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Summary:

This report for the Energy Research and Development Administration (ERDA) pointed to downsides of US and international pressures against pariah or otherwise beleaguered states such as South Africa and Israel and against would-be nuclear proliferants. They might cooperate to advance their goals.

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SOUTH AFRICA: MOTIVATIONS AND CAPABILITIES FOR NUCLEAR PROLIFERATION

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September 1977

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PREFACE

This paper has been prepared by members of the Proliferation Group, LLL Special Projects Division, in response to requirements of the Division of International Security Affairs of ERDA. It is a part of a general program of country studies at LLL. Parts of the report were distributed in preliminary, draft form in early September.

CONTENTS

FOREWORD

The recent discovery of the apparent nuclear test site in the Kalahari Desert has raised a series of questions about South Africa's nuclear intentions and capabilities. South Africa has long been included on the list of Nth countries, yet there is a paucity of information regarding both its political attitudes and its technological development. [redacted] b(1),b(6) DGA

Another reason for the lack of understanding and analysis on South Africa concerns the nature of potential proliferants in general. There is a tendency to assume that Nth countries will follow a single, defined path of proliferation and that they will all respond in a like manner to US pressures concerning their nuclear programs. For example, just after the news about the Kalahari site broke, US officials prepared to assemble a team to go and inspect South African facilities. This US response was much the same as in the case of Taiwan's reprocessing effort. In other words, the US assumption was that a precedent had been set: the US could demand site inspection as well as dismantlement and have the Nth country respond in the expected manner. This is simply not true. All Nth countries are not alike; each pursues nuclear capabilities in a unique manner, and each must be dealt with in a special way that takes cognizance of the nation's uniqueness.

This paper has been prepared as an effort toward describing South Africa's nuclear program and the unique attributes associated with it. Ample evidence is found to support an assumption that South Africa is highly motivated to pursue the highest level

of defense capability. On the technical side, there are indications of progress in some phases of nuclear development such as uranium enrichment. Yet there are gaps that prevent us from concluding that South Africa has complete weapons capability. [redacted]

One of the benefits of writing this report has been to take stock of the data we have and to evaluate how the information is being used. [redacted] DOE b(1) OGA b(1)

There is also great need for synthesis and analysis of information so that it will be readily available to policy formulators. This would enable them to treat South Africa as the unique case that it is, thus yielding greater results from our nonproliferation efforts. OGA b(1)

SUMMARY

This report is divided into five sections. The first, on motivations, examines the economic, political, and military setting in South Africa. Factors that might promote a desire for nuclear weapons capability are outlined. Following the section on motivations is a general description of South Africa's civil nuclear program, with emphasis on the organizations and facilities supporting the program. The overall conclusion reached is that the South African program is of high calibre, particularly with regard to reactor-fuel aspects of nuclear capability. The third section specifically addresses the Kalahari site. The fourth section isolates some of the questions most pertinent to judging South Africa's nuclear weapons capability. These questions concern matters on which there are insufficient data but on which some analytical speculation is necessary. The concluding section lists some general and specific collection suggestions.

The motivations section analyzes forces that could possibly push the South African government toward a decision to pursue nuclear weapons capability. The findings were:

- The South African economy is in poor shape; neither a conventional war nor prolonged regional/local instability can be tolerated without severe economic repercussions.
- South Africa confronts an enemy backed by Soviet weaponry and Cuban forces, while its own army suffers from manpower shortages.
- South Africans' sense of isolation is real; the country feels that it faces the threat of destruction without benefit of sympathy or help from allies.
- Conservative political figures are a powerful influence in Prime Minister Vorster's Nationalist Party; they may force him

to pursue their preferred policies rather than his current moderate stance.

The section on South Africa's civil nuclear program states:

- The nuclear program is primarily directed by two organizations. The Atomic Energy Board (AEB) formulates policy and directs the Pelindaba facility. The Council for Scientific and Industrial Research (CSIR) is comprised of several institutes, some of which carry on nuclear-related research and provide support services.
- Nuclear fuel--from the mining of uranium to its conversion and enrichment--has been a primary concern of the civil nuclear program. These fuel development activities are directed toward uranium as an export commodity.
- South African scientific literature reflects an interest in studies on reactor development, even though the country has elected to purchase its first light water reactor from France.
- Nuclear-related programs of study in South African universities are highly specialized. Government funding through the AEB and CSIR assures that efforts at one university will not be duplicated at another.
- There is a well-educated, well-supplied cadre of scientists working within South Africa's nuclear program.

Regarding the Kalahari site, we make the following points [redacted]

- It qualifies as a "probable underground nuclear test site under construction."
- The South Africans may well have wanted the site to be discovered.
- A probable headframe or tower, surrounded by a square visual/weather barrier and two newer fences, is the most likely present location for an underground test.

- There is evidence of a 1.4- to 2-m-diameter hole under the probable headframe. This hole and another at the drill rig are estimated to have depths of 120 to 150 m and 77.5 m, respectively. If complete containment of an underground explosion is desired, these holes could accommodate explosive yields of no more than 3.5 and 0.5 kt, respectively. Both yields are unduly low for an effective first test.
- A probable concrete pad covered by a plastic bubble is a good candidate for a forward recording site.
- Security is not very tight. Although the probable headframe area and part of the support camp have multiple fences, overall perimeter security is minimal.

In the fourth section, a number of special topics are addressed. The major conclusions are:

- South Africa may have obtained fissile material from another country, from its Valindaba facility, or from an unknown source such as a secret production reactor. It is unlikely that material could have been obtained from the SAFARI reactor.
- The recently identified possible criticality facility near Pelindaba may be related to a nuclear explosives program; however, the existence of a criticality facility is not proof of the existence of an explosives program.
- If an Nth country is assumed to have a source of highly enriched uranium, it does not follow that a gun-type device would be preferred over an implosion device.
- An underground test of significant yield at the Kalahari site would be detected and identified by the US AEDS seismic network.

MOTIVATIONS FOR PURSUING NUCLEAR WEAPONS CAPABILITY

Whether a nation will acquire nuclear weapons capability is determined by two factors: the level of its scientific and technical development and the nature of its motivations. The first, ability, is relatively easier to examine. A nation's ability can be measured by the sophistication of its weapons, training programs, organization, research, etc. If an evaluation of ability reveals that a nation has achieved a solid base for a nuclear weapons program, then the second factor, motivation, plays a crucial role.

South Africa is a nation that has been motivated to develop a civil nuclear program. Now that it has a fluorishing program, the question becomes: What motivations are there for directing the nuclear program toward the development of weapons capability? We will address this question in three spheres--economic, military, and political. Additionally, we will contrast the costs and benefits of developing a nuclear explosive in light of South African motivations. In conclusion we will examine possible policy changes in South Africa in a series of speculative scenarios. It should be noted that these scenarios are intended to stimulate thought; they are not in the mode of usual intelligence analyses.

The Economic Situation

The South African Government (SAG) has decided that spending should be greatly increased in two spheres: The defense budget needs to be expanded, and several major development projects must be financed. However, the South African economy is not healthy enough to support either. The real growth rate of the economy has steadily declined from 7% in 1974 to 1.4% in 1976. A decline in the inflow of foreign private capital has pressured the bal-

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ance of payments, forcing the government to continue restrictive monetary and fiscal policies. Although there has been an increase in its external public debt (an increase of 48.6% from 1975 to 1976), South Africa's ability to borrow is declining. The country's credit situation is worsening not only because of the economy's woes but also because of political uncertainties in the region and disturbances within the country. The lack of economic growth and decline in credit is compounded by South Africa's growing economic isolation. The prospects for improvement in the near future are not good for three primary reasons:

1) The South African economy is supported, in part, by the availability of cheap labor from the black work force. It is they who are feeling the effects of the economic downturn most sharply. The inflation rate in 1976 was 11%; real wages declined 1.4% in the first three quarters of 1976 compared with the same period in 1975; unemployment is estimated to be 13% of the work force among blacks. These pressures are likely to lead to more disturbances like those in Soweto in 1976 and 1977. In turn, the black protests and the SAG reactions to them result in hesitance by foreign investors and international lending institutions. Without loans and investments, the economy worsens, the black community takes the brunt, and there is further unrest.

2) Although SAG expenditures will cause inflation and have a negative influence on the economy, the decision to increase spending on defense in 1977/78 has been made. In late March 1977 the Minister of Defense submitted a White Paper to Parliament calling for an increase of 21% in the military budget. The approximately $2 billion total will be 19% of all state expenditures, slightly more than 5% of the total GNP. These figures are only those that are reported; many defense-related expenditures are hidden in other sections of the budget. Defense expenditures

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will not result in significant economic growth but will feed inflation and balance-of-payments problems.

3) The SAG senses that external political events may lead to economic sanctions being applied to it, just as they were to Rhodesia. South Africa knows, for example, that economically powerful Arab states are attempting to forge strong ties with Black African states. Such a Third World alliance could force oil-hungry Western states to follow an anti-South African economic policy. Thus, an Arab-African alliance could force South Africa's second largest export market, Japan, to refrain from further trade with South Africa in order to maintain Mideast oil supplies (just as Japan was forced to alter its Israel policy during the 1973-74 boycott).

South Africa's bleak economic picture has a direct impact on its incentive to acquire nuclear weapons capability. The SAG is aware that its economy cannot sustain a long-term war, whether conventional or against guerrillas. Even though the development of a nuclear weapon is expensive, it might deter foreign support of revolutionary activity, thus minimizing the cost of fighting rebels. Additionally, the South Africans know that the political disturbances are causing both lack of investment and unwillingness to extend credit. The prestige and power lent by having a nuclear weapon could make the black frontline nations less willing to confront South Africa. This would increase regional stability, making capital holders more confident.

In conclusion, South Africa may desire a nuclear weapon for two reasons related to its economy: to avoid the strains of prolonged war and to increase stability so that investment and growth will continue. The country probably does not fear economic repercussions for two reasons: They feel that they are already suffering from economic sanctions, and they feel that, in

the long run, the industrialized world will be forced to come to them for mineral resources.

The Military Situation

South Africa has the strongest army of any state in southern Africa. It has its own armaments production capabilities and has received sophisticated weaponry from abroad in spite of an arms embargo against it. South Africa would feel confident against even the most hostile of southern African states if it were not for the international interests involved in the region. South Africa is uneasy about its military capabilities for three primary reasons:

1) In its White Paper on Defense (March 1977) the South African Ministry of Defense declared, "African states do not possess the ability to successfully initiate aggression against the RSA, but some African countries are supported by a superpower with the ability to simultaneously wage integrated revolutionary and conventional warfare." The superpower referred to is the USSR and its partner, Cuba. Revolutionary activities in Angola, Zaire, Ethiopia, Rhodesia, and the frontline states have convinced Prime Minister Vorster that "...they want to establish a Marxist dictatorship throughout Africa." The USSR has made ample supplies available to revolutionaries, and Cuba has supplied advisors and extensive training. In a June 1977 visit to Zambia, Cuban Foreign Minister Isidoro Malmierca offered military assistance to all frontline states and black guerrilla movements in southern Africa. He made it clear that Cuba includes South Africa in its targets by stating, "...the struggle for freedom is incomplete until the people of Namibia, Zimbabwe, and South Africa are free."[1]

The SAG does not necessarily believe that Cuban troops will invade South Africa in the near future. The country views the Cuban threat to Rhodesia and Namibia as more immediate. The fate of Rhodesia is fairly well accepted; Prime Minister Vorster realizes that the Smith regime will soon be replaced. South Africa has not agreed, however, on the plans for Namibia. The SAG declared that it will retain control of Walvis Bay and in late August attempted to put the administration of the port under the authority of Cape Province. Continued heavy investments in uranium mining and other industries also indicate South Africa's interest in maintaining control over Namibia, whether it is independent or not. The SAG is aware that it would have difficulty in handling a multifront attack--trouble in Namibia and attacks from Mozambique, Zimbabwe, Swaziland, and Botswana--by troops supported by Cuba and the USSR.

2) Although it is true that South Africa produces much of its own armaments, it does depend on imports. In spite of an arms embargo against it since 1963, the SAG has been able to purchase almost anything it needs. This summer, however, France indicated that it would extend its arms embargo to include all types of equipment. With international pressure mounting, South Africa may find itself in a position of total dependence on its own armaments industry, a situation that could prove devastating in the event of a prolonged struggle against revolutionaries well supplied by Cubans and Soviets.

3) One of the most notable problems of South Africa's military mentioned in the White Paper on Defense is the shortage of manpower. Their present system depends on white males serving for one year. Because it would like to increase the ratio of those serving full time from the present 16.7% to 30.5%, the military is considering extending the length of service and/or training more Coloureds and Blacks. The first option would have

an adverse effect on the economy; the second might cause security problems.

All three of these problems could conceivably be alleviated by South Africa's acquisition of nuclear weapons capability. A nuclear weapon would be of limited use against Black African states or guerrillas; the prestige would be more important against them than would be the threat of actual use. Vis-a-vis the USSR and Cuba, however, possession of a nuclear weapon has more meaning. It is much more likely to have a deterrent effect, because the threat of its use would certainly force the US and Europe to enter as a restraining force in the event of a severe confrontation between South Africa and Cuba-USSR. There is even the long-range possibility of South Africa threatening to use a nuclear weapon against Cuba or Cuban troops, particularly if they attack Namibia. Additionally, the potential shortage of both conventional weapons and manpower make a nuclear weapon attractive as a compensation.

The Political Situation

The ruling Nationalist Party is by nature extremely conservative. Its members are Afrikaner Protestants, mostly from rural areas. The only serious conservative challenge to the rule of Prime Minister Vorster comes from a party commonly referred to as the HNP, a splinter group that broke off from the Nationalists in 1969. The HNP is even more conservative than the Nationalists, but the two are still tied closely together by two factors. The first is the Broederbond, an Afrikaner secret society. The Broederbond is very influential in both domestic and foreign policy formation and its high-level members fill almost all the key government posts. The society is responsible for Vorster being

Prime Minister, and it is unlikely that he could maintain power without Broederbond approval. Even if the Nationalist and the HNP disagree, the Broederbond will act as a mediating force.

The second factor that ties the Nationalist Party and the HNP together is the fact that a few key members of Vorster's government actually subscribe to the ultraconservatism of the HNP but have retained their membership in the Nationalist Party. Two important examples are the influential Minister of Information and Interior, Connie Mulder, and P. W. Botha, Minister of Defense. If Vorster were to lose these members of his government or to alienate the Broederbond, he would almost certainly be unable to rule. Thus, he must be responsive to the ultraconservative element.

On the other hand, Vorster is pressured by those who seek liberalization, particularly with regard to apartheid. The English-speaking community is predominantly liberal, yet they are divided; no one party represents all of their interests. These liberal forces may gain momentum, however, as international pressure increases. For example, the Carter Administration's efforts in the sphere of human rights will lend support to policies of the two major liberal parties. Although the liberal parties may not gain positions in the government, Vorster may be forced to comply with liberal demands due to pressures of world opinion. This will further polarize the Afrikaner-English and conservative-liberal factions, upsetting the balance Vorster has achieved.

Of all pressures on Prime Minister Vorster, the greatest is from the Black community. Worsening economic conditions have made Blacks more susceptible to politicization. The most successful protests have been organized by high school students who have forced their parents to stay home from work in protests. It is also the high school students who have achieved the greatest

cohesion and organization. As yet, South Africa has not suffered much from urban terrorism, but the student organization provides a structure through which seasoned terrorists can attack the regime. The SAG recognizes this challenge and is trying to gear its military to fight urban terrorism. Vorster knows that the single issue that could cause a split in his support is urban crises causing white backlash.

The domestic political scene is currently in balance. The ultraconservatives are kept in check by Vorster, who has successfully played them against the liberals. This balance is delicate, however. Any changes in the perception of threat to South Africa could result in concessions to the conservative bloc. Specifically, if rebellion spreads among nonwhites or if military attacks increase, there will be greater pressure on leadership to opt for demonstration of nuclear weapons capability.

Overall, the domestic political scene in South Africa is fairly calm at present. The most disturbing political pressures are foreign. The military threat posed by the Black African states in conjunction with the Soviets and Cubans has already been mentioned. It cannot be overemphasized that the South Africans truly believe that they will soon come under as much attack as Rhodesia now suffers. This belief alone would not necessarily make them desire to have nuclear weapons capability; however, there is another important factor. The SAG perceives that it is facing the Communist threat alone--that the United States is no longer willing to confront Soviet expansionism. Vietnam and Watergate are seen as the main reasons for the US attitude; Angola, Zaire, and Ethiopia are given as recent examples of US reluctance. But, South Africans do not see the US as even neutral. They believe that the US is inadvertently pursuing a policy that can destroy South Africa.[2] This policy takes the form of pressure for Black rights. Just prior to Vorster's

meeting in Vienna with Vice President Mondale, the South African press was quite optimistic. They believed that at least the US would recognize their position vis-a-vis the Soviets and the Cubans. However, the US used the opportunity to pressure for one man, one vote. Whereas the South Africans had not taken Andrew Young's position as being that of the US, after the Mondale-Vorster meeting they understood that it was.

South Africa's sense of isolation has never been so acute. Even before the human rights pressure began to divide the US and the South African governments, the Minister of Defense had stated, "The RSA does not form part of any alliance with any foreign power nor can it rely upon such an ally in time of war. Our forces must be so structured that they can meet the threats against the RSA without outside help." This need for self-reliance was elaborated upon by the conservative Minister of Information and Interior, Connie Mulder: "Let me just say that if we are attacked, no rules apply at all if it comes to a question of our existence. We will use all means at our disposal, whatever they may be. It is true that we have just completed our own pilot plant that used very advanced technology and that we have major uranium resources."

Costs and Benefits of Developing a Nuclear Weapon

The benefits of a nuclear explosives test to South Africa must be divided into two categories: benefits of an actual test and benefits of a threatened test. The suspected Kalahari test site may have achieved the policy objectives of the SAG; an actual test may have been unnecessary. For several months the South Africans have been worried that the US support for their position has been waning. They truly believe that they are facing a Communist threat that will destroy them unless they have Western

assistance. They do not see their conventional forces as being effective in a long-term war, particularly against one involving Cuban troops and Soviet weaponry. Thus, if the US could be made to promise assistance in return for their not testing a weapon, it might be worth the effort of constructing a site.

An additional benefit of arousing suspicions and causing international reaction would be its effect on Black African states. Even if there is no nuclear test, the frontline nations will now believe that South Africa has nuclear weapons capability. They will suspect the worst, even without the evidence of an explosion. Thus, South Africa may receive the benefit of prestige and seeming power without suffering the costs of an actual test.

If prestige and power (vis-a-vis the Black African states) can be achieved without a test, there would of course be no sense in proceeding with an explosion. As many have argued, a nuclear weapon would be of little use against South Africa's current problems--its own Black population and the guerrillas who strike sporadically in small numbers. The only obvious benefit of actually demonstrating a nuclear weapon would be to frighten Cuba and, perhaps, the capitals of Black frontline states. Cuban involvement throughout Africa has grown greatly since 1975. In addition to the large number of its troops committed, Cuba has offered financial and other assistance to the frontline nations for use in activity against South Africa, Namibia, and Zimbabwe. It is possible that Cuba would actually use its own troops in a future struggle with South Africa. Pretoria might believe that exhibiting nuclear weapons capability would deter Cuba. The SAG could contemplate using a nuclear weapon against Cuba, against Cuban troops in Africa, or against frontline states. Naimbia, for example, would be a possible target from the South African perspective. Not only is Namibia viewed as "South African," but

it is possible that Cuban troops will be active there in the near future.

The costs of actually exploding a nuclear device would be great in economic and political terms. South Africa not only would risk a general boycott, but it also might lose its contracts to purchase nuclear reactors and fuel. The effects of such isolation would be formidable. However, the weight of such repercussions should be viewed from the South African standpoint: They would consider that they already suffer a boycott that is steadily growing worse, the US is already declining to fully support the SAG, and isolation from the West is already a reality. In addition, the SAG has repeatedly stated that there will never be a complete economic embargo against it because the Western industrial world cannot do without the valuable minerals and other raw materials provided by South Africa. Thus economic threats would not carry as much weight with South Africa as others assume, nor would the threat to not sell reactors to South Africa. For the latter threat to be credible, the FRG, Italy, India, Japan, and all possible exporters of reactors would also have to agree to refrain from selling. Even then, the possibility that South Africa will be able to build its own reactors (possibly in conjunction with Taiwan, Korea, Israel, or Brazil) cannot be excluded.

In conclusion, there are few levers that can be used against South Africa to prevent it from exploding a nuclear device if it should so choose. The real question is whether the SAG has motive enough to go ahead with a test shot. There is no question of ability, and there are few constraining forces that are not now being applied. There is one tool, however, that could affect the South African perception of a nuclear weapon's benefit: an effort to diminish their fears and thus their need for nuclear prestige and power. A reduction in their perception of threat is

likely to be the only sure way of guaranteeing that South Africa will not eventually explode a nuclear device. Until then, the benefits will appear to outweigh the costs. Table 1 summarizes the costs and benefits discussed here.

Table 1. Costs vs benefits of demonstrating a nuclear weapons capability (from South Africa's point of view).

Area	Costs	Benefits
Economic	Diversion of funds from domestic development Politically inspired boycotts	Provide stable environment Avert unaffordable long-term warfare
Military	Diversion of funds from conventional weapons program	Counteract presence of superior USSR-Cuban conventional forces Deter rebels Supplement arsenal in face of conventional weapons boycott Compensate for lack of armed manpower
Political	Alienation of English-speaking liberals Isolation from industrialized nations	Satisfy Afrikaner conservatives Force US support or intervention Gain Third World prestige

Speculative Scenarios of South African Policy Changes

If the SAG has a desire to exhibit nuclear weapons capability, that desire stems from the country's perceptions of threats to its security. Generally stated, there are four primary threats:

- Striking and rioting by South African Black communities, possibly incited by foreign revolutionary groups.
- Commitment by Black African states to revolution in Namibia as well as South Africa.
- Cuban and Soviet support of revolutionaries in terms of policy, weapons, and manpower.
- Further isolation from former supporters in the US and Europe.

Because of changing economic and political circumstances, the impact of these threats on South African policies is likely to change in the near future. Of concern to us is whether or not the fears of South Africa will be reinforced. If they are, the SAG will have greater incentive to test a nuclear device. Thus we must ask: What events are likely to occur that will aggravate South Africa's sense of threat? If such events do occur, what indicators might there be that would signal a resulting shift in South African policy? As a final question, it would be useful to ask: Is there anything the US could do to diminish South African fears or preclude negative policy shifts? We address each of these questions in possible scenarios of what could happen regarding the threats to South Africa.

The South African Black Community

Black South Africans have repeatedly tried to organize in opposition to apartheid. The SAG has ruthlessly repressed each

effort. One of the more infamous confrontations took place in 1960--the Sharpstown Massacre--in which 67 Blacks were killed. Thus, demonstrations among the restive Black community are nothing new; the riots in Soweto during the summers of 1976 and 1977 were not without precedent.

The Soweto riots, however, mark an important break from the past. Although it is significant that the Black discontent was greater due to economic difficulties, the most important difference in these riots was the degree of public reaction to the SAG repression of the Blacks. The international and domestic press covered the riots thoroughly and critically in 1976. This helped bring about international pressure on South Africa to be more lenient and to change its policies towards Blacks. This international attention had two effects. On one hand, the SAG did alter its riot procedures from using real bullets to using rubber bullets, dogs, and riot gear. On the other hand, it made the SAG resentful of the press, particularly the South African liberal English-language press--the press of the opposition. The SAG reaction was to introduce laws to muzzle the press through censorship and heavy punishment for criticizing the government. These laws were not enacted, mostly because the Afrikaner press joined with the English in protest. The SAG still views the press as supportive of if not in part responsible for the Black unrest. An increase in unrest may again bring threat of censorship.

One of the reasons for the SAG's sharp reaction to Black unrest is the conservatives' view that Blacks riot not because they are discontented but because they are prompted to do so by outside forces. The SAG is particularly concerned about the degree of effective organization among high school students. The students' organization has been the driving force behind the Soweto riots and has forced parents to stay home from work in protest.

The fear is that the now visible organization and demonstrations will mature into an underground force that will make use of terrorism. In preparation for this, the South African Security Forces are developing units to cope with urban guerrilla warfare.

South African fears of guerrilla organization among its own Blacks are probably justified. As the Cuban-Soviet focus shifts from Rhodesia to Naimbia and South Africa, the Cubans-Soviets will increase their assistance to and training of local Blacks. Any increase in terrorist activity within South Africa (or directed against South Africans in Namibia) will feed the SAG's fear. The three initial reactions the SAG is likely to have are:

- An effort to censor the press.
- An increase in official comment on Cuban activities in southern Africa.
- Harsher government reaction to demonstrations; i.e., increases in arrests, deaths, and harassment.

Any one of these might be an indication of Vorster's shifting toward the hardline, conservative position advocated by some members of his government.

From the SAG point of view, US Government policy is the same as that of South Africa's opposition liberal parties; both advocate greater emphasis on human rights. It is likely that Western nations will use economic pressures to prompt SAG efforts to improve human rights. The ill effects of economic sanctions will be passed on by SAG economic policies to the Black laborers, who are already suffering from unemployment and inflation. This will in turn feed unrest, making the Black community even more susceptible to revolutionary organization. From the Western point of view, it will appear that the SAG policies toward its Blacks is worsening and that little progress is being made with regard to human rights. From the SAG point of view, however, it will appear that the human rights campaign, coupled with unfair economic

policies by industrialized nations, have promoted a security threat.

Although the US cannot reject its emphasis on human rights, it can take care in how the policy is presented. The US should try to express:

- A knowledge of the SAG perception of Black unrest as a security threat that is closely associated with revolutionary movements outside of South Africa.
- Economic alternatives that would lessen the impact of South Africa's economic problems on the Black community.
- Objectivity with regard to South Africa's internal difficulties (for example, attendance by the US ambassador at a highly charged, emotional funeral for a Black killed in detention can only anger and alienate the SAG).

Black States' Support of Revolution in Namibia and South Africa

It is quite possible that the commitment of Black African states to revolution in southern Africa will be moderated by co-operation among these states as well as by their fears for their own national sovereignty. The first force--organization--is coming about through meetings of national leaders and efforts of the Organization of African Unity. These meetings coordinate Black states' demands and select Black policies. This provides South Africa with a coherent, visible policy with which to deal, thus eliminating some of the frightened confusion that naturally results from trying to address confrontations with a variety of leaders and demands. As long as the SAG can view the process of organization as being coordinated by Black African leaders, the level of inherent threat will remain relatively constant. If it becomes obvious, however, that Cubans or Soviets are playing a

larger role in the meetings, the coordination of Black states' policies will sharply exacerbate the SAG sense of threat.

Another force for moderation of Black states' commitment to revolution is their interest in maintaining their own sovereignty. Some African states--Morocco, Somalia, Sudan, and Zaire--have already experienced military clashes; in each case Soviet-Cuban support has been involved. There is also awareness that accepting Soviet-Cuban aid will decrease a leadership's independence. Black African states will probably be made more aware of this risk in the near future; Arab states (led by Saudi Arabia) are alarmed by the current Soviet activity in the Horn of Africa, and they will urge their allies in Africa to beware.

Coordination among Black African leadership may increase, but it is not necessarily perceived as a threat by South Africa. What is a threat, however, is the policy of lumping changes in Rhodesia and Namibia with revolution in South Africa. The SAG has accepted that the two former must undergo change, but it is afraid that both will have hostile new governments.

South Africa is more sensitive to what happens in Namibia than in Rhodesia. Namibia is more politically and economically intertwined with South Africa, and the SAG views events in Namibia as forerunners of what will probably happen in South Africa. The SAG's plans to put the port of Walvis Bay under the administration of Cape Province have been postponed by protests from the US, UN Secretary General Waldheim, and SWAPO. That the SAG would hold off on such a move indicates that the country is not yet intransigent. The SAG still hopes to reach a settlement on Namibia that does not put yet another radical state hostile to South Africa on its border.

Some indicators that South Africa is changing its policy perspective on the Black states cooperation and Namibia would be:

- A decision to go ahead with putting Walvis Bay under the administration of Cape Province.
- Sending troops or other aid to Rhodesia and Namibia.
- Refusal to address issues or policies represented by Black African leaders.

There are two policy stances that the US could take that would help communication between South Africa and the Black African states. The first is to promote formulation of Black African policy by Blacks. The OAU, for example, should be encouraged to take responsible stands that should then be dealt with seriously. In this manner, the SAG will be less likely to be searching for Cubans or Soviets behind every Black decision. A second US policy that could help to calm the SAG and make it more willing to negotiate settlements on Rhodesia and Namibia is to avoid pushing for changes in those states simultaneously with changes in South Africa. For example, advocating the one-man, one-vote formula in Namibia as well as in South Africa causes the SAG to view any policies on Namibia as being precedents for what the world will demand of South Africa in the near future. Of course, changes in Namibia and Rhodesia are precedents for South Africa, but this should not be emphasized at this time. It is far more valuable to keep the SAG in a negotiating mood than to force immediate changes on the country.

Cuban and Soviet Support of Revolutionaries

The Soviets have significant sums of money and supplies of arms committed to various African states. Likewise, the Cubans have provided arms and troops. Their combined policy on the continent is to support revolution, apparently with the ultimate objective of creating pro-Communist spheres of influence. The SAG believes that this policy will continue and that South Africa

will ultimately be isolated and/or attacked. The Soviet-Cuban faction cannot harm South Africa, however, without the use and support of Black frontline states. Thus, the Soviet-Cuban policy will be to pursue close relations with the frontline states. If it appears that their policy is succeeding, South Africa will probably:

- Pursue guerrillas across international borders.
- Try to formulate an active alliance with non-Communist states such as Zaire.
- Attempt to gain Arab support (Libyans are siding with the Cubans in northeastern Africa, whereas Saudi Arabia and Egypt side with Sudan).
- Extend military service from one year to two and incorporate more Blacks, Coloureds, and women into the military.
- Maximize domestic armaments production.
- Seek weaponry from other Third World states such as Brazil, Israel, and Iran.

If South Africa takes these moves, this will signal that its perceptions of conflict in the region have changed. No longer will conflict be regional--on the border of South Africa--but it will be an active war in which South Africa is directly involved.

There is very little that the US can do in southern Africa to alter the Soviet-Cuban policies. However, there is something that the US can do regarding how that policy is pursued; i.e., the US can express its displeasure at the influx of armaments and, in particular, of Soviet-Cuban military personnel. By reversing its initial statement that it would supply arms to Somalia, the US has earned the appearance of being a moderate, unwilling to contribute to conflict on the Horn. The US should hinge its moderation on the expressed expectation that the Communist bloc will be moderate also.

Now that South Africa has been claimed to be in the process of developing a nuclear test site, Black frontline states may be frightened enough to turn to the Soviets and Cubans in spite of their desires to remain relatively independent. [redacted] OGA b(1) The US should make an active attempt to counter these fears of frontline states by keeping them informed and by assuring them in any way possible that a negotiated peace is feasible. In other words, high visibility of the US as a moderate will assuage their fears and make them less likely to view alliance with the Soviets and Cubans as a necessity.

Isolation from the West

There have been two important shifts in overall Western policy during recent years. The first is what some describe as detente and others call neo-isolationism; both descriptions have some validity. In either case, the US is now less willing to confront the USSR or its surrogate in events such as happened in Angola during 1975. The second change has to do with the relative influence of Third World states on the policies of the industrialized countries. For example, when Arab states decided to equate apartheid with Zionism as a concession to Black Africa, France and others paid attention in order to keep from aggravating the Arabs, their source of crude oil.

Prime Minister Vorster has acknowledged these overall policy shifts and has taken them as evidence that South Africa must be as self-sufficient as possible. In preparation for the day when South Africa may be left without allies of any sort, the SAG has begun stockpiling of oil and essential commodities. Meanwhile, however, the SAG is making an attempt to communicate to the US

its sense of urgency concerning Communist objectives in Africa. Thus, the SAG does not yet feel totally isolated; it still feels connected with the West philosophically. One indication of this closeness is the appointment of the former South African ambassador to the US, R. F. Botha, as Foreign Minister. Botha does not fit into the conservative mold of most of the leading ministers of the SAG. He is more liberal, more pro-US. It is hoped that he will be able to represent South Africa to the US more clearly and will forge a stronger relationship between the two.

Although South Africa will probably be increasingly isolated from the industrialized West (due to the new policies of the West and its compliance with economic sanctions), South Africa does have alternative allies. Certain members of the Third World are in positions politically similar to the SAG. These so-called pariah states--Taiwan, South Korea, Brazil, Israel, and Iran--may be willing to assist the SAG politically, economically, or militarily. Iran and Israel would be the two most likely candidates, for they have the most extensive relationship with South Africa in terms of investment, trade, and historical interaction. From this and the above-mentioned possibilities, there are a few indicators that may be used to gauge South Africa's sense of isolation:

- A sharp increase in the amount and types of items stockpiled.
- A decline in status or removal from office of R. W. Botha.
- Increased contact with the "pariah states" in terms of trade, diplomatic contact, and agreements.

The US policy, as described above, is restrained; the US does not want to become involved with supplying arms or aid in the event of major war in southern Africa. The possibility of a major war's occurring, however, does depend in part on US ac-

tions. The most productive move would be for the US to minimize South Africa's sense of isolation while involving it directly in seeking a solution, not for South Africa's racial problems, but for the status of Namibia and Rhodesia. The US could:

- Refrain (at least temporarily) from comment on South Africa's internal affairs.
- Assure the SAG that in the event of attack it will not be isolated economically.
- Consciously separate the issues of SAG domestic policies from SAG foreign policies (on Namibia and Rhodesia).

THE CIVIL NUCLEAR PROGRAM

South Africa's civil nuclear program has historically been concerned with research and production related to uranium sales. In recent years, the SAG has emphasized the application of higher technology in order to sell UF_6 and, eventually, enriched uranium rather than U_3O_8. As a result, work on conversion, fuel fabrication, and enrichment has constituted a major portion of the nuclear program.

In addition to its fuel-related activities, South Africa has been involved with developing a program to acquire nuclear power reactors. The first Koeberg reactor (being purchased from France) is scheduled for operation in 1983.

Both the fuel- and reactor-related activities are guided by government organizations. The actual research is carried out at universities as well as at government-owned institutes and facilities. We will describe these primary organizations and their activites in three major sections: organizations and programs, universities and the scientific community, and facilities.

Organizations and Programs

Atomic Energy Board

The primary government organization related to nuclear energy in South Africa is the Atomic Energy Board. First formed in 1949, the AEB acted as the administrative body overseeing extraction and sale of uranium. In 1959, the scope and responsibilities of the Board increased. Plans were then made to establish the research center at Pelindaba. The AEB continues as the overall administrative body for the nuclear program in general and Pelindaba in specific.

The responsibilities of the AEB are distributed among the following divisions:[4]

1. Chemistry (W. J. deWet).
2. Extractive Metallurgy (R. E. Robinson). Located at the National Institute for Metallurgy, Johannesburg. Extraction, refinement and production of nuclear-grade uranium oxide, metal and UO_2 pellets; similar work with thorium, zirconium, etc.
3. Geology (J. W. vonBackströus). Resource exploration.
4. Isotope and Radiation (J. K. Basson). Health physics, environmental radioactivity, isotope production, and industrial use.
5. Life Science (C. R. Jansen). Located at the Institute for Pathology, Pretoria.
6. Physical Metallurgy (N. P. Pienaar). Development of advanced nuclear fuels, physical properties of fuels and other reactor materials, mechanical testing, irradiation and postirradiation examination of reactor materials, behavior of liquid sodium coolant, radiation damage, etc.
7. Physics (E. Van der Spuy). Theoretical and applied mathematics, neutron and general physics, neutron capture.
8. Reactor Development (R. van der Walt). Reactor physics, reactor engineering, nuclear power economics.
9. Technical Group. Research reactor (operation of SAFARI and associated hot cells); chemical operations (decontamination and radioactive waste disposal); engineering services.

Council for Scientific and Industrial Research

The Council for Scientific and Industrial Research (CSIR) is a large, multifaceted organization that is responsible to the Minister of Planning and Environment. CSIR receives a large annual grant from Parliament as well as grants and contract funds. It then allocates these funds to its various research institutes and to specialized unversity programs according to the overall CSIR research objectives. Although the institutes are oriented toward a variety of fields, two of the most important nuclear-related institutes are the National Chemical Research Laboratory and the National Physical Research Laboratory. Nuclear research is also supported by other CSIR institutes such as mechanical engineering, mathematical sciences, technical services, and electrical engineering.

One of the more interesting organizations under CSIR is the National Institute for Defense Research. It was formed in 1963 to plan research for the Department of Defense. It has three sections that deal with physics, chemistry, and electronics. This institute reports directly to a committee under the chairmanship of the General Manager of the Armaments Board. Committee members are from the Defense Force and CSIR. It would be useful to know who the representatives are and something about their views because it is possible that this institute has formulated policies on defense-related nuclear research.

The Institute for Mathematical Sciences and Other Computer Facilities

South African organizations first began to use computers in 1959. As of late 1975, the country had more than 600 machines, most of which are US manufactured. Known to be included among

those computers are the Univac 1106 and 1108, Burroughs B6700, CDC 6500 and CYBER 174, ICL 1960s, and IBM 360/65 and 370/158. There may be more than one of each type of computer; there are at least three IBM 360/65 computers in South Africa.

One of the most important computation facilities is in the National Research Institute for Mathematical Sciences, a part of CSIR. It has an IBM 370/158 and a Control Data CYBER 174 with a double CPU installed. Between 1975 and 1976 the computer throughput at the Institute was increased threefold.

Uranium Resources and NUFCOR

South Africa holds about 25% of the world's known uranium reserves. All of the current U_3O_8 production is a by-product of gold mining operations. Table 2 lists the gold mining companies together with data on their uranium production.[5]

The tremendous uranium mining efforts in South Africa have been unrelated to domestic fuel requirements. The country's first major power reactor, Koeberg, is not due to go on stream until the early 1980s. Thus, uranium has been essentially an export commodity. In fact, one of the reasons for forming the AEB in 1949 was to deal with the extraction and sales of uranium. As sales grew, the need arose for a marketing agency. In 1952, NUFCOR (Nuclear Fuels Corporation of South Africa) was created to serve this need. It is a private company owned by gold and uranium mining companies and mining finance houses.

Aside from its involvement with sales, NUFCOR is concerned with the actual processing of uranium. Processing, in South Africa, is a two-stage operation: Initial separation from gold takes place at the mines, and the uranium slurry is then handed over to NUFCOR's central processing plant at Suurbekom near Johannesburg. The plant has a maximum annual capacity of 6000

Table 2. Major gold producers and their uranium production[a] (from Ref. 5).

Name	U_3O_8 production (short tons)		Potential or reserves	Estimated mine life
	Past	Present		
Africander Lease	495 (1954-61)	Inactive	Could operate at 0.55-1.1 million tons of ore by 1980	
Buffelsfontein	5.5 million (stockpiled)	Active	Unavailable	17 years
Free State	1.2 million (in 1974)	Active	Production to increase to 2.6 million tons of ore by 1981 (U ≈ 0.3 lb/ton)	17 years
Harmony	15.4 million (stockpiled)	Active	Ore reserves estimated at 17,445,000 tons (U ≈ 0.42 lb/ton)	25 years
Hartebeesfontein	4.1 million (stockpiled)	Active	Unavailable	19 years
Randfontein	Unavailable	1.9 million	Ore reserves estimated at 72 million (U ≈ 0.44 lb/ton)	Unavailable
Southvaal	Unavailable	1.65 million	Ore reserves estimated at 110 million	Unavailable
Bylvooruitzicht	Unavailable	Unavailable	Ore reserves estimated at 3,834,000 tons (U ≈ 0.51 lb/ton)	Unavailable
Vaal Reefs	Unavailable	2.4 million	Unavailable	Unavailable
West Rand	Unavailable	Unavailable	Unavailable	8 years

[a]It should also be noted that two South Africa firms have shares in the largest uranium processing facility in the world--Rossing Uranium Corp., Ltd.--located in Namibia. Together, the two South African firms control 20% of Rossing.

short tons of U_3O_8 (at 96% U_3O_8). Since it began operations in 1952, the NUFCOR plant has processed approximately 80,000 tons of U_3O_8. In 1975, the plant operated at about 50% of its capacity. In 1976, production increased, as did demand.

Because the price of processed uranium has risen so much over that of the raw product, NUFCOR has sought to increase South Africa's conversion capabilities. Recently, it has begun marketing uranium hexafluoride, and the stated objective is to sell enriched uranium in the 1980s. This will increase South Africa's earnings from uranium greatly--perhaps fivefold.

South Africa's overall policy toward its nuclear industry is exemplified by its uranium sales program. It hopes to continually upgrade its technology until it can supply finished products rather than raw materials or parts. The strategy is business oriented rather than political. This can be seen by the fact that delivery commitments are distributed among consumers. South Africa is conscious, however, of the fact that sales can be political. It exercised caution when recently approached by a West German company wanting uranium for Pakistan. South Africa wanted assurance that it was not going to get involved in a politically hot situation by making such a sale.

UCOR's Isotope Enrichment Program

Isotope enrichment was seriously considered from the early 1960s with work directed at evaluating various technologies being subsidized in Holland and perhaps elsewhere.[6,7] Public announcement of an intent to commercialize uranium enrichment using a proprietary method was first made by Vorster in July 1970, and shortly thereafter the Uranium Enrichment Corporation (UCOR), a government corporation, was founded. The Valindaba facility, constructed by UCOR, is described under "Facilities." The sub-

stantial, permanent, well-planned nature of this plant is worth restating here together with estimates of cost ranging from $100 to $200 million for equivalent construction in the US.

The separation process has been tightly held and consequently has become the subject of much speculation. It was originally declared to be entirely new, then it gradually was conceded to be aerodynamic in nature. At the European Nuclear Conference (April 1975) it was described as a "stationary wall centrifuge." Several persons have talked to A. J. A. Roux, head of the AEB, and have hypothesized a chemical exchange process (not very credible), a vortex tube, a crossed beam (Anderson method), or a Becker nozzle. No physical evidence is available to support or deny any of these. Inquiries to the US and others regarding fabrication technology (electroforming) led to further speculation of a system like the Fenn jet membrane, but again no clear connection existed.

Future plans call for development of larger separation modules (50 tonnes SWU/yr each) and ultimate (e.g., 1985 to 1990) construction of a 5000-tonne-SWU/yr plant. The location, power source, and financing of this plant have not been defined. The South Africans are confident of their progress, however. In June 1976 UCORs Deputy General Manager announced at the International Conference on Uranium Enrichment that UCOR is ready to enter into contracts to supply enriched uranium in the late 1980s.

The general behavior pattern of the South Africans seems to be one of developing independence, and in large measure they appear to be able to accomplish this. Much was made of the indigenous production of equipment for Valindaba, for example. We are aware of only a few attempts to purchase items such as special valves in large numbers, clearly an economic move, or turbine compressors. Such compressors may indeed be beyond their present capability. Because of this modest and probably not crucial de-

pendence on external supplies, it is hard to see now US-instigated specific embargoes can have an effect greater than a slight delay in the program. This conclusion is strengthened by the observation that the South Africans manifest careful long-range planning and hence are not likely to expose themselves to crippling externally created shortages.

Reactor Program

The South African AEB has been concerned with the country's need for nuclear electric plants and the technical details involved in the design of such plants. The first study of power needs appeared in May 1968[8-11] and was subsequently updated and given wider exposure to the public. Additionally, several reports present the evolution of computer methods for the estimation of power needs.[12] These studies have converged on an acquisition program, the first element of which is the Koeberg plant presently under construction north of Capetown by a French company. The analysis[9-10] considers seven different assumptions of fuel, capital costs, and demand, which lead to the schedules differing slightly from the reference case (given in Table 3).

Table 3. Reactor acquisition schedule (reference case).

Location	Operational	Size (MW)
Western Cape	1983	950
Western Cape	1984	900
Western Cape	1987	1150
Eastern Cape	1990	1350
Eastern Cape	1992	1700
Western Cape	1996	2200
Western Cape	1998	2000
Western Cape	1999	2000

In addition to studies on power needs and acquisition schedules, there have been reports examining various reactor systems with emphasis on their applicability in South Africa.[13-16] South African AEB annual reports reveal that work has also been done on actual engineering problems associated with reactors. Some of the reactor-program-related activities summarized in the AEB annual reports are:

- Resource development. Gamma surveys to locate uranium and thorium, development of better extractive methods using ion-exchange columns and other techniques, exploration for related materials (e.g., beryllium, zirconium).
- Fuel fabrication technology. Much effort is spent on oxides, carbides, and some on sulfides (more lengthy papers also appear). An interesting note is the successful attempt in 1969 to fabricate fuel elements for the SAFARI reactor, an aluminum-clad uranium-aluminum alloy formed into plates. After demonstrating capability, the effort was concluded to be uneconomical and was dropped.

- Fuel irradiation behavior. Compatibility problems, swelling, gas release, etc., are exhaustively reported and the inference given that much of the SAFARI operation goes to this project. No data are available on what becomes of the plutonium inevitably produced.
- Isotope production. An annual schedule of useful isotopes for medical and other use is reported, as well as notes on the processing and remote handling of these materials.
- Production and purification of UF_4 and UF_6.
- Some work on molten salt-liquid metal extraction.
- Liquid sodium technology.

No information is presented on critical measurements on specific reactor design efforts, although several lengthy reports cover basic calculational capabilities.[17,18]

South Africa appears to have the capability to design and construct reactors without significant foreign assistance, yet there is no evidence of specific efforts at comprehensive design. Also, no work is apparent in the area of high heat transfer rates--an essential and difficult aspect of design.

The possibility of production of finished reactor fuel for direct sale was mentioned at the beginning of this section as a commercially advantageous move, although the research work here described is much more than that limited objective would justify. In support of this possibility it should be mentioned that a sample unenriched UO_2 pellet of a size suitable for PWR reactors was presented to a member of the safeguards inspection team that visited South Africa in 1975. There was speculation that automated measuring equipment purchased in 1975 may be associated with this possibility.

Universities and the Scientific Community

South African universities have a wide range of course offerings; most have basic physics and chemistry. Highly developed intensive programs in specific nuclear-related fields are not duplicated among universities. Thus, for example, a uranium chemistry research unit is located at the University of Port Elizabeth and not elsewhere. This division of research among universities is accomplished primarily through the process of funding. Both the CSIR and the AEB support various programs; they also act as coordinating and planning bodies.

Of all the universities, three emphasize nuclear-related studies more than others: the Universities of Witwatersrand, Capetown, and Stellenbosch. Witwatersrand has a nuclear physics research unit that has staff members seconded from the National Institute of Metallurgy. Their activities concern nuclear-structure physics and applied nuclear physics. The unit has a 2-MeV pressured Cockroft-Walton accelerator and a Van de Graaff accelerator.

At advanced levels of research there is need for greater integration between programs. The efforts at Capetown and Stellenbosch are coordinated through the Southern Universities Nuclear Institute (SUNI). SUNI is financed, in part, by the AEB. It has a 6-MeV Van de Graaff accelerator.

South Africa has an impressive list of scientists and research institutions contributing to its domestic nuclear program. A computer search of Nuclear Science Abstracts (NSA) for the years 1968-74 revealed a substantial number of authors affiliated with South African institutions. By associating authors, their institutions, and the subjects of their article, we can draw some interesting conclusions:

- During the seven-year period the number of scientific articles published more than doubled, from 86 in 1968 to 187 in 1974.
- Nuclear-related research is done at national laboratories as well as at universities. This is advantageous because it provides an atmosphere for theoretical research as well as for government-funded directed projects.
- South African universities tend to specialize in specific areas of research. For example, the University of Port Elizabeth is active in the chemistry of uranium, while the University of Orange Free State emphasizes solvent extraction. This is very important to well-coordinated intensive research.
- Nuclear-related research is being conducted at 19 locations, and there are at least 144 scientists who published more than two scientific articles during the seven-year period examined.

[redacted] OGA b(1)

Facilities

Pelindaba

The National Nuclear Research Center at Pelindaba (see Fig. 1) is the principal facility of the AEB. It is located about 25 km west of Pretoria in a low-population-density, nonagricultural area. Dominant among the installations at the site is the SAFARI

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OGA
b(1), 1.4(c), 1.4f

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reactor, a 20-MW MTR-type unit of US construction and for which the US has provided fuel. A nominal core load consists of about 5 kg of 90% uranium-235; there are also 5 to 10 kg of reserves in new fuel elements and 10 to 15 kg of spent elements in the cooling pond. A year's operation consumes roughly 5 kg. Hot cells and other radiochemistry facilities are also available on site.

From 1966 through 1971 a low-enrichment heavy-water-moderated critical facility, Pelinduna Zero, was located in the Reactor Development Division building. In 1971 the fuel (2% uranium-235) was sent to Great Britain for reprocessing and not replaced. About the same time, construction began in an area adjoining Pelindaba on what was later tentatively identified as a critical facility[20] (see Fig. 1). This consists of an isolated, fenced building with apparent underground connections to a laboratory/administration building to which members of the Reactor Development Division were later moved. The utility of such a facility in support of a possible weapon program is discussed later in this report.

A physics building houses a Tokamak and related plasma physics work. Also in the physics building is a computer facility that includes an IBM 370/155 commissioned in 1972.

Besides the ubiquitous administration and library buildings, there is substantial shop space, some of which was devoted to support of the enrichment program in its earlier phases. Although no detail is available on the actual equipment available, there has been casual reference to electron-beam welding equipment and to metrology facilities. The descriptions of the CSIR computer facility at the National Research Institute for Mathematical Sciences specifically refer to generating output for numerically controlled machine tools; however, no implication is made that such actually exist at Pelindaba.

Two recently constructed buildings are identified as a UF_6 facility and a UO_2 pellet-fabrication facility. No detailed data are available.

Valindaba

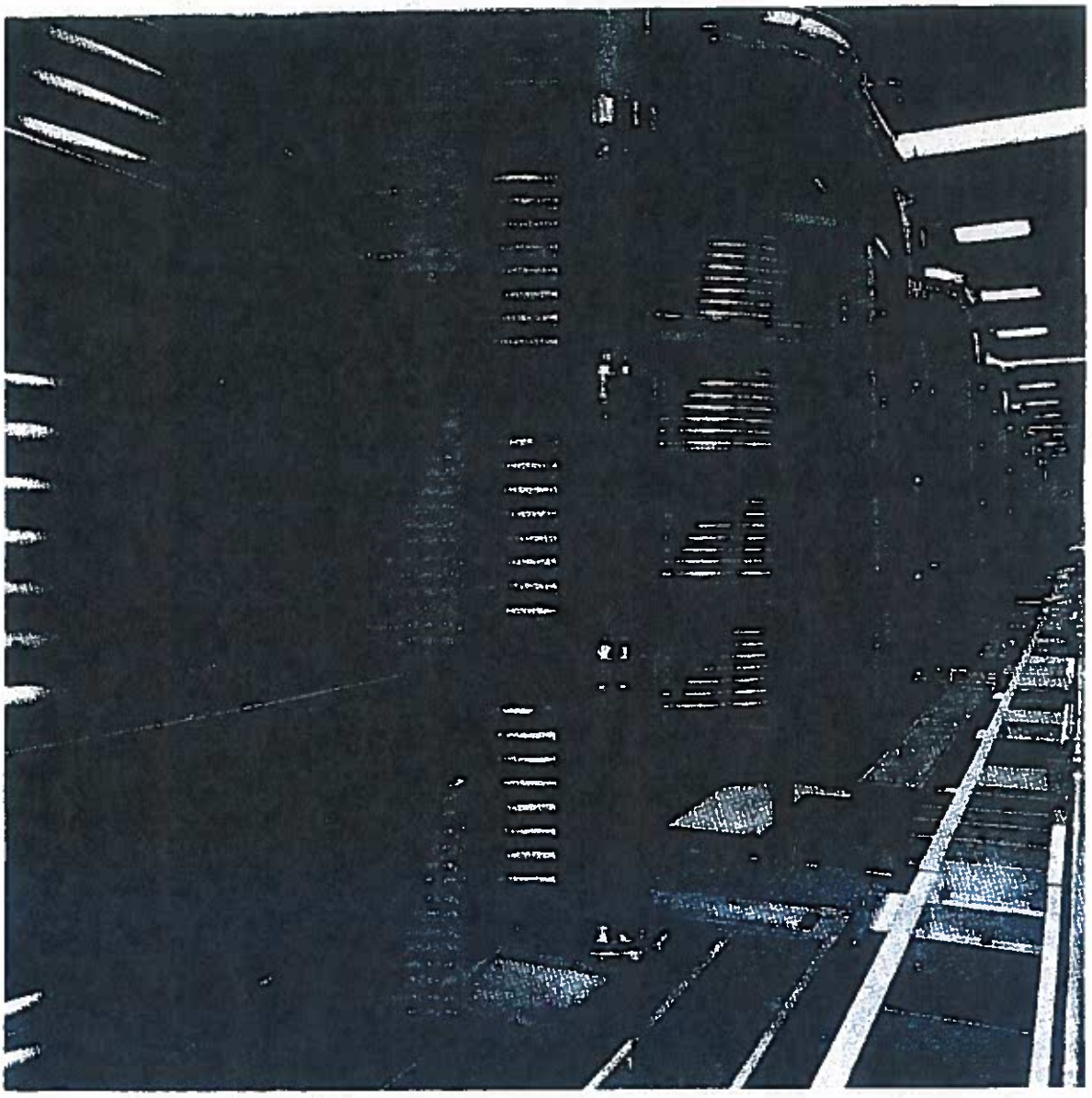
Construction of the Valindaba uranium enrichment plant was begun some time in 1970, roughly coincident with Prime Minister Vorster's statement in July of that year announcing the discovery of a unique separation process. UCOR, mentioned under "Organizations and Programs," was established the following year as the operating agency. The site is about 2 km from Pelindaba (see Fig. 1).

Construction proceeded at a uniform, nonpanic pace to apparent external completion in 1974, at which time the site included two large shop buildings, three unique process buildings, a process-control/computer building, a very substantial electric power substation and distribution system, administration building, warehouses, and numerous smaller buildings, plus some pipe galleries between the process buildings and the shops. The site is now well landscaped and conveniently and compactly laid out, giving the impression of permanence with no anticipation of addition or modification. This appearance is reinforced by the substantial construction--heavy poured-concrete walls, posts, and floors in the process buildings. [redacted] OGA b(1)

The most striking feature of the unique process buildings is the elaborate air-handling equipment. For each building it consists of three interconnected blower systems that force air into the lowest of three floors; the air is then collected through a large number of small ducts that are combined; and the air is discharged through three tall stacks. The three process build-

ings exhibit the same design pattern but with variation in length and height. Each accomodates six rows of equipment cells roughly 8 m square that are coordinated vertically through the four floors of each building. A total of 492 such cells exist in the three buildings. Interior pictures published by the South Africans[22] are reproduced as Figs. 2 and 3. A consensus on the function of the components shown does not exist.

Although the Valindaba site itself appears closed and complete, another facility was constructed about 1 km farther west beginning in 1975. This was described as a commercial prototype; however, the one set of photographs showing the interior of the one large building suggests a heavy equipment shop. There is a traveling crane estimated to have a 50 to 100 tonne capacity, a plain ground floor, and no aboveground floors. Several small outbuildings and a substation fed from Valindaba again give the appearance of a completed facility.



(U)

Fig. 2. Lengthwise view on third floor of process building (from Ref. 22).

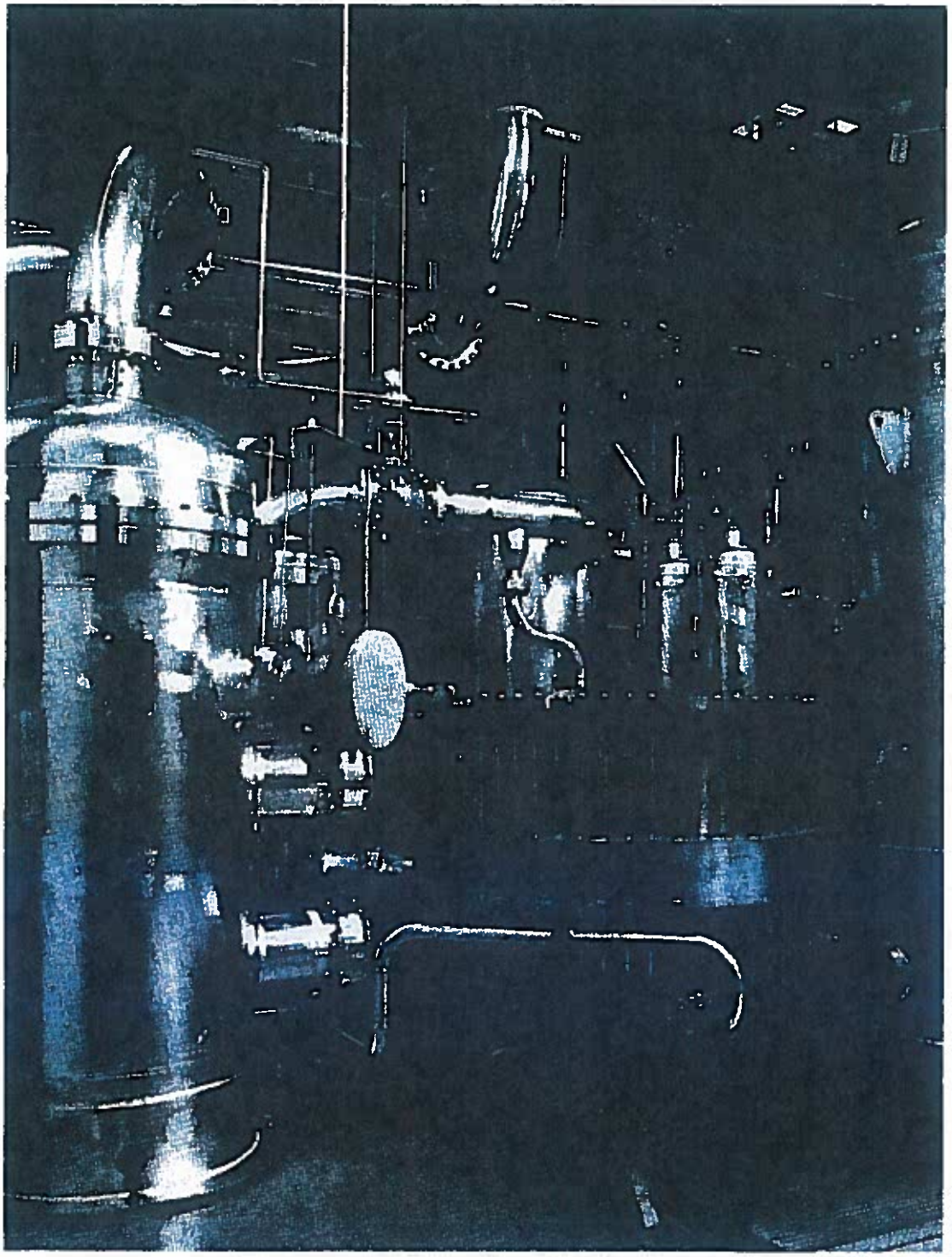


Fig. 3. Equipment cell on second floor of process building (from Ref. 22). (U)

THE KALAHARI SITE

The Kalahari site qualifies as a probable underground nuclear test site under construction. Whether it is real or a dummy site constructed for political reasons presently cannot be determined. In fact, there are several speculative alternative explanations for the site. The pros and cons of the explanations are as follows.

1. Nuclear Test Site

A. Atmospheric Test Site

Pro	Con
Premise: Tower is a shot tower	No suitable towers or airdrop markers
Site isolated	Sight barrier ineffective for a shot tower
Security suitable for a test site	"Pad" is too close to test location
	No close-in bunkers for diagnostics
	No purpose for drill rig
	Perimeter secured area small
	Tower too short for good diagnostics
	Tower has a hole below

B. Underground Test Site

Pro	Con
Site isolated	Unusual pad shape at "headframe"
Underground preparations	Loop road into "headframe" area
- Drill rig	Questions about "headframe"
- "Headframe"	- No separate hoisting facilities
Adequate secured area	- No cage or bucket identifiable
Visual barrier fairly effective	Apparent shallow holes
Candidate for forward recording site and control point	
Candidate for cableway	

C. Dummy Nuclear Test Site

Pro	Con
Overly elaborate effort including:	Drill rig active
- Perimeter patrol roads	Bubble dome preventing activity observations
- Overbuilt communications tower	Constant activity overall
Very large water pits for shallow drilling	
Airfield status questionable	
Small support facilities	
Shallow holes	
Security force necessarily small	

2. Missile Test or Operational Launch Site

Pro	Con
Premise: Tower is a missile "gantry"	Small restricted area
"Gantry" pad shape	Launch location at center of restricted area
Loop road to "gantry"	No propellant storage
Security adequate	Dynamite shack at "gantry"
	Visual barrier ineffective
	Not enough support
	No missile-related vehicles
	No missile-assembly buildings
	No buried cabling
	Airfield and support sites do not need to be removed from operations
	Hole below the "gantry"
	No nearby launch control candidate

3. Mining Operation

A. Mining Exploration

Pro	Con
Underground preparations	No delineation of an ore body
- Drill rig	Airfield not used for logistic support
- "Headframe"	No purpose for pad with bubble dome
Earth moving and hauling vehicles	Unusual security
	1-m-diam hole too large

B. Mining Exploitation

Pro	Con
Underground preparations	No delineation of an ore body
- Drill rig	Airfield has no support facilities
- "Headframe"	
Earth moving and hauling vehicles	No purpose for pad with bubble dome
Airfield could be used for ore transport	Unusual security for an area not having gold, diamonds, uranium, or platinum
	1-m-diam hole too small
	"Headframe" not presently active

Some alternatives considered but not included above were: a facility for the storage of contaminated waste, a special munitions testing area, a laser weapons development site, and an area for biological/chemical warfare development. These, however, have been excluded from discussion due to lack of motivation or evidence for such projects.

One of the unusual aspects of the Kalahari site is that no attempt has been made to prevent the site's discovery by airborne or satellite reconnaissance. The boldness of the markings at the airfield, the double-trail perimeter patrol roads, the heavy barrier screen used at the probable headframe, the overzealous scraping of roads and security boundaries all have been done with no ragard to their being noticed. No attempt has been made to minimize or conceal this site's presence. Therefore we must conclude that, whether the site is real or dummy, there was no political concern about the site's being discovered.

The conclusion reached after weighing the listed alternatives is that the Kalahari site is an underground nuclear test site under construction. There are unusual characteristics, however. For example, the apparent shallowness of two holes observed on the site (indicated by the type of headframe presently over one hole and a casing count at the other hole) dictates that only small yields could be completely contained. At the drilling location, the indicated depth of 77.5 m* would contain only about 0.5 kt. At the probable headframe (maximum depth 150 m) a yield of up to 3.5 kt could be contained. Both yields appear unduly low for an effective first test. [redacted] DOE b(1)

[redacted] If 50 m/kt$^{1/3.4}$, the scaled depth of burial for optimum cratering, is used, 4.5 kt can be fired at the drill site and 40 kt can be fired at the probable headframe.

In summary, the photo data available suggest that a nominal first-test yield of approximately 20 kt could only be attained by cratering at either location (270 m of overburden are required to contain a 20 kt explosion).

Operations Area

Probable Headframe Location

The probable headframe or tower location is commonly believed to be the most important location. Most distance measurements have been made in relation to this location. The 3.8-m- [redacted] DOE b(1)

high visual/weather barrier, forming a 50-m square around the probable headframe, was present on 4 July 1977 photography. This location and the associated probable pad fall approximately in the middle of the restricted site (see Fig. 4).

The 10-m-high steel tower is a probable headframe, identified as such because of the tower configuration and height and the identification of an open 1.4- to 2-m-diam hole in the concrete pad underlying the tower (see Fig. 5). The lack of a hoist house external to the tower is an enigma. It may be that the hole depth does not require elaborate lowering and hoisting facilities and the probable headframe is self-contained. A self-contained headframe would have the cable of required diameter and length mounted atop the tower. No cage or bucket is identifiable. A self-contained headframe of this type could lower and raise small loads to depths of up to 120 to 150 m. The probable headframe could have been used for minimal custom mining at the bottom of the drilled hole and could be used for device emplacement.

The presence of a remnant water pit on the sand ridge to the east of the fenced probable headframe gives supporting evidence that a drill rig was once at the probable headframe location (see Fig. 6). A ground scar, probably the trace of a water line, runs directly toward the headframe from the old water pit. The entire area around the probable headframe, both inside and outside the fence, has been cleared. Much bulldozed material, some of which would be spoil from drilling or mining, is piled up east and south of the probable headframe. We feel that a drill rig drilled the hole at this location, the area was then cleared, and finally the concrete pad and probable headframe were installed. We cannot ascertain if the probable headframe has been used.

Until the recent addition of two concertina-wire security fences (which are not yet complete) around the probable headframe

[redacted] OGA / b(1), 1.4(c), 1.4(

[redacted] OGA b(1), 1.4(c), 1.4(f)

at approximate distances of 300 and 400 m, the visual/weather barrier was ineffective in preventing activities within the fence from being seen from atop the nearby dunes, which are up to 8 m high.

Seven cleared areas, which could be used for instrumentation and camera stations, are situated around the probable headframe. Their approximate distances and directions are: 150 m NE, 175 m NW, 260 m ESE, 120 m S, 160 m SSE, 400 m S, and 600 m S.

The hole depth at this location, on the basis of the type of headframe presently seen, is probably shallow and could be similar to the apparent 77.5-m depth at the drilling location (see "Drilling Location" below). [redacted] DOE b(3)

Probable Concrete Pad Location

The probable concrete pad 2.8 km SSE of the probable headframe is a candidate for a forward recording site. The bubble dome could be for concealment of activity, but it is more likely for environmental protection (see Fig. 7). The protection and cooling of instrumentation is desirable. There is no evidence of instrumentation trailers like the US and the Soviets use. The distance from the probable headframe, an obvious candidate for surface ground zero, is much farther than even the Soviets would use for a contained test; it suggests an uncertainty in the yield or possible venting. The location is well outside the maximum ejecta range for a cratering test in the 1-kt range.

The two objects on the probable pad on the 12 August 1977 coverage were probably the blowers for the environmental cover, which appeared later. A straight-line trail runs between the probable pad and the probable headframe. There is no evidence

[redacted] OGA b(1) 1.4(c) 1.4(f)

that this contains buried cables. Along the trail are piles of objects, probably stanchions or supports to be placed along the trail at a later date. Cabling could be suspended from these.

Drilling Location

The drill rig, approximately 20 m high, is about the size of those used to drill holes for Yucca Flat tests (see Fig. 8). This site is a candidate for a second test hole; or, less likely, it could be an instrument hole for a test at the probable headframe location. The distance (1 km) from the probable headframe and the large diameter of the hole (1 m casing) suggest that it is not an instrumentation hole. The Soviets used a similar 1-km spacing for their original drilling program of test holes at the Konystan Test Area.

The purpose of the four groups of small buildings near the drill rig has not been determined. Some of the larger structures in these clusters are merely protective open shelters to house vehicles or equipment.

This site showed the most activity between 12 August and 18 September 1977. Drilling was completed in the first week in September. Thirty-one pieces of 1-m-diameter casing 2.5 m in length, totaling 77.5 m, were delivered to the site. This casing was about 20% installed by 21 September.

The installation of casing through 21 September was at an inexplicably slow rate. This slow rate might be explained partially if only one shift of drillers operate the rig.

Subsurface stratigraphy of the general Kalahari Desert area indicates that a hole 77.5 m deep would probably penetrate about 15 m of sand lying unconformably on a siliceous saturated limestone and sandstone normally 60 m thick and varying up to 120 m thick.[23] Underlying the limestone and sandstone is a shaley

OGA b(1), 1.4(c), 1.4(f)

[redacted]

marl. If drilling stopped at 77.5 m, as indicated by the casing, the hole stopped at approximately the contact of the marl and limestone-sandstone sequence. It is improbable that the hole was not cased into the marl if it was drilled deeper than 77.5 m. An uncased hole drilled in typical unconsolidated marl would be subject to serious caving problems.

[redacted]

Possible Geophysical Exploration

There is a limited amount of evidence of exploration in the area before construction of the site. On [redacted] photography a series of small light-toned spots on the dunes, presumably cleared spots, lead in toward the possible headframe from at least 8 km to the west to 2 km west of the probable headframe. They vary in their distance apart from 100 to 300 m. Several other straight-line traces in the vicinity of the probable headframe may have been used for geophysical profiles. OGA b(1) 1.4(c) 1.4(f)

Site Security

The only fencing seen to be installed specifically for the Kalahari site appears to be the 3.8-m-high sight/environmental barrier around the probable headframe, the two concertina-wire fences presently being installed around the probable headframe, the double-secured area at the support camp, and a few fences installed across roads at security checkpoints.

The double-trail patrol roads around the entire site probably follow previously existing ranch fencing. Normal ranch-type fencing is used at the site entrance from the main road through the area.

The small total number of people at this site (100-150) indicates that relatively few security personnel are present. Few

patrol vehicles are available to patrol the perimeter or inside the site. No helicopters or small aircraft are available at the site for security patrol. There may be patrol aircraft available at Upington Airfield.

Our overall impression of site security is that it is not tight. We believe penetration of the site would be relatively easy. Things that might be checked on-site are: numbers of personnel and shifts working at the rig, purposes of the clusters of small buildings near the rig, personnel counts, counts of drill pipe at the rig for hole-depth determination, observation of what organization(s) the vehicles belong to, site routine, etc. We also suggest that photocoverage time be varied to catch more of the routine work schedules of the site and possibly to catch security patrol routine.

Support Facilities

Support Camp

The support camp is adequate to support a limited nuclear testing operation (see Fig. 9). Not differing much from the Pokaran Supply Depot used to support India's 1974 nuclear test, the Kalahari support area has limited housing, technical work space, and storage.

We calculate that there are about 7750 ft^2 of what we believe is housing. Using a minimum area of 75 ft^2 per person, we arrive at about 100 personnel, with a maximum of 150 possible. We cannot determine if any workers commute from nearby localities, but the secrecy of this site probably precludes this.

OGA b(1) 1.4(c) 1.4(f)

The number of vehicles counted [redacted] has varied from 50 to 58, 33 to 43 of which are

[redacted] OGA b(1), 1.4(d), 1.4(f)

[redacted]

usually in the support area. The total breakdown of vehicle types is as follows:

Earth movers, loaders, graders	7-10
Earth handlers (dump truckes)	9-10
General haulers (lorries)	~8
Cranes	1-2
Land Rovers, Jeeps, small vans	10-12
Water trucks	~6
Small trailers, generator vans	~10
	51-58

No buses have been identified, but the large number of available vehicles in relation to the resident manpower exludes the need for buses.

The 72-m-high antenna seems over-constructed for radio transmission, but it is visible from both the probable headframe and the drill rig. It could be used for microwave transmission of firing signals for a nuclear test. Therefore, the secured technical building at the support area could be used as the control point for a nuclear test.

Airfield

The 1600-m-long, 16-m-wide runway has no facilities for refueling or service (see Fig. 10). The runway itself appears to be a thin macadam or asphalt surface. The turnarounds at each end are already badly eroded and appear to have been oiled sand. The runway was constructed along an existing trail. No aircraft have been detected at the airfield, and no marks indicating landings are visible on the runway.

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[redacted] OGA b(1), 1.4(c), 1.4(f)

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OGA b(1), b(6)

[redacted]

~~TOP SECRET~~ [redacted] OGA b(1) DOE b(1)

[redacted]

SPECIAL CONSIDERATIONS

Possible Sources of Fissile Material

[redacted] DOE b(1)

The civil nuclear program certainly could provide all the necessary equipment, manpower, and cover for a small nuclear explosives program and already has provided an extensive opportunity for training and familiarization with the unique materials used. Chemical explosives technology appears adequate because there is a large industry supporting both mining and the extensive indigenous production of conventional ordnance. [redacted] DOE b

The crucial question is whether or not South Africa posesses sufficient fissile material to test a device. If it does, the question then becomes whether it has enough such material to produce one or more devices--i.e., can South Africa become a nuclear military power. [redacted]

[redacted] OGA b(1), b(6) DOE b(1) [redacted]

Rather than assuming that South Africa would have to acquire its fissile material from abroad, we could plausibly assume that Valindaba could produce it. Estimates of Valindaba's capacity vary widely. [redacted] DOE b

[redacted]

If South Africa were to produce HEU for explosives testing purposes, Valindaba would be a likely site. DOE b(1)

Some thought has been given to the possibility that the SAFARI 20-MW(t) research reactor could be used to produce kilogram quantities of plutonium. However, the general conclusion is that the SAFARI reactor is a relatively poor plutonium producer.

OGA b(1) b(6) [redacted]

OGA b(1) b(6) [redacted] It should also be noted that the SAFARI reactor is under IAEA safeguards and that there have been no discrepancies reported from periodic safeguards inspections. The HEU fuel supplied by the US has been used and returned according to schedule.

A final possibility is that South Africa has secretly commissioned a production reactor. Such a reactor may have been built some years ago; there is no evidence of this, but South Africa does have the technical capabilities required for such a project. Such a reactor would, of course, provide a source of plutonium.

In conclusion, there is no hard evidence that South Africa has in fact produced or acquired fissile material. Yet, the country does have a facility and the expertise required to produce HEU and, perhaps, plutonium.

Possible Critical Facility at Pelindaba

A structure near the Pelindaba Nuclear Research Center has been identified recently as a "probable critical facility."[26] This identification was based on similarity to the French facility at Valduc and is supported by several local features such as the fenced perimeter, comparative isolation, separate fencing of central buildings, and a cable trench to the nearby laboratory/office building.

OGA b(1) b(6) [redacted]

The facility presents a somewhat conflicting picture of isolation and proximity without a clear indication of whether the

overall concern is for safety or security. A particularly striking feature is the double fence around the "criticality building." There are strong indications of a remote operation, yet the possibility that toxic material could be dispersed has not been seriously considered because the control building--including offices--is within the limited perimeter and, apparently, no environmental sampling is provided for. There is also an employee picnic area just outside the perimeter in one direction, and the main Pelindaba site adjoins in the other direction. For comparison, the critical facility at Livermore, although even less isolated from other campus buildings, is heavily constructed with a clear intent to contain any accident (and it has successfully done so). The Pelindaba building is of sheet metal construction with no known containment capability. In the paragraphs that follow we discuss the possible relevance of this facility in a nuclear-weapons program.

The nuclear explosives designer is faced with the problem of calculating the neutronic behavior--the multiplication rate--of a highly supercritical assemblage of fissile material. [redacted] DOE b(3) Unfortunately, however, experimental confirmation of these calculated results is difficult to attain. One can either do marginally critical but safe experiments that differ significantly from the desired configuration and compare these with calculations using the same codes, or one can do full-scale nuclear tests.

In the early phases of the US weapons program it was essential to gain data as accurate and diverse as possible on the actual behavior of critical or near-critical systems to verify

and normalize calculations. [redacted] DOE b(3)

The situation today is quite different. Not only are there available data on many critical systems, including metallic configurations, but calculational methods and procedures are also available for nothing more than the cost of reproduction on magnetic tape. Furthermore, both data and computation are "certified" through association with competent organizations. Nuclear Science Abstracts lists literally thousands of references under such headings as "Criticality Studies," "Criticality Experiments," "Zero Power Reactors," and numerous secondary references to installation names. This information originates in the US, Canada, Great Britain, France, and Germany, as well as occasionally elsewhere. Both original and summary papers are included that cover, among other things, tamped and untamped metallic systems that would be of greatest interest to the potential weapon designer. The greatest bulk of publication, however, relates to reactor design studies. Report TID-7028, Critical Dimensions of Systems Containing U^{235}, Pu^{239}, and U^{233}, by Paxton et al. (1964), is one of the more comprehensive and generally useful summaries. Other reports specifically compare calculation and experiment for a variety of configurations,[28] emphasizing but not limited to hydrogen (moderator)-containing assemblies, because these are more difficult computationally and also are of greater interest in the reactor context.

Codes for neutronics calculations have also become legion and are catalogued in ANL-7411, Compilation of Program Abstracts, by the Argonne Code Center. The code itself, a sample problem or two, and descriptive material can be obtained from them. ANISN,

the prototype for much neutronic calculation here at LLL, is number 151 in this compilation. [redacted] DOE b(3)

Why, then, in the face of this apparent surfeit of knowledge would anyone undertake critical measurements today? Clearly, to study a configuration not amenable to calculation or one for which the calculations are not regarded as trustworthy. Three such situations come to mind. The first is a complex lattice such as an innovative reactor design, particularly a nonthermal (i.e., "fast") reactor. The calculational difficulty is that it is not possible to represent mathematically the necessary detail in individual fuel cells in the same global calculation that embraces the entire core, tamper, and blanket. The difficulty is underscored by the fact that it is a subject of continuing research. Even an interative approach alternating between microscopic and macroscopic views is uncertain, so recourse is to experiment, e.g., a "zero power reactor." As indicated earlier, explosives configurations are inherently simple; hence, this situation does not arise in the explosives context.

A second situation is to be found in a weapon design using a large quantity of fissile material, so that there might be a real possibility of static criticality; the designer might then require criticality measurements for reasons of safety. [redacted] DOE b(1)

[redacted] DOE b(3)

The third situation in which criticality measurements might be undertaken is that scientists of the proliferant nation are distrustful of the data and seek independent verification; this argument is based essentially on the frequently conservative nature of scientists. Apparently this view is widely held; however, we reject it as grounds for the construction of an expensive special facility. The South Africans, in fact, were probably in a very good position to have verified the generally available data without recourse to a new facility because the metallic uranium (2%) and heavy water critical facility, Pelinduna Zero, was operated from 1967 through 1971. As a final point, the SAFARI reactor, an MTR type, is related to a large body of literature, thus permitting further data verification.

Thus, in summary, no direct connection to a weapon program is obvious; if this is in fact a criticality facility, it certainly does not prove the existence of a weapons program. No clear need for a critical facility as part of a weapon program exists, although a "final verification of safety" type experiment might be done in the existing facilities at Pelindaba, which would be more than adequate for the purpose. An expanding reactor-development program, particularly one exploiting a unique concept, would, in contrast, almost certainly include a critical facility. (Regarding this final point, many of the personnel at the new facility were members of the "Reactor Development Group" at Pelindaba.)

Regarding the hemispheres (appearing to be made of aluminum) that were brought under tight security from the new facility to

the Pelindaba metrology laboratory: We see no link between aluminum hemispheres, precise metrology, and criticality measurements. Metal hemispheres are of course important in a weapons program involving implosion systems, but the observation of such parts is scant evidence of a weapons program. There are too many other uses for metal spheres.

Perhaps the most significant evidence that this new facility is connected to nuclear-explosives development is its explicit description as the "weapons site." The handling of metal spheres and the existence of specially secured facilities are consistent with (though not proof of) such an identification. We emphasize that, if the South Africans are as close to testing a nuclear device as recent events might indicate, then a significant research and development facility exists somewhere; perhaps this facility near Pelindaba is that facility. Certain problems follow, however:

- As already outlined above, we do not understand the significance of the "criticality building." It could conceivably be an "assembly building," though it seems unnecessarily tall for that function.
- We would expect some offices and laboratories to be within the maximum-security area.
- Connection with a high-explosives program remains to be made. Precise metrology involving spherical parts is much more likely to be associated with "hydrodynamics" aspects of the design problem than with criticality aspects; it is unlikely however, that major high-explosives work, even the assembly of major devices, would be done so close to Pelindaba.

Nth Country Device Using HEU: Implosion vs Gun Type

From discussions with people outside the nuclear explosives development field, it appears that there is considerable confusion about the relative advantages of a high-explosive implosion assembly system over a gun-type assembly system. [redacted] DOE b(1)

In any nuclear explosive, the reaction rate increases with the density of the reacting material. The extremely high pressure created by the high-explosive-generated shock wave in an implosion device actually compresses the metallic fissionable material. This allows a subcritical amount of material to become supercritical. The critical mass decreases approximately as the square of the material density. The most important disadvantage of a gun-type system is that it cannot compress the fissional material, so it requires more material per device than does an implosion system. Implosion-type devices also have the potential for achieving higher efficiency in the yield produced from a given amount of active material. [redacted] DOE b(1) DOE b(3) DOE b(1)

Gun-type devices have two advantages of importance to countries having elementary technology of explosive development. Such devices can be made smaller in diameter than implosion systems, and their simpler engineering design allows them to be built to survive more violent treatment, as in an artillery shell or ground-penetrating bomb.

It is relevant to note two additional points. First, we are not aware of any radioactive debris from any foreign test that indicates that a gun design has been fired. Of course, one could have been tested underground, from which debris samples cannot be obtained. Second, the US fired a gun-type design at Hiroshima without prior testing with nuclear yield. Extensive and complex measurements were made of neutron multiplication, both below and slightly above (for a very brief time) critical. This development program was based on an earlier decision that a gun-type design would be completed as back-up insurance against last minute development problems or an unexpected failure of the implosion technology.

The question as to whether a gun-type or an implosion-type device is easier to develop depends primarily on the skills and background of the personnel involved, the facilities available, and the amount and nature of fissionable material available. DOE b(1) [redacted]

Seismic Detection of Underground Tests in South Africa

A nominal-yield (15-20 kt) first device fired underground in the Kalahari Desert would be detected, and identified as a nuclear event, by the US AEDS seismic network. A partial ring of stations in [redacted] provides good azimuthal coverage at a distance range (8000-9000 km) that provides particularly clear paths for seismic signals. Good capability for determination of surface-wave to body-wave magnitude ratios is expected, thus providing the basis for identification of an event as a nuclear test rather than a natural seismic occurrence. In general, AEDS capability against a South African test would be about as good as against tests in the Soviet Union. b(1),(6)

The AEDS stations would provide a good basis for yield determination and a fair basis for location. Regarding location, the AEDS capability would be augmented in an important way by the WWSSN (World Wide Standard Seismic Network) system, which has several stations in the African continent, including one at Capetown. These stations report to a central location at Boulder, Colorado, and AFTAC has priority access to these data.

OGA b(1), b(6)

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OGA b(1) b(6) [redacted] DOE b(1)

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DOE b(1)

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OGA b(1),b(6)

APPENDIX A

The Feasibility of Production of Highly Enriched Uranium in the Valindaba Pilot Plant[29]

[redacted] DOE b(1) DOE b(3) DOE b(1) DOE b(3)

By reducing the product withdrawal rates, one can get higher enrichments in such a plant. [redacted] DOE b(3)

[redacted] DOE b(3)

The holdup per unit of separative work should be appreciably less for this process than for gaseous diffusion, primarily because of the higher stage-separation factor.

[redacted] DOE b(3)

[redacted] DOE b(3)

[redacted]

[redacted] DOE b(3)

Evidence related to start of operation has been reviewed and previous conclusions reexamined:

1. The South Africans said they had started operation in April 1975 and expected to be fully on stream by the summer of 1975.

[redacted] OGA b(1), b

APPENDIX B

[redacted] DOE b(1)

For more than 25 years, relations between Israel and South Africa were strained. During these years the Israelis pursued close relations with Black African states. They invested heavily there; at one time there were more than 1800 Israeli technicians working in Black Africa. As a part of this policy, Israel took an antiapartheid stance in the UN. The rejection of South Africa in favor of Black Africa caused deep resentment by the Afrikaner government. Within South Africa there were occasional flareups of antisemitism against its Jewish community of 120,000. In turn, Israeli feelings toward Pretoria hardened, and there were frequent references to the fact that Vorster and other leading Afrikaners had been jailed during the war due to their pro-Nazi sentiments.

It was not until 1973 that Israeli policy toward Africa changed. Many of the Black states that had accepted Israel's friendship and aid opted for the Arabs. With great shock and resentment, Israel realized that its diplomacy had failed. Its trade with South Africa began to increase as a result. It grew from $20 million in 1972 to $73 million by 1975. Although South Africa willingly increased its contacts with Israel, it still felt lingering resentment and was still trying to effect its own policy of befriending Black Africa.

In 1975, Angola exploded. South Africa became acutely aware of Soviet-Cuban support for revolutionary activity in Africa. It was equally obvious to them that the Black nations around South Africa were condoning, and in some cases supporting, the foreign intervention. South Africa reacted to the threat by sending in

its troops, an action for which Black leaders strongly criticized Pretoria. It was at this point that South Africa realized that detente with Black Africa was not realistic. Thus, by 1975 South Africa joined Israel in rejecting the notion that its outcast status could be circumvented through diplomacy. The world had seemingly lumped Israel and South Africa together; Zionism was equated with apartheid, each faced enemies backed by the USSR, and both had failed to win support from the Third World.

After South Africa's military forces entered Angola in 1975, the SAG recognized that there were problems of logistics, arms handling, etc. They asked for help.

OGA b(1) b(6) [redacted] Thereafter, events moved rapidly. In April 1976 Vorster visited Jerusalem. He discussed expanding the already large volume of trade between the two countries, purchasing armaments, and developing scientific and technical cooperation.

Aside from an increase in economic and diplomatic ties, the most observable results of the South African-Israel link have been South Africa's purchase of two Reshef II fast patrol boats with Gabriel II SSMs and the establishement of an electronics plant near Pretoria. The plant, according to Israeli newspapers, is built by Tadiran Electronics, a subsidiary of Israel Aircraft Industries. There have also been numerous visits to South Africa by Israeli advisors. There is every indication that the trend of cooperation between the two will continue. Recently, two scientific and technical agreements were concluded between South Africa's Council for Scientific and Industrial Research and Israel's National Council for Research and Development.[30]

Given the closeness in policy and outlook that has developed between Israel and South Africa over the past four years, it is not unreasonable to speculate that they might cooperate in the

[redacted] OGA b(1),b(6) DOE b(1)

development of nuclear weapons capability.

[redacted] Both see their enemies becoming stronger and more aggressive while their ally, the US, is viewed as softening its support. Israel believes that the US is less pro-Israel if not more pro-Arab. Their election of a conservative leadership reflects the growth of hardline thinking. At the same time, the Begin administration would be more likely to pursue nuclear cooperation with South Africa than its predecessor would have been. Like Israel, South Africa sees US support waning and Soviet-Cuban confidence growing. The SAG leadership is repeatedly saying that the country's survival is at stake and that no rules will apply if it is faced with destruction. [redacted] OGA b(1) b(6) DOE b(1)

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OGA b(1), b(6)

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DOE b(1)

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DOE b(1)

OGA b(1)

APPENDIX C

Possible Lateral Cooperation Among Proliferants

The US has thus far attempted to stop progress toward nuclear weapons capability in four states--South Korea, Taiwan, Brazil, and Pakistan. Now there is South Africa, and the list is likely to grow longer in the future. In each case, however, the US has succeeded only in temporarily halting the progress; the desire and the research continues in each of the five states. One of the very real dangers is that these nations (or any subset thereof) will join forces in defying the Western powers. The tools that have been used in pressuring the nations to alter their nuclear programs are the threat of losing financing, technology, or alliance with the US. Since one of the reasons that these nations want nuclear capability is that they feel the US umbrella is ineffective, such a threat is increasingly useless. The threat of losing financing or technology is still effective, but both could be circumvented by lateral cooperation between these states. For example, Taiwan and South Korea have recently signed a science and technology agreement; South Korea and Iran have sought cooperation with India; Pakistan has agreed to share its technology with the Peoples Republic of China; South Korea has invited top nuclear officials from Brazil to visit and consider nuclear cooperation; Argentina has agreed to help Peru develop a nuclear program. Along these lines, it is possible that if the US and Europe pressure South Africa, it may pursue cooperation with Iran and Israel, with Iran and Taiwan, or even with South Korea. In these scenarios, both technology and financing would be available.

Another possible repercussion of the Western pressure is that Nth countries will seek technology in pieces from different

sources. It will no longer be easy to buy a package without giving extensive guarantees and complying with safeguards. To avoid such obstacles, Nth countries might buy components of a nuclear program from Italy, Japan, the US, and others. Potential proliferants may even purchase in bulk and sell the excess to other Nth countries. International engineering firms, mercenary scientists, or indigenous talent could then be used to put the system together.

In conclusion, the Western pressure against South Africa is likely to make potential proliferants realize that they must be more artful in their efforts to acquire nuclear technology and weapons capability; otherwise, they too will be pressured. To circumvent US policy, they are likely to seek cooperation among themselves, emphasize secrecy, and diversify their sources of technology and materials.

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