field.[81] In 1963 two German firms had helped develop uranium production at the Palabora copper mine and other firms had supplied equipment for Safari 1 and 2.[82] Most importantly, in 1969 the training of four South African scientists in the jet-nozzle technique was begun at Karlsruhe at the Kernforschungzentrum, a subsidiary of GfK.[83] The year before, STEAG, which had not then received the world rights on the jet-nozzle, had already discussed cooperation in uranium enrichment with the South African AEB.[84]

In July 1970 Vorster announced that South African scientists had developed a process of uranium enrichment which was claimed to be unique: the establishment of the Uranium Enrichment Corporation (UCOR) was announced, with the objective of turning South Africa into an independent manufacturer of nuclear fuels.[85]

The claim that the process was unique has been treated with massive scepticism by almost all observers. It also seems to be the case that the announcement was premature. As the basis for the claim that a process had been developed, there seem to be two possibilities: either it was expertise gained by South African scientists trained at Karlsruhe, in which case it was clearly untrue to state the process was unique; or, according to some press speculation,[86] the process was the ion-exchange technique which had been tested and discarded in the US, in which case the claimed uniqueness was still non-existent. If the process in question was ion-exchange, South African scientists were probably quickly disabused of the notion that they could develop it on a large scale.

In fact in 1972 UCOR sought cooperation both with the FRG and with the British-Dutch-German Urenco consortium.[87] The fact that Urenco was approached may suggest that what UCOR sought was not merely financial backing to develop commercial exploitation of its 'unique' enrichment technique, but cooperation and assistance in developing the basic technology. If so, this would confirm the prematurity of the 1971 announcement.

Urenco refused cooperation with South Africa but, in the FRG, STEAG was willing. It applied to the FRG's Cabinet for permission to collaborate with UCOR in establishing an enrichment plant using the jet-nozzle technique. The decision was deferred because of concern about possible political controversy arising from such cooperation and because of the objections of some ministers. In the wake of this, in October 1973, STEAG withdrew its application but continued its collaboration with UCOR in establishing the pilot enrichment plant at Valindaba.[88]

STEAG provided finance and the basic technical know-how to establish the Valindaba facility,[89] and in return held the right to process uranium through the plant and use it for fuel elsewhere in its commercial activities. It was reported that additional finance came from Iran under a 1975 agreement in which the Shah's regime would receive some 14,000 tons of enriched uranium from South Africa for its own uses.[90]

The plant started operation in 1975, initially with a very small capacity, but quickly expanded to be capable of

METHODS OF URANIUM ENRICHMENT

I am aware of six methods of uranium enrichment:*

Electromagnetic
This appears to have been used on a small scale during World War II. It would appear adequate for producing small quantities of highly enriched uranium for testing and research but would be outrageously expensive on a large scale and does not now seem to be in use anywhere.

Ion-exchange
This technique, based on an acid wash, seems never to have gone beyond the research stage on a small scale. In the US it is regarded as definitely not viable on a large scale. It may have been considered for development in South Africa at one time.

Gaseous diffusion
Like the next two techniques, which are its close cousins, gaseous diffusion utilises the differences in movement of ions, due to their weight differences, to separate and discard unwanted isotopes. Like the next two techniques, it requires a gaseous form of uranium. Requiring enormous plants and used by Britain, France and the US among others, it can be regarded as the basic enrichment technique for larger scale use.

Gas centrifuge
Originally researched in Germany in World War II, its main users now will be the British-Dutch-German Urenco consortium. It is in operation at Capenhurst in Britain.

Jet nozzle
A German adaptation of gas centrifuge, in which gaseous uranium mixed with a light gas (hydrogen or helium) is sent at high speed through a nozzle along curved walls.

Laser enrichment
This technique promises to be cheaper and more adaptable than any currently operating technique; it is now in the research stage. The US in particular has made a major investment in it and South Africa has expressed its interest.

* South African nuclear scientists would claim a seventh technique exists – their own; however, I am unconvinced that their variation on the jet-nozzle can be rightly regarded as a separate technique. For a discussion, see note 89.

EQUIPMENT SUPPLIERS FOR THE VALINDABA PLANT

Machinery	*Supplier**
Separating elements	Siemens AG and Messerschmidt-Boelkow-Blohm GmbH
Engines	Siemens AG
Compressors	GHH-Sterkrade (subsidiary of MAN AG)** Hispano-Suiza (subsidiary of SNECMA, a French state-owned company) Sulzer (Swiss)
Cooling aggregates	Linde AG
Coating of the jet-nozzles	International Nickel Deutschland
Containers	Leybold-Heraus
Pipes and pipe coils	Lurgi
Slide valves	Leybold-Heraus (valves are tested by Interatom, a subsidiary of Siemens AG)
Measuring devices for concentration of isotopes	Varian MAT (West German subsidiary of Varian A, an American company)***
Electronic components	Siemens Foxboro International (US) Federal Products (US) (and possibly also Honeywell and Leeds & Northrup, both of the US)
Ventilation devices and cooling systems	Kassler & Luch (subsidiary of STEAG) SWF Gustav Rau (West German subsidiary of ITT of the US)

* Suppliers are companies from the FRG unless otherwise stated.

** This contract was reportedly lost after STEAG pulled out of the Valindaba project in March 1976 – Cervenka and Rogers, *The Nuclear Axis*, p 84.

*** The continued involvement of Varian MAT was confirmed by Dr Weber, the company's Executive Secretary, on a West German television programme, 'German help for South Africa's bomb?', made by Claus Richter, shown on Channel 1 on 20 November 1979 – extracts from transcript made available in English by the Anti-Apartheid Bewegung, 22 November 1979.

Source: Anti-Apartheid Bewegung (FRG), *Western Nuclear Shield for Apartheid* mimeo, December 1977.

producing each year 50 tons of uranium enriched to consist three per cent of Uranium-235.[91] In March 1976 STEAG withdrew from the collaboration, apparently because it was unable to reach agreement with UCOR about terms for the further exploitation of the jet-nozzle technique.[92]

STEAG has undoubtedly benefited from its collaboration with UCOR. At Valindaba it was able to test and further develop its enrichment technology, preparing it for further commercial exploitation. An example of the possibilities is a very large deal concluded between the FRG and Brazil in 1975 relating to nuclear power, as part of which STEAG will participate with Nuclebras, the Brazilian nuclear company, in a joint enrichment programme using the jet-nozzle.[93] But behind it in South Africa STEAG has left an enrichment plant subject to no international inspection of safeguards whatsoever and an enrichment technique in which South Africa by now has several years of practical experience.

STEAG was not the only foreign participant in the Valindaba project. Several firms, mostly from the FRG, have been named by the Anti-Apartheid Movement in the FRG as suppliers of equipment for the enrichment plant as it expands.

A further component in South African development of uranium enrichment has been the construction of a plant at Pelindaba to manufacture uranium hexafluoride, the gaseous form of uranium needed for the enrichment process. The plant was commissioned in 1975 and started operation in 1978.[94] There have been suggestions that the British Atomic Energy Authority was involved in helping to establish this plant.[95]

In 1975, when the pilot enrichment plant at Valindaba was starting operation, South Africa announced its decision to proceed to the construction of a far larger enrichment plant – one able to produce each year 5,000 tons of uranium enriched to three per cent.[96] The aim was not only to supply domestic South African requirements, but also to transform South Africa into a major exporter of enriched uranium. The proposed plant could also enrich uranium to higher levels to produce material for nuclear weapons.

Immense problems were, however, attached to such grandiose plans. Firstly, it was not clear, despite the generally intensified interest in nuclear energy in the mid-1970s, that the world market could produce the demand needed to justify such an enormous increase in the supply of enriched uranium.[97] Secondly, there was the problem of cost: the Valindaba pilot plant cost roughly four times as much as was expected and the problem of cost over-run would be serious with such an ambitious project, despite the experience gained at Valindaba. In South Africa capital costs of $1 billion were suggested but some experts inside the US government reportedly argued that $4 billion would be nearer the mark, and that figure excluded costs of research and development.[98]

Such large sums could be generated within South Africa only with enormous difficulty; accordingly, UCOR offered its plans around the world, apparently meeting with no satisfactory response – the investment capital simply was not on offer.[99]

By late 1977 it seemed evident that plans would have to be changed and in February 1978 the South African government announced that the pilot plant at Valindaba would be expanded into a 'relatively small' production facility.[100] It appears that the intention is to develop the plant at Valindaba so that it is capable of meeting South Africa's domestic requirements, with the option of further expansion to produce enriched uranium for export held open for further consideration depending upon commercial considerations. Currently, a plant capable of producing between 200 and 300 tons of three per cent enriched uranium annually is planned to start operation around 1981/82.[101]

South Africa has also expressed interest in the use of lasers for enriching uranium. In late 1976 research laboratories in the US were approached by South African representatives with enquiries about laser enrichment.[102] Apart from the US, several states, including Israel, conduct research on laser enrichment and it may therefore be worth noting in passing the reports of increased Israeli-South African nuclear cooperation, allegedly including the presence of Israeli scientists at Valindaba,[103] although firm evidence is lacking. At present South Africa probably lacks the capacity for independent development of laser enrichment, so should it wish to develop the technique it will need foreign assistance.

5. Koeberg

With the projected construction of two large nuclear reactors at Koeberg, about 30 km from Cape Town, South Africa will move out of the purely research stage of nuclear development and into the practical utilisation of energy generated at a nuclear power station. The two pressurised water reactors, to be constructed by a mainly French consortium using a Westinghouse design, will each have a capacity of 922 Megawatts of electricity. The first is due to start operation in 1982 and the second in the following year.[104]

The contract between the consortium and the South African Electricity Supply Commission (ESCOM) was signed in August 1976 and work began the following month.[105] That the contract was awarded to the consortium was something of a surprise since another consortium, headed by General Electric of the US and including Dutch and Swiss interests, had not only been thought the favourite for the contract but had actually received a letter of intent. That the contract went to the French consortium may have been partly due to the Dutch government, under pressure, postponing its decision on providing an export licence and financial cover for the Dutch element of the rival consortium.[106] It may also be that the French consortium was able to offer less stringent requirements for safeguards on the use of the plutonium produced by the Koeberg reactors. At the time the deal was announced there was no agreement on safeguards for the plutonium, though one was apparently concluded in 1977 after the discovery of the test site in the Kalahari Desert.[107]

The reactors will use three per cent enriched uranium, which is to be supplied from the US under an agreement signed with the Energy Research and Development Agency in January 1975 and covering the period to 1992.[108] It is not clear, however, whether this agreement will be compatible with new US legislation restricting nuclear exports to those cases where the importing state accepts international safeguards on all its nuclear facilities to prevent the diversion of civil nuclear technology to military ends.[109] Fabrication of the uranium into fuel rods will be done through Eurofuel, a Belgian-French company, under a contract which lasts to 1994 and it is possible that Eurofuel will also reprocess spent fuel.[110]

Most of the finance, 82 per cent, for Koeberg has been put up by a group of French banks headed by the state-owned

THE KOEBERG CONSORTIUM

A 40 per cent share in the consortium is held by *Framatome* which will construct the two 922 MWe Pressurised Water Reactors.

Framatome is owned 51 per cent by Creusot-Loire (a Franco-Belgian subsidiary of Schneider-Eupain)
30 per cent by Commissariat a l'Energie Atomique (a French parastatal agency)
15 per cent by Westinghouse (of the US)

A further 40 per cent share is held by *Spie-Batignolles* which is responsible for the civil engineering works at Koeberg and is 91 per cent owned by Schneider.

A 20 per cent share is held by *Alsthom* which will supply the turbo-generators and is a subsidiary of Compagnie Generale d'Electricite of France.

Source: UN Special Committee Against Apartheid, *Collaboration by Member States of the United Nations in Developing South Africa's Nuclear Weapons Capability* (Report of the Sub-Committee on the Implementation of United Nations Resolutions and Collaboration with South Africa), June 1978.

Credit Lyonnais and the Banque de l'Indochine et de Suez.[111]

In addition, France will train 100 South African technicians for about a year to prepare them for operating the Koeberg installation.[112]

Apart from the benefit of nuclear-generated electricity and the possible benefit of the plutonium which will be produced at Koeberg, it has also been alleged, on the basis of research by the Anti-Apartheid Movement in the FRG, that Koeberg has another benefit for the South African government and certain contractors.[113] This is that supplies of equipment designated for Koeberg, and thus for a plant without military connotations, are actually sent to Valindaba for the uranium enrichment plant. The companies in question are Alsthom of France (a shareholder in the Koeberg consortium), three Japanese companies – Hitachi, Mitsubishi and Toshiba – and two American companies – Combustion Engineering and Babcock & Wilcox (who have also supplied fuel for Safari 1 and are perhaps better known as the designers of the reactor at Three Mile Island, near Harrisburg in Pennsylvania, which came perilously close to a major disaster in spring 1979).

6. The collaborators

A dominant theme in the story of South African nuclear technology is the collaboration the regime has received from foreign states, parastatal agencies and corporations. The 1977 discovery of a test site in the Kalahari and the 1979 report of an atmospheric nuclear test in the vicinity of South Africa should have emphasised what ought to have been clear throughout: this collaboration has carried the risk of contributing to a South African capability to make nuclear weapons. Recent statements by some of the collaborators that their particular piece of collaboration did not or does not have military applications are irrelevant and misleading, probably deliberately: external nuclear collaboration with South Africa is a kind of jig-saw, in which each piece has had its own particular part to play.

The inherent connection between civil and military nuclear technology is now widely recognised. Technological organisations which have experience in handling civil nuclear activities provide a foundation on which to build an expertise in the military applications. The normal functioning of nuclear power stations produces plutonium which, if treated appropriately, can be used to construct a highly destructive and reliable nuclear device. The technology to enrich uranium for use as a civil nuclear fuel can be developed to provide material for nuclear weapons. Indeed, civil nuclear energy programmes began as a spin-off from military nuclear research; the fact that the spin-off can work the other way is hardly surprising.

Recognition of the relationship between civil and military nuclear technology was especially important in the negotiations which led up to the Non-Proliferation Treaty, first signed in 1968, and in the text of the Treaty itself which specifically obligates Parties who do not have nuclear weapons to enter a system of international safeguards, administered by the International Atomic Energy Agency, to prevent diversion of materials and technology from civil to military nuclear purposes.[114] The concern which gave rise to the Non-Proliferation Treaty, and to further efforts in the 1970s to prevent the proliferation of nuclear weapon possession, has been a generalised concern at the prospects for world peace if more states obtain nuclear weapons.

In the specific case of South Africa there has been additional cause for concern. Since the early 1960s leading South African figures have expressed their interest in nuclear weapons, sometimes explicitly, sometimes obliquely. These statements and hints have been intended for an international audience as well as for white South Africa. Their general import has been quite clear. One must therefore enquire about the motives for this external collaboration which the white regime has so gratefully received and without which its nuclear programme would be not nearly so extensive.

In the case of the private corporations which have been involved, one can ascribe the motivation to the search for profit and leave it at that. South Africa has long been a happy hunting ground for investors from Western Europe or North America and, to a large extent, uranium mining and the nuclear industry are simply part of the pattern. It is the collaboration of states and parastatal agencies which requires particular consideration. And it should not be forgotten that corporations exporting nuclear equipment to South Africa usually need export licences from their own governments, while participation in major investment projects often requires government assistance, including credit guarantees and other financial arrangements.

The early and sustained boost given to South African uranium mining by Britain and the US can be traced directly to the immediate interest both states had in obtaining uranium for their own civil and military nuclear programmes. The US itself has vast natural resources of uranium and might therefore have felt less urgency than Britain about establishing a secure source of supply. But it could still be expected to take seriously the task of supplementing its indigenous supplies with others and may also have considered it a priority to be in at the beginning of the development of a vast new source of uranium. South African uranium is also particularly attractive because of its cheapness – a result both of the super-exploitation of black

labour and of the fact that uranium mining was possible in already opened gold mines. Since the South African regime was not prepared to be a passive partner in the exploitation of uranium and since Britain and the US regarded South Africa as an ally, it is not surprising that the *quid pro quo* for exporting uranium to Britain and the US included technological and other cooperation in establishing uranium oxide plants.

Through STEAG, a parastatal agency, the FRG has delivered the technology of uranium enrichment to South Africa. It would appear that South Africa was able to offer STEAG the opportunity to test the jet-nozzle enrichment technique on a scale which it would have been unable to afford by itself. And this advantage would seem to have been so attractive that it was prepared even to keep at least some elected cabinet ministers unaware of its activities (it should be noted that the case of a state pursuing nuclear development without the full knowledge of the elected government is by no means unique – another case is British development of military nuclear technology during the 1940s and early 1950s).[115] Moreover, given the sensitivities surrounding the question of possible possession of nuclear weapons by the FRG, it is very likely that strong political inhibitions exist within the FRG against proceeding with certain aspects of nuclear development in the FRG itself. Since the early 1960s successive administrations in the FRG proposed cooperation in enrichment technology with the Dutch government.[116] Significantly, when this cooperation began through the Urenco alliance, formed in 1970 together with Britain, the FRG was the only one of the three partners not to have an enrichment plant on its own territory.[117] Thus South Africa provided a kind of help for West German enrichment technology which has been clearly advantageous and perhaps even essential.

The export of major items of equipment, up to and including nuclear reactors, has now become a major feature of the international nuclear industry and a highly competitive business. When, in the 1950s, the US launched its 'Atoms for Peace' programme, of which the 1957 agreement with South Africa and the subsequent supply of Safari 1 and uranium fuel were a part, this was not the case and the programme was presented, and in many quarters accepted, as a kind of altruism, with the US sharing with the world a beneficial technology. But technological aid from the US, or from any industrialised state, has never been purely altruistic. Where the US government has led with aid, US industry has tended to follow with sales and with profits.

The nuclear industry is, moreover, a technology-intensive industry demanding large capital outlays. One way of sustaining such industries which does not involve the state constantly incurring extra costs to an untenable level is to export. In this respect the nuclear industry bears a strong resemblance to another high technology industry with which states have a particularly close relation – the arms industry, in which the 1960s and 1970s have seen increasing pressures to export to new arms markets.

Thus American nuclear aid through 'Atoms for Peace' helped generate markets for American companies which could, among other things, play a role in keeping the US nuclear industry strong. Similarly, Britain was able to use some of its capacity for fuel fabrication by supplying Safari 1 and 2. The French consortium which won the Koeberg contract was aided by the French government because, even using reactors of American design, the deal contributes to the strength of

THE RECORD OF COLLABORATION

BELGIUM **has provided guarantees for a long-term contract to purchase South African uranium; Belgian interests are involved in Creusot-Loire which holds majority shares in Framatome, the consortium supplying reactors to the Koeberg project; Belgian interests are also involved in Eurofuel which will fabricate the fuel elements for Koeberg.**

BRITAIN **helped establish uranium mining and the manufacture of uranium oxide in South Africa; it has been a consistent and major purchaser of South African uranium and is a major purchaser of uranium from the Rossing mine in Namibia in which Rio Tinto Zinc, a British multinational corporation, is the largest foreign shareholder. RTZ is also a leading participant in current uranium mining operations at Palabora. Since the mid-1950s at least there have been regular exchanges and high level contacts between the British and South African nuclear industries which have undoubtedly facilitated the recruitment of Britons to important positions in the South African industry. Imperial College, London, runs a course in nuclear science and engineering for which South Africa has arranged to pay students' fees. Britain fabricated and shipped fuel elements for Safari 1 and 2 and may possibly have helped in the construction of the uranium hexafluoride plant.**

CANADA: **Falconbridge, a Canadian company, is involved in prospecting for uranium in South Africa while Rio Algo, a subsidiary of Rio Tinto Zinc, is a major participant at the Rossing mine.**

THE FEDERAL REPUBLIC OF GERMANY **has, most importantly, been the main collaborator in South Africa's development of the technology for enriching uranium. Companies from the FRG were the main foreign suppliers of equipment for the enrichment plant. Two companies from the FRG were major partners in initiating uranium mining at Palabora in 1962; the FRG has imported South African uranium and now imports uranium from Rossing in which FRG state companies initially were shareholders. In the 1970s companies from the FRG have prospected for uranium in South Africa. In 1962 the FRG and South Africa concluded an agreement including scientific cooperation. Since then there have been regular exchanges between the two countries' nuclear industries and in 1969 the FRG began training some South African scientists in uranium enrichment technology. Two companies from the FRG supplied equipment for Safari 1.**

FRANCE **has shares in the Rossing mine, from which it also purchases uranium as it purchases other South African uranium; one French state company is prospecting for uranium in South Africa while another has financed a major mining operation. French companies supplied equipment for Safari 1. France has been sending technicians to South Africa and training South African technicians since 1966. French state support and finance, together with training of technicians, has made possible the construction of a nuclear power station at Koeberg by a consortium dominated by French interests.**

IRAN, **under the regime of the deposed Shah, reportedly provided financial support for uranium enrichment in South Africa in return for the promise of uranium supplies.**

ISRAEL **agreed in 1976 to increase scientific cooperation with South Africa, possibly including the nuclear field, and there have been rumours of Israeli personnel working at the Valindaba enrichment plant.**

JAPAN **is a major purchaser of South African uranium with several companies, including Kansai, purchasing uranium from Rossing. Equipment supplied by Hitachi, Mitsubishi and Toshiba, designated for Koeberg, may actually be destined for Valindaba.**

THE NETHERLANDS **will, through Urenco, use uranium produced at Rossing.**

SWITZERLAND **imports South African uranium and Swiss equipment supplied by Sulzer is used at Valindaba.**

continued...

THE RECORD OF COLLABORATION (cont...)

THE UNITED STATES OF AMERICA **helped, with Britain, to establish uranium mining in South Africa and was a major importer of South African uranium until 1971; several American companies still import significant quantities of South African uranium, while other American companies prospect for uranium in Namibia and South Africa. Under the 1957 cooperation agreement there have been major exchanges of personnel and training of South African technicians. An American company with government approval constructed Safari 1; American uranium, some of it fabricated into fuel elements in the US, fuelled both Safari 1 and 2. The US has exported other nuclear materials to South Africa, including the heavy water needed for Safari 2, and American companies supplied equipment to the Valindaba enrichment plant, while Westinghouse has shares in the consortium constructing the Koeberg power station using Westinghouse designs for the reactor.**

France's nuclear industry. Nuclear exports to South Africa derive from the general condition of the nuclear industry and are different in South Africa's case only because of the specific dangers, to which a blind eye has been resolutely turned.[118]

Thus, commercial and economic considerations have over-ridden the obvious political dangers.

Yet one could also say that *political* considerations have over-ridden the political dangers. For South Africa has been seen as a particularly important ally of the leading capitalist states, despite political pressure by the anti-apartheid movements and the majority of the world's states. A strong white regime in South Africa has been seen as in the West's interests, partly because of its strategic position, partly because of its natural resources, partly because of the amount of Western investment there. And while too close a relationship with South Africa can be embarrassing because the white regime is so obnoxious, this general attitude has created a general willingness to cooperate with South Africa as much as has been politically possible. One could mount strategic arguments to show that the assumed geo-strategic importance of South Africa depends in part on outmoded and anachronistic ideas; one could argue that supporting the South African regime, directly or indirectly, is not only disgusting but also, in pragmatic terms, shortsighted; one could argue that the interests of peace, human liberty and social justice demand that commercial considerations be over-ridden. But one cannot deny that Western states have seen South Africa as an important ally – and while political pressures have led to (leaky) arms embargoes,[119] all other possible support was provided freely. And this has included nuclear aid and cooperation.

In the end, then, nuclear collaboration with South Africa intertwines with two other strands of international politics: the general process of nuclear aid and trade; and the general pattern of Western collaboration with and investment in South Africa. Yet it also stands out as a particularly dangerous aspect of the international nuclear trade, a particularly dangerous form of collaboration.

South African nuclear technology: a short chronology

1949 South African Atomic Energy Institute founded.
1950 Agreement with American-British Combined Development Agency on uranium mining (27 mines opened during 1950s)
1952 First uranium oxide plant opened (17 constructed during 1950s)
1957 South African Atomic Energy Board founded.
Agreement on nuclear cooperation with US (amended to expand scope and duration 1962, 1967 and 1974).
1958 Joint US and South African team monitored US nuclear tests in south Atlantic.
1959 Development of jet-nozzle technique for uranium enrichment begun in the FRG by Gesellschaft fur Kerforschung.
1960 Secret work on uranium enrichment begun within South African AEB.
1961 US company of Allis Chalmers contracts to construct Safari 1.
1962 Cultural agreement between the FRG and South Africa including scientific cooperation.
1963 Uranium production at Palabora initiated.
1965 Safari 1 went critical.
(1965-76: US supplied uranium for Safari 1.)
1966 France began training South African nuclear scientists.
1967 South African scientists joined with British to monitor French nuclear tests in Pacific.
Safari 2 went critical.
(1967-74: Britain fabricated the fuel for Safari 1.)
1968 STEAG of the FRG discussed cooperation in uranium enrichment with South Africa.
1969 FRG began training South African scientists in jet-nozzle technique.
1970 STEAG obtained world rights on commercial development of jet-nozzle.
South Africa announced it had developed 'unique' method of uranium enrichment.
1972 South Africa approached FRG and Urenco for cooperation in uranium enrichment.
1973 STEAG applied unsuccessfully for FRG cabinet approval for its cooperation with South Africa in enrichment; went ahead anyway.
1975 Valindaba pilot enrichment plant opened.
Nuclear agreement between Iran and South Africa.
1976 Uranium production started at Rossing.
Work begun to build Koeberg nuclear power station.
STEAG withdrew from Valindaba enrichment project.
Scientific agreement between Israel and South Africa.
South Africa approached US research centres working on laser enrichment of uranium.
1977 US held up further contract for supplying uranium for Safari 1.
Site for testing nuclear explosives discovered in Kalahari by Soviet satellite photography.
1978 Expansion of Valindaba enrichment plant into production facility announced.
Uranium hexafluoride plant opened at Pelindaba.
1979 US satellite identified double-flash over south Atlantic in vicinity of South Africa, indicative of nuclear test.
(1981-2? Expanded Valindaba plant to start operation.)
(1982? First Koeberg reactor to start operation.)
(1983? Second Koeberg reactor to start operation.)

THE POLITICS OF SOUTH AFRICA'S NUCLEAR TECHNOLOGY

So far we have considered two strong pieces of evidence that South Africa has nuclear weapons and considered the path by which it has arrived in a position where it could make nuelear weapons. We have seen that the role of foreign collaboration has been crucial. But it is necessary also to consider the possible effects of, and the motives of the South African regime for, its nuclear development efforts. For the regime has pursued a strategy with several aspects through nuclear development and, although the possibility of South Africa manufacturing or already having nuclear weapons is undoubtedly the most dramatic of those aspects, it is only one of them. Whether or not South Africa could make or has made nuclear weapons, the nuclear collaboration it has received would still be extremely important to the regime, to its continued survival and ability to resist pressures for change. In directing particular attention to the military dimensions of its nuclear technology, the importance of the civil dimensions should not be ignored.

1. Independence and energy

States rich in natural resources but lacking the levels of industrialisation attained by Japan, Western Europe and the US face a common problem: the need to have some control or influence over the way in which those resources are exploited. This question has become crucial to the political, economic and social development of the less developed countries, where there can be sharp contradictions between local needs and the interests of the foreign corporations that exploit the natural resources.

In the exploitation of its uranium South Africa has been able to avoid subservience to or dependence on foreign interests. The South African state and local economic interests were involved in uranium mining, and the manufacture of uranium oxide, right from the beginning. Foreign investment and assistance was required but there has been no passivity in the face of this external involvement. Crucial for this has been South Africa's ability to develop a political-technological infrastructure capable of identifying South Africa's requirements, together with the political will to assert them. The US-British Combined Development Agency, formed to exploit South African uranium, concluded its agreement on developing the first four uranium mines with the Atomic Energy Institute, the forerunner of the AEB. From the outset South Africa was seeking its own road based on its own requirements. The development of a nuclear technological capacity in South Africa has made it possible for the regime to plan to enrich its own uranium and become an exporter of enriched uranium in its own right. The creation of a nuclear industry in South Africa has helped the regime avoid the potential domination of the uranium mining industry and its development by foreign corporations and states.

The South African regime could capitalise on its uranium resources to carve out a crucial place for itself in the international energy market. This aspect will be considered in the next section.

Nuclear technology as a means of generating electricity is also important to the regime. Because South Africa has very large coal reserves and exports much of its coal,[120] it is tempting to suppose that the regime could have no rational interest in developing nuclear power and that its nuclear power plans are therefore no more than a cover for its military nuclear plans. But many states which are rich in coal resources are nonetheless intent on developing nuclear power. Indeed, on a world scale, it would appear that coal can be used to generate electricity for longer than uranium will be available, although the geographical distribution of coal means that this does not hold true for all states.[121] Despite this apparent abundance of non-nuclear energy sources, nuclear energy is a major issue of the present and, while nuclear energy is running into trouble and delays in the US, in other countries nuclear programmes are proceeding apace.[122]

Since the Arab states used oil as a politico-diplomatic weapon in 1973/74 and since the general hike in oil prices from 1974, energy has come to be seen as a critical component of the independence of states. This issue has a particular significance for South Africa, which lacks oil resources,and which fears oil boycotts against it, despite the now evident leakiness of the oil sanctions against the illegal Rhodesian regime.[123] Indeed, in the SASOL project, South Africa has invested a major effort in extracting oil from coal, using a technique used in Germany in World War II and not now in use anywhere else in the world.[124]

It is not surprising if the general concern, though often exaggerated, in the industrialised world about future energy supplies is reflected in South Africa. Worries about the use of oil as a political weapon must intensify this concern. A regime as determined and resourceful as that in South Africa could only be expected to increase its insurance against energy starvation by following the route of nuclear energy, taken by so many other states. At the same time one should not assume that technological institutions in South Africa are immune from developing the kind of momentum shown by technological institutions elsewhere. For such institutions and infrastructures, rational appraisal of further development often takes second place to the need for self-perpetuation and for maintaining the pace of technological advance. Clearly the South African nuclear industry has been vested with a particular favour by the regime. The development of nuclear power almost certainly owes something to this factor in South Africa as it does almost everywhere else.

But this technological momentum also fits well with the need of the South African regime to increase its options in its short- and long-term battle for survival and continued white supremacy. Even if it were certain that South Africa had no

plans for nuclear weapons, nuclear collaboration with it would still be a contribution of importance to the maintenance of apartheid.

In the context of probable worries about the 'oil weapon', the export of uranium and the possibility that South Africa will become an exporter of enriched uranium assume a further importance. Nuclear power programmes around the world mean that South Africa possesses in its uranium a raw material of the same kind of strategic importance as oil. It is not inconceivable that against a threat of oil sanctions South Africa would attempt to use uranium as a counter-weapon. This might be done by threatening to withhold uranium from states who collaborated in the sanctions or maintained friendly relations with those who implemented the sanctions. Or it might be done by using uranium to buy and barter a way round or through the sanctions. The agreement under which the deposed Shah of Iran invested in South African uranium enrichment in return for supplies of uranium was an effort not only to gain investment finance but also to ensure friendly relations with a major oil supplier. In general, in the absence of the use of the oil weapon against it, South Africa can use its uranium to buy off some of the international pressure against it.

2. The international energy market

The more important the regime can make itself and, in this context, its uranium to other states, the greater protection it will have against hostile international pressure. This protection might not include open statements of support, or even the absence of statements of condemnation, but it could include quiet efforts to water down international action against the regime in forums such as the United Nations. It is in this light that we must understand South African attempts to carve out a distinct and essential role in the international energy market, attempts based on its uranium resources and, at least potentially, its technology of uranium enrichment. Ironically, this strategy is made possible by the differential conditions of uranium supply which result from concern at the prospect of nuclear weapons proliferation.

This concern has led to restrictions on the supply of nuclear technology and materials, in the form of safeguards embodied in the Non-Proliferation Treaty (NPT) and Nuclear Suppliers Club (NSC) of nuclear exporters, formed in 1975.[125] The US, the largest uranium exporter in the capitalist international economy, is now in the process of renegotiating agreements on the supply of nuclear materials with several countries. Under its Nuclear Non-Proliferation Act, with effect from September 1979, the US must ensure that importers of its materials submit all their nuclear facilities to safeguards laid down by the International Atomic Energy Agency (IAEA). IAEA safeguards on all facilities (full-scope safeguards) are also required on non-nuclear weapon states who are Parties to the NPT. Australia and Canada, two other major uranium exporters, require similar kinds of safeguards from states they supply.[126]

However, NSC safeguards apply only to the facilities in the importing country which actually use the material in question. Thus, NSC safeguards are distinctly less onerous than American, Australian, Canadian or NPT safeguards. If states wishing to import equipment or material find the stricter safeguards too burdensome, they are therefore likely to turn to West Europe for equipment and technology, and would probably look to meet their uranium requirements with material supplied from Gabon and Niger through France or from South Africa. Uranium from these sources could be enriched in West Europe by the commercial enrichment consortia of Eurodif, Coredif and Urenco.

This situation could tempt West European states to take American, Australian or Canadian uranium with full-scope safeguards for their own domestic needs, but to use unsafeguarded uranium from South Africa for enrichment and re-export under the NSC limited safeguards. States who have not ratified the NPT (such as Argentina, Brazil, Egypt, India, Indonesia, Israel and Pakistan), and who object for one reason or another to the more stringent safeguards, could be expected to turn to the easier conditions available by importing South African uranium through West Europe.

However, West European states may also tighten up their export conditions, even retrospectively renegotiating for tighter conditions as happened with Urenco's contract to enrich uranium for Brazil.[127] This situation would open the way for South Africa to revive its plans for large-scale export of enriched uranium, providing the material with no safeguards, enriched in facilities themselves not subject to safeguards.

Thus the situation may make it possible for South Africa to become an essential part of the international energy network, either supplying uranium for enrichment in West Europe and export with limited safeguards to third parties, or itself directly exporting enriched uranium, while still possibly supplying domestic needs in Japan and West Europe. This position could help alleviate pressure on it, creating new allies for apartheid. It is in this sense that importing or treating South African uranium must be seen as a form of nuclear collaboration with apartheid, as important in its own way as the supply of equipment, material and expertise.

3. Nuclear weapons

Nuclear technology has been and will continue to be politically important to South Africa, regardless of any plans it might have to develop nuclear weapons. But the greatest concern has been quite rightly focused on the possibility that South Africa either has or could have at short notice a small nuclear arsenal. To assess how probable it is that South Africa has nuclear weapons or might have them we need to consider both how nuclear weapons might be used and the feasibility of South Africa producing them.

That the existence of the white South African state is threatened is recognised by just about everybody, including the regime. To help meet the threat, the armed forces have been increased over the years by staggering proportions. South African militarisation really dates from 1961 when in one year military spending was increased by 60 per cent in real terms (ie after accounting for inflation), and has been sustained ever since, receiving another major boost in the mid-1970s in the wake of the Portuguese revolution which signalled the imminent demise of Portuguese colonialism in southern Africa, thus removing major regional allies of apartheid.

Taking 1960 as the base year, by 1978 annual military spending had increased by over 5,000 per cent in actual expenditure, equivalent to a real increase of about 1,730 per cent. In 1977 the annual military budget accounted for 5.5 per

cent of Gross Domestic Product, up from 0.8 per cent in 1960.[128]

Total military and paramilitary personnel, including reserves, increased by around 130 per cent between 1966 and 1979 – from 172,300 to 404,500 – with an increase in active military forces (ie regular and conscripted personnel, excluding reserves and paramilitary forces) that was nearly threefold – from 22,000 to 63,250.[129] The South African Air Force flies 416 combat aircraft, including operational trainers and aircraft with the Citizen Force, while the army is equipped with 270 medium and heavy tanks, 1,600 armoured cars, 230 scout cars and 1,780 armoured personnel carriers.[130] This is a powerful military establishment, built up by a determined and sustained effort.[131]

Even so, the South African regime may think this is not enough. In 1976 the military expedition into Angola received a very rough handling from the Cuban and Angolan (MPLA) forces.[132] White South Africa's myth of its military invincibility, a myth built on a racist foundation, was sorely challenged. While propaganda attempted to retrieve and resuscitate the myth, more sober and accurate assessments were probably to be found within the regime itself, and one of the effects of the adventure was probably to solidify the conviction that something more was needed. But both economically and in terms of personnel, the current military effort is already stretching South Africa; if there were to be 'something more', it would have to be some dramatic increase in the capacity to apply force. And that immediately directs attention towards nuclear weapons.

There is no problem for South Africa in regard to means of delivering nuclear weapons: it has combat aircraft capable of carrying nuclear weapons, including British *Buccaneers* and *Canberras* and French *Mirages.*

It is likely that the South African regime has specific targets in mind. It might consider that the nuclear destruction of major guerrilla camps and bases would be a dramatic demonstration of its determination; the use of nuclear weapons against the towns of any state aiding guerrilla forces might be expected to cause an abrupt termination of that aid. More important, the regime might expect that the threat, whether explicit or implicit, of nuclear bombardment would deter states such as Angola, Mozambique and Tanzania from aiding the guerrillas. Indeed, if South Africa were to use its possession of nuclear weapons to deter threats to it, the object or target of that deterrence would almost certainly be those states who could be expected to aid guerrilla forces fighting the white regime.

Indirectly, however, South African nuclear deterrence would have other objectives. The threat that it might use nuclear weapons might be expected to deter the regime's international allies from jettisoning it. States such as Britain, France, the FRG and the US who might, for pragmatic reasons, prefer to 'drop' the South African regime might be persuaded to press for accommodation with South Africa for fear that otherwise it would unleash a nuclear catastrophe.

Of course, whether or not South African nuclear deterrence would work against either direct or indirect targets can only be a matter for conjecture, for South African strategic planners no less than for outside observers. But the success of nuclear deterrence can only ever be a matter for conjecture; the problem is no more likely to dissuade South Africa from developing nuclear weapons than it has dissuaded any of the current nuclear weapon states. What is likely to count most in the calculations is the prospect of having some extra insurance when the South African state's very existence is at stake.

If (or when) South Africa possesses nuclear weapons, it would thus have an additional option of threatening to use them or by actually using them. Yet it must also fear that should it announce it has nuclear weapons, let alone if it actually uses them, there will be a tidal wave of outrage which its would-be allies around the world would find hard to resist; short-term advantages could be wiped out and the demise of the regime actually hastened. The opposition to the regime activated by such events as the Sharpeville and Soweto massacres or the murder of Steve Biko would be as nothing compared to the pressure it would come under if it used or threatened to use nuclear weapons.

Awareness of this probably explains South Africa's use of the 'politics of uncertainty', the use of hints and contradictory statements about its military nuclear ambitions (such as Vorster's repeated but later denied assurances to President Carter that there were no plans to produce nuclear weapons or conduct nuclear tests).

One of the advantages of this strategy is that it places Western states in a dilemma. If they acknowledge that South Africa has, or will soon have, nuclear weapons, they might thereby appear to be deterred from certain courses of action by that assessment. But if they minimise the dangers, they are unable to exert public pressure on South Africa to try to get it to abandon its military nuclear programme. They may, of course, exert pressure secretly, but secret diplomacy is of limited use, particularly in the face of corporate interests in their own country who favour continued cooperation with South Africa.

A major task in the international response to the military dimension of South African nuclear technology must be to devise a strategy which makes it possible to cut through this knot. The ambiguities and prevarications of the responses of some Western states play right into the hands of the South African use of uncertainty.

In sum, the South African regime may well believe it needs nuclear weapons; it has the means to deliver them to targets; it can probably identify specific uses for them; and, above all, it expects political advantages from the possession of nuclear weapons. We must next ask whether it has the capacity to manufacture them.

The short answer is that it does have the capacity. Unless it has obtained nuclear weapons material by theft or other clandestine means, it could enrich uranium at Valindaba to a high proportion of Uranium-235, even before the expansion of the pilot enrichment plant into a production facility. It is most unlikely, unless there have been clandestine means of obtaining weapons-grade material, that either Uranium-233 or, at this stage, plutonium has been used.

To have material for nuclear weapons by the Uranium-235 route, South Africa both needs and has uranium, plants to manufacture uranium oxide, a uranium hexafluoride plant and an enrichment facility.

The amount of weapons-grade uranium which could have been produced at Valindaba by now cannot be known without access to detailed specifications of the enrichment cycle. However, one model of an enrichment cycle compatible with the adapted jet-nozzle technique suggests that the pilot plant is capable of producing slightly more 90 per cent enriched

uranium each year than would be necessary to build a single nuclear weapon of the size that destroyed Hiroshima, Japan, on 6 August 1945.[133] Since the pilot plant began operation in April 1975[134] at a lower capacity than it eventually attained (50 tons a year of three per cent enriched uranium), it seems likely that at the time of writing (December 1979) it could have produced enough weapons-grade material for four Hiroshima-size nuclear weapons. Of course, this would also be material enough for a larger number of smaller weapons; the nuclear explosion over the south Atlantic in September 1979 was calculated to be less than four kilotons,[135] so that if it was a South African nuclear test this may suggest the regime is thinking in terms of weapons smaller than that which devastated Hiroshima. Accordingly, we could speculate that enough material has been produced for about a dozen relatively small nuclear weapons.

Such an estimation of the range of sizes for South Africa's possible nuclear stockpile is vulnerable in a number of ways. Firstly, it assumes a particular form of the enrichment cycle which may not be totally accurate. Secondly, it assumes that no weapons-grade material has been obtained by theft or other clandestine means. Thirdly, it assumes that all of the Valindaba plant's output is highly enriched uranium destined for the production of nuclear explosives. If South Africa wanted to keep Safari 1 operating, since a new contract for supply of uranium by the US has been held up, it would presumably have to use Valindaba's output for this. Judging from the rate at which American uranium has been used in Safari 1 (81 kg from 1965 to 1976)[136] keeping it operating would absorb most of Valindaba's current potential output of highly enriched uranium, leaving enough over for possibly one weapon of approximately Hiroshima-size. But to use some of Valindaba's output for Safari 1, South Africa would need also to have a facility to fabricate the fuel elements. There is no evidence available that South Africa has such a facility, and the third assumption therefore seems reasonable.

To summarise, it appears (in December 1979) that South Africa could have enough material to make four Hiroshima-size nuclear weapons, or around a dozen smaller nuclear weapons.

The view that South Africa has the capacity to make nuclear weapons is widely held. In February 1977 US government officials were quoted as saying that South Africa could develop nuclear weapons by 1981, or within a few months if it devoted all its nuclear resources to the task.[137] In the same month Raymond Barre, the French premier, stated that South Africa already had a military nuclear capacity, to which the Koeberg reactors would add nothing.[138] It is not, in fact, true that Koeberg would add nothing to South Africa's military nuclear capacity. The plutonium which the reactors will produce could, if South Africa were to develop its own chemical reprocessing plant,[139] be used for the manufacture of nuclear weapons. Together with uranium from the Valindaba plant after its expansion in 1981, this would transform South Africa's situation, from being able to produce a very small nuclear arsenal to being able to produce an arsenal which, within a few years, could number above 300 weapons.

Thus, to argue that South Africa has a military nuclear capacity and nothing can be done about it is misleading. South Africa now has a very small military nuclear capacity which could be changed within a few years to an extremely significant one. This emphasises the urgency of international action, and it emphasises that there is still time for effective action.

NUCLEAR WEAPON MATERIAL

There are three routes to nuclear weapons:

1. **Nuclear weapons can be made of uranium, usually enriched so that it consists about 90 per cent or more of the isotope Uranium-235. A bomb made of this material, with a yield of about 14 kilotons (ie equivalent in explosive power to 14,000 tons of TNT) was used to destroy Hiroshima on 6 August 1945.**
2. **Nuclear weapons can also be made of plutonium which is a by-product of most normally operating nuclear reactors and power stations. A bomb made of plutonium, with a yield of nearly 20 kilotons, destroyed half of Nagasaki on 9 August 1945. Until recently it was believed that commercial grade plutonium would not make an efficient nuclear weapon because of the build-up of plutonium-240 and -241 which would make the bomb likely to explode before the right time. It was thought that weapons-grade plutonium should consist about 96 per cent of plutonium-239 and only four per cent of other isotopes. The way to prevent the build-up of other isotopes was simply to remove the fuel rods earlier than would be economic if the intention were simply to generate energy for electricity. It is now known that commercial grade plutonium can make an efficient nuclear explosive. After extraction from the reactor core, the fuel rods need to be chemically reprocessed to remove other materials present in them.**
3. **It is also possible to make nuclear explosives from Uranium-233, which is bred by subjecting thorium to neutron irradiation.**

CONCLUSION

On the basis of the evidence available, it is possible to reach the unambiguous conclusion that South Africa *could* now have a small nuclear arsenal. It is possible that the efficiency of its weapon design has been tested with an actual nuclear explosion. But to say this does not mean it is certain South Africa *does* have nuclear weapons or that it has set aside material from which to construct them. There is no definitive proof on this score.

That South Africa has a military nuclear capacity is clear. So far I have seen no evidence of any use for uranium enriched at the Valindaba pilot plant and no alternative to military uses comes easily to mind. If we accept that the American satellite which identified the double flash over the south Atlantic in September 1979 was functioning properly, it seems clear that a nuclear test occurred, and it is not clear what states other than South Africa might have been responsible for it.

Because of these two points, I have to conclude that South Africa probably has at least set aside material for nuclear weapons, that it has developed and tested a weapon design, and that producing a small arsenal from its available material would be the task of a few weeks at most.

NOTES

NB: Discovering basic information about South African nuclear development has never been easy. Researchers who have done the fact-finding have had to work with a paucity of material and a great deal of estimation has been involved. Nonetheless, there is now a considerable body of knowledge and the accuracy of most of the factual material presented here is widely accepted. Yet it must be freely admitted that at certain points the lack of hard facts has been a major problem, leading different researchers to different factual conclusions. To prepare this paper I have drawn largely on the work of other people. But I have not drawn on it uncritically: where possible, information from one source has been verified by reference to other sources. Therefore, while acknowledging the problem, I take responsibility for the factual material presented here except, of course, where I have indicated that the reference is to allegations, rumours or unsubstantiated reports. These comments are not intended to throw doubt on the formidable job of research done by numerous people over the years but merely to draw attention to problems inevitable in studying the subject.

1. This narrative is based on Anti-Apartheid Bewegung (Federal Republic of Germany), *Western Nuclear Shield for Apartheid,* mimeo, December 1977
2. See African National Congress of South Africa, *The Nuclear Conspiracy: FRG collaborates to strengthen Apartheid,* September 1975, and *Conspiracy to Arm Apartheid Continues: FRG-SA Collaboration,* 1977
3. Cervenka, Z and Rogers, B, *The Nuclear Axis* (London: Julian Friedmann, 1978), p 279
4. *Ibid,* pp 278, 280-1; and Anti-Apartheid Bewegung, *op cit*
5. *Philadelphia Enquirer,* 4 September 1977
6. See Anti-Apartheid Bewegung, *op cit*
7. Walters, R W, 'US Policy and Nuclear Proliferation in South Africa', in Western Massachusetts Association of Concerned African Scholars (ed) *US Military Involvement in South Africa* (Boston: South End Press, 1978), p 192
8. *Ibid*
9. Anti-Apartheid Bewegung, *op cit*
10. *Washington Star,* 1 March 1978
11. Marder, M and Oberdorfer, D in *The Washington Post,* 23 August 1977
12. *International Herald Tribune,* 27-28 October 1979
13. *International Herald Tribune,* 5 November 1979; one kiloton is equivalent to the explosive force of 1,000 tons of TNT
14. *Ibid*
15. *International Herald Tribune,* 15 January 1980
16. *International Herald Tribune,* 27-28 October 1979; the South African regime repeated its denial in response to an inquiry by the UN Secretary General, including as supporting evidence a report from the South African Atomic Energy Board which stated that no recent

increases in radioactivity had been measured at Pelindaba or a site near Cape Town, and thus argued that no nuclear test had taken place: Statement of 30 October 1979 attached to *Inquiry into the reports concerning a nuclear explosion by South Africa: Report of the Secretary General,* A/34/674, 12 November 1979, UN General Assembly

17. *International Herald Tribune,* 29 October 1979
18. *Ibid;* and *The Guardian,* 30 October 1979
19. *International Herald Tribune,* 29 October 1979; and W Sullivan, in *International Herald Tribune,* 3-4 November 1979
20. *International Herald Tribune,* 5 November 1979
21. Cervenka and Rogers, *op cit,* pp 278, 280-1
22. Jackson, H, in *The Guardian,* 27 October 1979
23. *The Washington Post,* 16 February 1977
24. Cervenka and Rogers, *op cit,* p 211
25. *South African Digest,* 13 August 1965
26. *The Washington Post,* 16 February 1977
27. Quoted by Jackson, H, in *The Guardian,* 27 October 1979
28. *Southern Africa,* August-September 1978
29. See Section 3 for details.
30. The African National Congress of South Africa, *The Nuclear Threat Posed by the Apartheid Regime,* UN Centre Against Apartheid, March 1979
31. 'Pelindaba' is a contraction of a Zulu expression meaning 'We don't talk about this any more'; 'Valindaba' means 'We don't talk about this at all' (Cervenka and Rogers, *op cit,* p 210); for details on Valindaba's operation, see Section 4
32. See Section 2 for details
33. See Cervenka and Rogers, *op cit,* p 198; also, Burhop, E, *Assessment of the Dangers of South Africa in relation to the Dissemination, Production and Use of Nuclear Weapons,* UN Centre Against Apartheid, March 1979
34. See Section 4
35. See Section 5
36. See *New African,* October 1977; also UN Special Committee against Apartheid, *Collaboration by Member States of the United Nations in Developing South Africa's Nuclear Weapons Capability* (Report by the Sub-Committee on the Implementation of United Nations Resolutions and Collaboration with South Africa), June 1978; also ANC, *Conspiracy ... Continues, op cit*
37. In mines the proportion of gold to uranium is reportedly about three to one: Walters, R W, *Uranium Politics and United States Foreign Policy in Southern Africa,* UN Centre Against Apartheid, March 1979; Cervenka and Rogers state that in such mines the value of uranium production is about one-fifteenth the value of gold produced, *op cit,* p 112
38. The British Anti-Apartheid Movement, *Nuclear Collaboration with South Africa: Britain's Profile,* UN Centre Against Apartheid, March 1979; and Levy, A, *Le soutien de la France au Regime d'Apartheid dans le Domaine Nucleaire,* mimeo, February 1979
39. British AAM, *op cit*
40. ANC, *The Nuclear Conspiracy..., op cit*
41. Walters, *Uranium Politics..., op cit*
42. *Ibid*
43. *The Sunday Times,* 18 November 1979
44. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit;* Huisman, R, *The Netherlands' Involvement in Processing Namibian Uranium,* mimeo, November 1978; and Juffermans, P and Kouwenaar, A, *The Dutch Involvement in the Nuclear Complex of South Africa,* mimeo, February 1979
45. Geisler, W, *The Military Cooperation Between the Federal Republic of Germany and South Africa in the Nuclear and Conventional Fields,* mimeo, undated (1978?); and UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*
46. Cervenka and Rogers, *op cit,* pp 111-3
47. British AAM, *op cit,*
48. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*
49. British AAM, *op cit*
50. Huisman, *op cit;* and UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*
51. British Nuclear Fuels, Ltd, Ultra Centrifuge Nederland BV and Uranit (of the FRG) each hold a one-third share in Urenco. BNFL is a parastatal agency; the largest shareholder in UCN is the Dutch state; Uranit is constituted as follows: one-third of shares are held by Gelsenberg which is owned by Veba, a state-owned corporation that also has a stake in Urangesellschaft; a further third is held by NUKEM, which is owned by a consortium that includes Rio Tinto Zinc; and the final third is held by Hoechst Farbwerke. See Juffermans and Kouwenaar, *op cit,* and Cervenka and Rogers, *op cit,* p 300
52. Huisman, *op cit*
53. See UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit,* and Cervenka and Rogers, *op cit,* chap 4; see also Anti-Apartheid Bewegung, untitled, mimeo; Clarke, S, *The Role of Transnational Corporations in Financing Apartheid,* mimeo; and Nsekela, HE A J, *Partners in Apartheid,* address -- presentations at the International Seminar on the Role of Transnational Corporations in South Africa, London, 2-4 November 1979, organised by the British Anti-Apartheid Movement in cooperation with the UN Special Committee against Apartheid
54. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

55. *Ibid*

56. Cervenka and Rogers, *op cit*, p 242

57. Walters, *Uranium Politics..., op cit*

58. Lodgaard, S, *Nuclear Collaboration with South Africa, Status and Prospects*, UN Centre Against Apartheid, March 1979

59. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

60. Walters, *Uranium Politics..., op cit*

61. Attachment 2 to letter to Senator J Glenn from W A Anders, Chairman of the US Nuclear Regulatory Commission, 6 June 1975, cited by Cervenka and Rogers, *op cit*, pp 243-4

62. Walters, *Uranium Politics..., op cit*

63. Statement by N Sievering, US Energy Research and Development Administration, June 1976, to US House of Representatives International Relations Committee, Subcommittee on International Resources, Food and Energy, cited by Cervenka and Rogers, *op cit*, p 245

64. Levy, *op cit;* and statement by W Geisler at a United Nations Seminar, London, February 1979, in *Nuclear Collaboration with South Africa*, World Campaign against Military and Nuclear Collaboration with South Africa, March 1979, p 12

65. ANC, *The Nuclear Conspiracy..., op cit;* Safari 2 is also known as 'Pelindaba Zero'

66. Lodgaard, *op cit;* it is also reported that Nukem of the FRG fabricated and shipped fuel elements for Safari 2 in 1966-7: Cervenka and Rogers, *op cit*, p 248; spent fuel from Safari 2 is reprocessed in Britain according to Burhop, *op cit*

67. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

68. In fact it is almost certain that some equipment was obtained outside South Africa in view of the general level of South African industry in the 1960s. It has been reported that two firms from the FRG – BBC and Krupp – supplied equipment: statement by W Geisler in *Nuclear Collaboration..., op cit*, p 12

69. These two figures are widely cited: see, among others, UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

70. *Ibid*

71. Cervenka and Rogers, *op cit*, p 252

72. British AAM, *op cit*

73. See Cervenka and Rogers, *op cit*, pp 159-60

74. *The Observer*, 28 October 1979

75. *The Sunday Times*, 28 October 1979

76. British AAM, *op cit*

77. Levy, *op cit*

78. ANC, *The Nuclear Conspiracy..., op cit*

79. *Ibid*

80. *Ibid*

81. ANC, *Conspiracy...Continues, op cit*

82. See Sections 2 and 3

83. Geisler, *The Military Cooperation..., op cit;* and ANC, *The Nuclear Conspiracy..., op cit:* in the latter it is reported that South African scientists were being trained in the FRG some years before 1967, although this probably does not refer to training in uranium enrichment

84. Geisler, *ibid;* Cervenka and Rogers' account suggests FRG-South African discussions on enrichment may not have begun until after Donald Sole, previously the South African representative on the International Atomic Energy Agency's Board of Governors, took up the position of ambassador to the FRG in February 1969, *op cit*, p 60

85. ANC, *The Nuclear Conspiracy..., op cit*

86. *Wall Street Journal*, 23 October 1970

87. Cervenka and Rogers, *op cit*, p 178

88. See the narratives in ANC, *The Nuclear Conspiracy...* and *Conspiracy...Continues, op cit;* and Cervenka and Rogers, *op cit*

89. Partly because the South African authorities continue to insist that their enrichment technique is their own invention, there remains doubt about the extent of the technical knowledge passed on to UCOR by STEAG. The South African adaptation of the jet-nozzle utilises the American 'vortex tube' concept, 'in which centrifugal force in a gas stream is obtained by making it swirl aerodynamically in a fixed tube'. Dr Roux, president of both UCOR and the South African AEB, has asserted that the South African enrichment technique owes more to this concept than to the jet-nozzle – see *World Armaments and Disarmament' SIPRI Yearbook 1978* (London: Taylor & Francis, 1978), pp 72-3. Recently one writer has classified the South African technique as 'the advanced vortex tube process', a technique completely distinct from the jet-nozzle –Boskma, P, 'Jet nozzle and vortex tube enrichment technologies', in Barnaby, F *et al* (eds), *Nuclear Energy and Nuclear Weapon Proliferation* (London: Taylor & Francis, 1979). However, the technical details in Boskma's paper, together with the very fact of collaboration between STEAG and UCOR convince me that the South African technique is just a variation on the jet-nozzle, a variation which would not have been possible without basic technical assistance from STEAG

90. *International Herald Tribune*, 13 October 1975; *The Economist*, 6 December 1975

91. Burhop, *op cit*, among others: officially the capacity of the pilot enrichment plant remains secret

92. Cervenka and Rogers, *op cit*, p 84

93. For some details see Boskma, *op cit*

94. ANC, *The Nuclear Threat..., op cit;* and Cervenka and Rogers, *op cit*, p 184

95. Cervenka and Rogers, *op cit*, pp 184-5; and British AAM, *op cit*

96. Cervenka and Rogers, *op cit*, p 185. There is much confusion surrounding this figure of a 5,000 ton capacity for the expanded enrichment plant, which I have been unable to resolve. Cervenka and Rogers clearly see the figure as referring to *output*, as do other sources – eg Burhop, *op cit*, 'Such a plant, if constructed, would produce around 5,000 tons of three per cent enriched uranium per annum.' On the other hand, the statement in *The Nuclear Conspiracy* (ANC, *op cit*) that 'The plant ... could produce 1,250 tons of enriched uranium per annum' suggests that, according to those authors' sources, the figure of 5,000 tons referred to the *input* of uranium oxide. Elsewhere, the plant's projected capacity is recorded as 5 million Separation Work Units per year – *SIPRI Yearbook 1978, op cit*, p 72.However, since it now appears that the expansion will not be on this scale – to either 1,250 or 5,000 tons output – the confusion is not so important.

97. If the figure of 5,000 tons referred to output of enriched uranium, Cervenka and Rogers would be right to point to a further problem: that the input would probably be around 20,000 tons of uranium oxide, more than South Africa is currently planning for annual production in the mid-1980s and arguably more than its uranium mining industry could sustain – *op cit*, p 187. On the face of it, planning for an input to the enrichment plant so far above existing uranium oxide production plans would be rather unlikely, suggesting that the figure of 5,000 tons refers to input, a figure within South African capabilities. In 1978, including Namibian uranium, South African production was 6,285 tons (*World Armaments and Disarmament: SIPRI Yearbook 1979* (London: Taylor & Francis, 1979), p 321)

98. Cervenka and Rogers, *op cit*, p 190

99. *Ibid*, pp 190-2

100. *The Economist*, 25 February 1978

101. This figure (which definitely refers to *output*) is based on the announcement of the expansion by Fanie Botha, Minister of Mines (see *ibid*) in which he stated the expanded plant would satisfy the needs of the two Koeberg power reactors (see section 5) which were calculated as 200-300 tons of uranium enriched to three per cent; see also Cervenka and Rogers, *op cit*, pp 191-2. Reactors of the Koeberg type (Pressurised Water Reactors) and size could be expected to consume about 140 short tons of uranium oxide a year – von Hippel, F *et al*, 'An evolutionary strategy for nuclear power' in Barnaby *et al* (eds), *op cit*, p 16

102. Walters, R W, *South Africa's Nuclear Build-up and its Implications*, UN Centre Against Apartheid, September 1978

103. Cervenka and Rogers, *op cit*, p 160; an agreement in 1976 between Israel and South Africa to expand scientific and technical cooperation caused speculation that this included the nuclear field (*idem*, p 327), including some suspicions that the nuclear device which would have been tested at the Kalahari test site in 1977 was actually made by Israel – *Newsweek*, 12 September 1977

104. *SIPRI Yearbook 1979, op cit*, p 308

105. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

106. Juffermans and Kouwenaar, *op cit*

107. Cervenka and Rogers, *op cit*, p 200

108. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

109. See *SIPRI Yearbook 1979, op cit*, pp 313-22 *passim*

110. Anti-Apartheid Bewegung, *op cit*

111. UN Spec Comm against Apartheid, *Collaboration by Member States..., op cit*

112. *Ibid*

113. Anti-Apartheid Bewegung, *op cit*

114. On the Treaty and safeguards, see Appendix below

115. See Gowing, M, *Independence and Deterrence*, two volumes (London: Macmillan, 1974)

116. Cervenka and Rogers, *op cit*, p 304

117. Preparations are now being made to establish an enrichment plant in the FRG, probably at Gronau – Boskma, *op cit*, p 67

118. It should be noted that the profitability of sales of nuclear reactors and other major items is arguable; indeed, one of the reasons for heavy state involvement in the nuclear industry of most countries is the doubtful profitability of the business compared to the massive capital outlays which have been necessary. Without nuclear exports, however, it could be argued that either nuclear capacity would have to lie idle or else the state would incur yet higher costs.

119. On evasions of the arms embargo, see Klare, M T and Prokosch, E, 'Evading the Embargo: How the US Arms South Africa and Rhodesia', in Western Massachusetts Association of Concerned African Scholars (ed) *op cit*

120. *New African*, October 1977

121. In the mid-1970s nuclear power programmes looked so ambitious that it was speculated that a world-wide nuclear power capacity of 2,000 GW(e) would be attained by the end of the century; it has been calculated that if there were no further growth after that point economically recoverable uranium would be exhausted before 2020: Rotblat, J, 'Nuclear energy and nuclear weapon proliferation', in Barnaby *et al* (eds), *op cit*, p 384. Nuclear power capacity is now unlikely to attain that level unless there is a radical change in the current situation and this would, of course, extend the time that uranium will be available at reasonable costs. However, the estimates for the durability of coal resources are far higher. One projection of future use of coal suggests worldwide coal reserves would be exhausted for practical purposes in about 800 years: Foley, C, *The Energy Question* (Harmondsworth: Penguin, 1976), p 120.

122. Most recently the British government is preparing an ambitious expansion of nuclear power: *The Observer*, 9 December 1979

123. See Bailey, M, *Oilgate* (London: Coronet, 1979)

124. *New African*, October 1977; and Foley, *op cit*, pp 241-2

125. See Appendix below

126. See Lodgaard, *op cit*; and *SIPRI Yearbook 1979, op cit*, pp 313-22

127. *SIPRI Yearbook 1979, op cit*, p 321

128. *Ibid*, pp 48-53, Tables 1A.23, 1A.24 and 1A.25

129. *The Military Balance 1966-1967* and *idem 1979-1980* (London: IISS, 1966 and 1979)

130. *The Military Balance 1979-1980, op cit*

131. It has been convincingly shown that the International Institute for Strategic Studies (IISS) has underestimated South Africa's armed force in past years: see Gervasi, S, 'Breakdown of the US Arms Embargo', in Western Massachusetts Association of Concerned African Scholars (ed), *op cit.* Whether or not the figures recorded in the text to note 130 are similarly an understatement is not clear

132. IISS commented that the resistance of South African forces to the Cuban-MPLA offensive in early 1976 was no more effective than that of the FNLA forces: *Strategic Survey 1976* (London: IISS, 1977), p 44

133. See Burhop, *op cit*

134. ANC, *Conspiracy...Continues, op cit*

135. *International Herald Tribune,* 5 November 1979

136. Statement by N Sievering, US Energy Research and Development Administration, June 1976, cited by Cervenka and Rogers, *op cit,* p 245

137. *The Washington Post,* 16 February 1977

138. *International Herald Tribune,* 18 February 1977

139. There have been references to South Africa already possessing a chemical reprocessing facility, but no firm evidence: see note 33 above

APPENDIX
THE NON-PROLIFERATION TREATY AND NUCLEAR SAFEGUARDS

One method proposed for preventing South African acquisition of nuclear weapons has been for it to sign and ratify the Nuclear Non-Proliferation Treaty (NPT).[1] There has recently been considerable US pressure on South Africa to accede to the NPT, a step the regime has hitherto steadfastly resisted.[2]

Ratification of the NPT by the South African regime would bring it within the scope of international efforts to prevent the proliferation of nuclear weapons, efforts which have been supplemented in recent years by the Nuclear Suppliers Club (NSC), sometimes known as the London Club, and by restrictions on nuclear exports imposed by certain states. It is therefore important to consider these efforts and thus to assess their potential value in the context of South Africa.

The NPT can be summarised as an important but defective instrument for preventing the proliferation of nuclear weapons. Its weakness is partly due to the refusal of certain important states to ratify it, states such as Argentina, Brazil, China, Egypt. France, India, Indonesia, Israel, Pakistan and South Africa. Their refusal to ratify is the result of different motivations – some regard it as imposing heavier burdens on non-nuclear weapon states than on nuclear weapon states; others see it as a device not of nuclear disarmament (despite Article VI) but of monopolisation of nuclear force by a small number of states; others reject it in order to keep open the option of developing nuclear weapons.

Perhaps more important is that the NPT swings on a bargain between the nuclear 'have-nots' and 'haves': while the 'have-nots' are free to remain 'have-nots' (Articles I and II) the 'haves' undertake to take steps towards becoming 'have-nots' (Article VI). Despite arms limitation talks and agreements between the US and the USSR, this bargain has not been kept and, among non-nuclear weapon states who are Parties to the NPT, there is increasing frustration and impatience with this, threatening the fabric of the Treaty.

One could therefore argue that it would be wrong to entrust the task of countering South African military nuclear plans to a diplomatic instrument whose central bargain is not kept, an instrument which is consequently in danger of falling apart.[3]

In addition, the NPT contains a clause (Article X) permitting withdrawal on three months' notice, which could permit a state to accumulate weapons material, announce its intention to withdraw and actually construct its first nuclear weapons by the time the withdrawal took effect.

This clause would not be quite such a problem if the NPT banned or limited certain forms of civil nuclear technology; but it does the opposite, encouraging the transfer of expertise, equipment and materials as long as everything is subject to IAEA safeguards. In fact, there have been complaints that the NPT discriminates against those states that become Parties to it, that non-NPT states have often received more nuclear aid, trade and cooperation than the Parties, thus removing the incentive to ratify the Treaty. As the cases of states such as Argentina, Brazil, India and South Africa itself demonstrate, there is much truth in this complaint – even so, the text of the Treaty makes it clear that the apparently civil development of nuclear technology, on which South Africa's military nuclear capacity rests, would not be hindered if it ratified the NPT. Indeed, it is likely that its civil nuclear development would be eased, both materially, in the sense that it might find necessary imports easier to come by, and politically, in that its ratification of the NPT would ease some of the pressure upon it.

The NPT also obligates the non-nuclear weapon states that have ratified the Treaty to subject their nuclear facilities to safeguards administered by the International Atomic Energy Agency (IAEA). The system of safeguards is designed to meet the objection that ratification of the NPT could provide a state with greater access to civil nuclear technology, on the basis of which it could clandestinely develop military nuclear technology. However, the IAEA safeguards system is itself flawed.

IAEA safeguards are designed to detect the diversion of nuclear materials from peaceful nuclear activities to the manufacture of nuclear weapons, other nuclear explosives or unknown ends, and by creating the risk that such diversion will be detected at an early stage, to deter it from happening at all. It should be noted that the safeguards are not designed to *prevent* diversion, and the IAEA has no such power. When diversions of material from civil to military activities are detected, they are to be reported to the UN Security Council which would presumably take some form of action to penalise the violator, though exactly what form of action is not specified.

Safeguards work through a system of reports and records sent from the national government to the IAEA, which then checks them and can send Inspectors to a state's nuclear facilities to measure the actual inventories of material by various means.[4] In 1977 it was reported that the IAEA employed only 60 Inspectors,[5] a size of staff which would become increasingly stretched with the expansion of nuclear programmes around the world.

Two of the weaknesses of the system have been mentioned already: it is a system of detection only and relies upon a staff which is too small. There is an additional important problem: the reliance of the IAEA Inspectors on goodwill on the part of the state whose facilities they are inspecting. The Inspectors are not detectives who snoop around. Their visits to facilities must be announced in advance in order to secure the technical cooperation they need to carry out the inspection of the inventories. IAEA safeguards are a valuable instrument against nuclear proliferation and they could be made stronger through the investment of greater resources in the IAEA. But they can

be circumvented. To do so would require determination, resourcefulness and a willingness to take risks in pursuit of prioritised objectives; some may think that adds up to a description of the South African regime.

In addition to the points made above about the weaknesses of the NPT, the problem of access to civil nuclear technology, the withdrawal clause and the flaws in the system of safeguards, two additional points are relevant. So far the South African regime has resisted pressure to sign and ratify the NPT and has even so been able to receive nuclear collaboration. Should it bow to the pressure on it and accede to the Treaty, it could be argued that this would be an important moral victory which would not only further isolate those states who have not ratified the Treaty but would also perhaps the strongest practical argument against inviting the regime to sign and ratify the NPT.

As a non-Party to the NPT, South Africa could still be brought within the range of safeguards, either through the Nuclear Suppliers Club (NSC) or through other states adopting the kind of restrictions on nuclear trade and assistance adopted by the US through the Nuclear Non-Proliferation Act.

The NSC, consisting of the main nuclear exporters,[6] has adopted a 'trigger list'. Items on the list, if exported above certain quantities, would trigger the application of IAEA safeguards to the nuclear material produced, processed or used in the facility for which the items are supplied. The items include nuclear materials (plutonium-239, different forms of uranium, thorium) and non-nuclear materials (deuterium, heavy water, high-grade graphite), reactors capable of producing more than 100 grammes of plutonium a year and equipment for such reactors, plants and equipment for producing deuterium, deuterium compounds and heavy water, plants for fuel fabrication or for reprocessing spent fuel, and equipment for uranium enrichment.[7] When triggered, the IAEA safeguards would apply only to those facilities for which the materials or equipment were destined or facilities derived from them – a narrower application than for safeguards under the NPT, even though they could apply to non-Parties. A further weakness of NSC safeguards compared to NPT safeguards is that the adoption of the former is not binding on any of the NSC's members: what is involved is an agreement on a set of guidelines, not a treaty with specific obligations, let alone one with sanctions for those who fail to fulfil the

MAIN POINTS OF THE NON-PROLIFERATION TREATY

The Preamble declares the concern of the Parties to the Treaty at the devastation nuclear war would cause and their belief that nuclear proliferation would increase the danger of nuclear war; it affirms support for the dissemination of nuclear technology for peaceful uses and announces the intention to achieve an end to the nuclear arms race and positive progress towards nuclear disarmament.

Article I pledges nuclear weapon states not to transfer 'to any recipient whatsoever' nuclear weapons or control over nuclear weapons, either directly or indirectly.

Article II pledges non-nuclear weapon states not to receive 'from any transferor whatsoever' nuclear weapons or control over nuclear weapons.

Article III requires non-nuclear weapon states to submit their nuclear facilities to IAEA safeguards to verify their compliance with the Treaty; source or special fissionable material, or equipment or material designed for reprocessing, using or producing special fissionable material, may not be transferred to a non-nuclear weapon state unless it is subject to IAEA safeguards; the safeguards shall be implemented consistently with Article IV and shall not hamper nuclear development.

Article IV affirms the right to develop peaceful uses of nuclear technology and pledges Parties to facilitate the exchange of equipment, materials and expertise to this end; Parties able to do so shall cooperate in the further development of nuclear technology for peaceful purposes, especially in the territory of non-nuclear weapon states.

Article V provides for sharing of the benefits of peaceful nuclear explosions.

Article VI pledges Parties 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 of general and complete disarmament'.

Article VII affirms the right of states to conclude regional treaties banning nuclear weapons from a particular region.

Article VIII outlines procedures for amending the Treaty and provides for a conference of Parties to review the Treaty five years after it enters into force, with the option of further five-yearly conferences if a majority of Parties desires them.

Article IX describes the process of ratification.

Article X provides that any Party may withdraw from the Treaty with three months' notice 'if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardised the supreme interests of its country'; 25 years after the Treaty enters into force, a conference shall be convened to decide if it shall continue in force indefinitely or for a further fixed period.

Article XI states where the texts of the Treaty, in five languages, shall be deposited.

The Treaty was first signed in 1968 and entered into force in 1970; the first review conference was held in 1975 and the second will be in 1980.

mean South Africa declaring itself a state without military nuclear ambitions. It might then find it harder to practise the politics of uncertainty by dropping subtle and not-so-subtle hints about military nuclear possibilities. Despite the flaws in the IAEA safeguards system, there would be some element of control and accountability introduced into its nuclear activities. On the other hand, secondly, acceding to the NPT could lead to relaxed international concern about the problem, and accordingly to a less wary eye being turned to South African nuclear developments. This could create the conditions within which the regime could attempt clandestine diversion of materials from civil to military purposes. South African ratification of the NPT could, in other words, provide an international legitimacy and create a level of complacency in certain quarters which the regime could then exploit. This is

obligations.[8]

More exacting safeguards exist through the Nuclear Non-Proliferation Act (NNPA) which became US law in March 1978. The US has had to renegotiate 27 agreements on nuclear supplies and cooperation to accommodate the conditions specified in the NNPA.[9] These conditions include the need for full-scope IAEA safeguards (ie applied to all nuclear activities) for non-nuclear weapon states who receive US materials or equipment. Prior US approval of reprocessing, enrichment, alteration and means of storage of nuclear material is required, and US agreement is needed before any materials, information or equipment imported from the US by a state can be re-exported, a condition which also covers materials produced as a result of imports from the US.[10] Australia and Canada have developed similar conditions on nuclear exports, although other exporters have been slower and may seek to take advantage of these self-imposed restrictions on US trade.[11]

The adoption of conditions on nuclear exports on NNPA lines by more states, and their application to exports to South Africa, would introduce into South African nuclear development that element of control and accountability which would also result from NPT ratification by the regime, even though the regime would not thereby be a Party to the NPT. It is, however, doubtful at the present whether all other exporters will want to follow the American pattern. Should they consider doing so, other states apart from South Africa could be expected to resist the imposition of such conditions. On the other hand, it might be possible to impose them only in South Africa's case (although the argument that they should not be imposed on all nuclear exports would then be somewhat thin). The question then, of course, is whether or not South Africa would accept the conditions. In the case of the NNPA, failure to accept the conditions means in principle that the transaction in question cannot go ahead; violation of the conditions after acceptance means that further transactions are ruled out. Thus, were there to be a concerted effort to apply the full-scope safeguards and accompanying conditions to the case of South Africa, and were South Africa to refuse the conditions, the consequence would be a complete nuclear cut-off from South Africa. Were South Africa to accept the conditions, it would be accepting accountability about all its nuclear facilities, although the comments on the weaknesses of the present IAEA safeguards system, discussed above in relation to the NPT, would be equally relevant in this case.

The prospects of South Africa either acceding to the NPT or accepting NNPA-style conditions on further nuclear imports must be in doubt, not least because it was excluded from the December 1979 general conference of the IAEA by a large majority (49 votes to 24) which does not seem likely to erode in future years.[12]

NOTES

1. The African National Congress of South Africa opposes acceptance of South African ratification of the Non-Proliferation Treaty; see the statement by Y Zungu, representing the ANC, at a United Nations Seminar, London, February 1979, in *Nuclear Collaboration with South Africa,* World Campaign against Military and Nuclear Collaboration with South Africa, March 1979, pp 15-16
2. Boskma, P, 'Jet nozzle and vortex tube enrichment technologies', in Barnaby, F, *et al* (eds), *Nuclear Energy and Nuclear Weapon Proliferation* (London: Taylor & Francis, 1979), pp 68-9
3. Clearly the disintegration of the NPT, despite its weaknesses, would be a catastrophe with implications and effects reaching far beyond the subject of this paper
4. See von Baeckmann, A, 'IAEA safeguards technology', in Barnaby *et al* (eds), *op cit*
5. Griffiths, D and Smith, D, *How Many More? The Spread of Nuclear Weapons,* Campaign for Nuclear Disarmament, 1977
6. In 1977 the Nuclear Suppliers Club had 14 members: Belgium, Canada, Czechoslovakia, Federal Republic of Germany, France, German Democratic Republic, Italy, Japan, the Netherlands, Poland, Sweden, the USSR, the UK and the US; Switzerland was participating as an observer: *World Armaments and Disarmament: SIPRI Yearbook 1977* (London: MIT Press, 1977), p 20
7. *Ibid,* pp 20-21
8. *Ibid,* pp 22-23
9. *World Armaments and Disarmament: SIPRI Yearbook 1979* (London: Taylor & Francis, 1979), p 313
10. Donnelly, W H, 'Applications of US non-proliferation legislation', in Barnaby *et al* (eds), *op cit*
11. See *SIPRI Yearbook 1979, op cit,* pp 320-22; see also the discussion of this question in the main part of this paper
12. *International Herald Tribune,* 6 December 1979

CONCLUSIONS AND RECOMMENDATIONS OF THE UNITED NATIONS SEMINAR ON NUCLEAR COLLABORATION WITH SOUTH AFRICA
London, 24-25 February 1979

The Seminar unanimously adopted the following conclusions and recommendations:

1. The Seminar expresses its grave concern over the serious and immediate threat which South Africa's nuclear capacity now presents to world peace and in particular to all African States. The threat to international peace, resulting from the policies and actions of the *apartheid* regime, has assumed new dimensions. There is now the grave danger that the *apartheid* regime, armed with nuclear weapons, may, in its desperation, unleash a major regional war which could precipitate a global confrontation.

2. This grave danger has been caused by the collaboration at various levels with the *apartheid* regime by the United States of America, the United Kingdom, France and the Federal Republic of Germany, as well as Belgium, Israel, Japan, Netherlands and Switzerland, through assistance in uranium extraction and processing, supply of nuclear equipment, transfer of technology, provision of training and exchange of scientists. This collaboration, as well as external financial support for its nuclear programme, have encouraged the Pretoria regime in its defiance of the international community and have been an obstacle to the elimination of *apartheid.*

3. There must be an immediate end to all forms of nuclear collaboration with the Pretoria regime and effective international action taken to prevent it from pursuing its plans.

4. In the context of the nature of the Pretoria regime and its record, the Seminar rejects that any meaningful distinction can be made between 'peaceful' and 'military' nuclear collaboration with that regime. The major Western powers, which have always claimed that their 'peaceful' nuclear collaboration would not give South Africa any capability to develop nuclear explosive devices, were obliged in 1977 to warn the Pretoria regime not to proceed with its planned nuclear explosion.

5. The abhorrent *apartheid* regime is both illegitimate and criminal. It continues to increase its oppression of the black people of South Africa and is engaged in a virtual war with the great majority of the population. It has a long record of deliberate and systematic aggression against African States and persists in its defiance of international law and morality. It is prepared to go to any lengths and resort to desperate means in order to perpetuate the system of racist domination. Faced with growing internal resistance and increasing international pressure, it is relying more and more on military power and the use of violence in order to maintain the *apartheid* system.

6. In this context the threat that South Africa presents to the world when it is armed with nuclear weapons is obvious. In addition, when it develops its uranium enrichment plant, the Pretoria regime will gain substantial international bargaining power. It will use its nuclear weapon capability and its role as a major supplier of enriched uranium to blackmail the international community.

7. In view of the availability of raw uranium fuel from other sources, there is no compelling reason for governments and corporations to trade in uranium with South Africa.

8. Moreover, the natural resources of South Africa, including uranium, belong to the people of that country and not to the *apartheid* regime.

9. It is essential, therefore, that urgent action be taken to ensure, within the context of an international policy of comprehensive sanctions against South Africa, that there is no further nuclear collaboration in any form with South Africa, or financial or other assistance to its nuclear programme. The international community will have to adopt firm measures to prevent South Africa from continuing its present nuclear programme.

10. In view of the nature and record of the *apartheid* regime, no international or bilateral safeguards, including the International Atomic Energy Agency safeguard system and the system of control of the Nuclear Non-Proliferation Treaty (to which South Africa is not a party), are adequate. The Seminar rejects and denounces the moves by certain Western powers to offer to the *apartheid* regime the benefits of international nuclear collaboration, and security and other guarantees, in return for adherence to the NPT. There must be international action against the *apartheid* regime, not provision of additional benefits to that regime, which would result were South Africa to become a party to the NPT.

11. The Seminar recommends that the Security Council consider the matter urgently and adopt a mandatory decision, under Chapter VII of the Charter, to end all nuclear collaboration with South Africa, to require the dismantling of its nuclear plants and to warn the Pretoria regime that any efforts by it to continue its nuclear programme or to build a uranium enrichment plant would result in further international action, including effective collective sanctions.

12. Urgent action must be taken by the United Nations and the international community to ensure that all nuclear contracts and agreements between South Africa and other countries, such as the United States of America, the United Kingdom, France, Federal Republic of Germany, Belgium and Israel, be terminated and the supply to South Africa of nuclear equipment by these and other countries ended. Equally, the following areas of collaboration need to be ended:

(a) the training of, and exchanges with, South African scientists involved in the nuclear sector and the granting of visas to them

(b) contracts and agreements concerning uranium extraction and processing in South Africa

(c) the import of South African and Namibian uranium

(d) the reprocessing of South Africa's spent nuclear fuel, and in particular the return to it of plutonium

(e) all financial, economic and other forms of support for South Africa's nuclear industry or any ancillary and related industry; and

(f) the transfer of technology, supply of equipment and financial support for South Africa's uranium enrichment programme, including isotope separation.

13. Decree No 1 of the United Nations Council for Namibia on the Protection of the Natural Resources of Namibia should be fully enforced.

14. All countries concerned should enact effective legislation to make illegal all forms of nuclear collaboration with South Africa by corporations and institutions. There should be severe penalties for all infringements; parent companies should be held responsible for offences committed by their subsidiaries and associates operating in South Africa.

15. The Seminar urges African and other governments committed to the struggle against *apartheid* urgently to take all necessary initiatives at the United Nations, and make direct contact with the States concerned in order to achieve the above objectives.

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