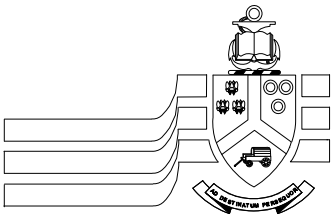

UNIVERSITY OF PRETORIA

GRADUATE SCHOOL OF TECHNOLOGY MANAGEMENT

Research Report

Proliferation Risk Assessment of Former Nuclear Explosives/Weapons Program Personnel:

The South African Case Study

21 July 2007

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EXECUTIVE SUMMARY

This research provides detailed information on the fate of South Africa's former Nuclear Explosives/Weapons Program (NEWP) personnel after the termination of the program in 1991. Some of the findings of the study were that there is a strong and direct association between the type of post-termination employment and mode of termination of employment of former NEWP personnel. Only a few (10%) of those that resigned were unemployed or went into retirement. The majority (63%) of those that were retrenched or retired was unemployed or went into retirement.

The study also found a strong association between the personal income and the type of employment of the former NEWP personnel after leaving the program. The income of most (78%) of those that joined another firm increased or was unchanged. The income of most (58%) of those that were transferred was unchanged, and the income of the majority (84%) of those that became unemployed, retired or started their own businesses declined. A major finding of this research is therefore that many of South Africa's former NEWP personnel suffered financially after termination of the program. It is therefore not surprising that of the former NEWP personnel that were retrenched the majority (71%) was “very dissatisfied”, whereas only 6% and 8% of those that resigned or were transferred were “very dissatisfied”.

This new knowledge contributes to our understanding of the potential proliferation risk posed by former NEWP personnel. This insight should be valuable for the development of appropriate policies and programs to minimize future proliferation risks of this nature. This research will be of benefit to governments and international bodies such as the International Atomic Energy Agency, non-governmental organizations and the non-proliferation community at large.

CONTENTS

1. BACKGROUND

1.1 Introduction

To date, nine countries - Britain, France, China, India, Israel, Pakistan, Russia, South Africa, and the United States - are known to have acquired nuclear weapons. Of these, South Africa remains the only one that has subsequently dismantled its program. Four countries - Iran, Iraq, Libya, and North Korea – had active Nuclear Weapons Programs that have been terminated or are currently under international pressure to terminate their programs. The security situation facing countries such as South Korea, Japan, Taiwan, Algeria, and Yugoslavia continue to raise concerns that they may decide to seek nuclear weapons in the future.

The fate of the former nuclear explosives/weapons program personnel of nuclear and near-nuclear weapons states is a global non-proliferation concern. Such personnel have specialized knowledge and skills that are of interest to potential proliferators. It is therefore important that research be conducted to access the proliferation risk that former NEWP personnel pose. South Africa offers a unique opportunity for such research, as it is the only nuclear weapons state to date that has terminated and completely dismantled its program. This knowledge will contribute to our understanding of the potential proliferation risk posed by former nuclear explosives/weapons program personnel. This should be an interesting case study as some observers have stated that the risk of maverick South African nuclear scientists and bomb makers selling their services in the interests of proliferation was not insignificant (Fig 2005:75).

This research study investigated the fate of South Africa's former nuclear explosives/weapons program personnel. For the purpose of this study only those personnel that were employed by the *Reaktor Ontwikkeling*[1] (RO) Division of the former South African Atomic Energy Board[2] (AEB), and *Kentron Circle*[3], the former South African nuclear weapons plant, as these were the only personnel directly involved in explosives/weapons work. Although many other personnel were indirectly involved in the program, such as some personnel of the *Atomic Energy Corporation* (AEC), the *Uranium Enrichment Corporation* (UCOR) and the *Armaments Corporation of South Africa* (Armscor), these were not included in this study.

[1] Afrikaans for 'Reactor Development'.
[2] Later renamed the Atomic Energy Corporation (AEC), currently the Nuclear Energy Corporation of South Africa (NECSA).
[3] Renamed Advena in 1992.

1.2 Historical overview of the South African Nuclear Explosives/Weapons Program

South Africa's nuclear program consisted of five major phases as shown in Figure 1. Appendix 7.3 contains a chronology of the major milestones of South Africa's Nuclear Program.

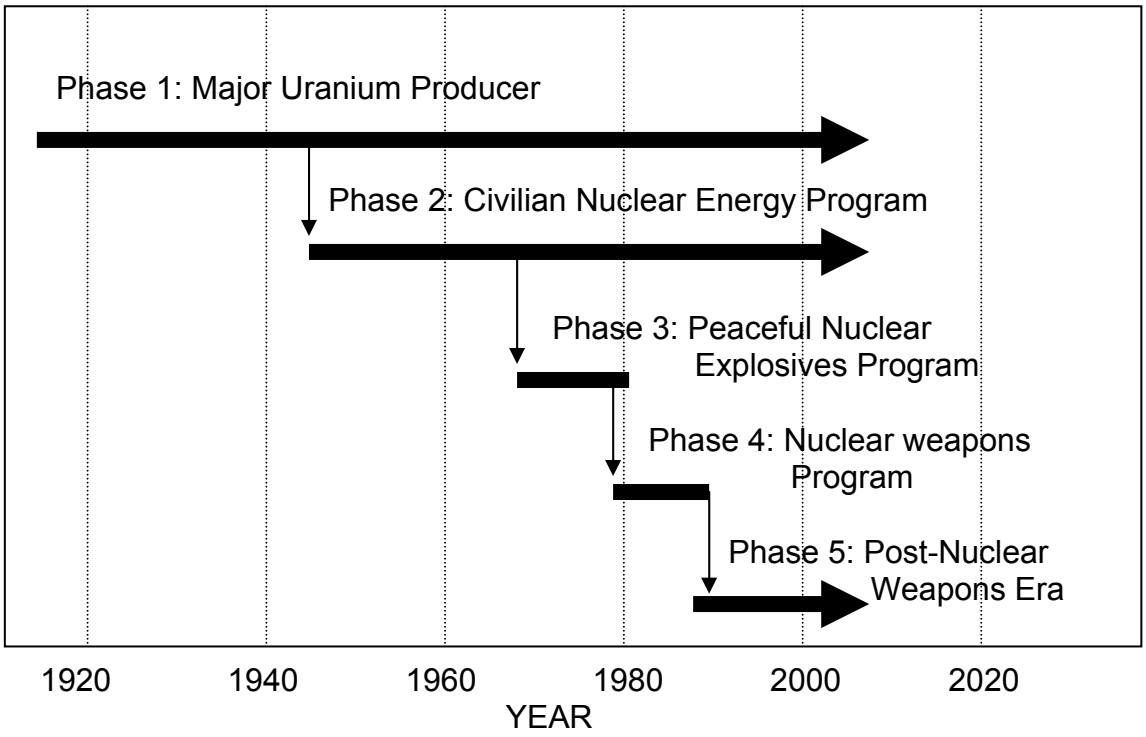

Figure 1: South Africa's Nuclear Program, 1915 - 2004

The Nuclear Explosives/Weapons Program (NEWP) consisted of two phases. The initial phase was the Peaceful Nuclear Explosives (PNE) Program. This was part of the Civilian Nuclear Energy Program of the AEB. The second phase was the Nuclear Weapons Program that was part of the armaments development and production program of Armscor.

The aim of the PNE Program was to investigate and develop nuclear explosives for civilian applications such as mining and civil construction projects. For this purpose a basic nuclear fission 'gun' type explosive device was developed.

Most of the nuclear physics design of the nuclear explosive was done during the PNE Program. This included the development of computer programs for the design of nuclear explosive devices that were also used during the later Nuclear Weapons Program for the design of nuclear warheads. The confidence in these models (e.g. explosive yield calculations) was initially low and it was felt that a fully instrumented underground test explosion would be required to verify and calibrate the theoretical models. However, as the theoretical and experimental work, particularly with a critical facility and fast pulse reactor, progressed, confidence in the models increased to the point where a test explosion was no longer a necessity. After the nuclear test

site was discovered by Soviet and USA surveillance satellites in August 1977, the program for the scientific underground testing of a PNE was terminated. The following year the South African Government adopted a nuclear deterrent strategy and a 'rapid-deployment' nuclear explosive for an underground capability-demonstration test was completed in 1979. It was decided to weaponize the PNE technology and the technology was transferred to Armscor. The PNE Program was terminated in 1980.

Although the Nuclear Weapons Program was officially approved in the late 1970's, it only became a reality with the construction of Armscor's Kentron Circle Nuclear Weapons facility at the Elandsfontein Vehicle Test Range west of Pretoria in 1980. The AEB's 'rapid-deployment' nuclear explosive device was transferred to Circle and retained as an underground demonstration-test device as part of the nuclear deterrent strategy. The first nuclear weapon (an unguided aircraft bomb) was manufactured at Kentron Circle in 1982.

It was decided to developed and manufactured nuclear warheads for the H2 weapons system, a locally developed aircraft-launched precision-guided weapon. The weaponization effort at Circle concentrated mainly on the safety, security and reliability aspects of the nuclear weapons (Steyn, Van der Walt and Van Loggerenberg 2003:83). During the period 1982-1989 six nuclear warheads for the H2 weapons system was produced.

Figure 2: SAAF Buccaneer S Mk 50 aircraft armed with two H2 long-range precision-guided weapons.

Part of the Nuclear Weapons Program was a limited nuclear weapons technology research project. This project looked at advanced types of nuclear warheads such as implosion, thermonuclear and enhanced radiation types. Warhead designs for other delivery systems were also investigated, including warheads for the RSA-2 Intermediate Range Ballistic Missile System. The technology research project consisted of theoretical studies, experimental work and concept warhead designs but no actual development of prototypes were undertaken.

1.3 The human resources of the South African Nuclear Explosives/Weapons Program

Figure 3: The RO Division's Building 5100 at Pelindaba where an estimated average of 70 people worked on the PNE Program from 1971 to 1980.

The South African NEWP was unique in a number of aspects. Albright (1994) reported that the scale of the program was small - at its peak it could produce only one or two nuclear warheads per year. In the early 1980s, the NEWP employed about 70 people, and by the time the program was terminated in 1989, the workforce had risen to about 230, with about half directly involved in nuclear explosives or nuclear weapons work. These numbers excludes the personnel of the AEC, UCOR and Armscor that were indirectly involved in the program. It is estimated that a total of about 400 personnel were directly involved in the program during the 23-year lifespan of the program (1970-1993). The NEWP was classified top secret and to ensure total secrecy only native South Africans were employed or informed of the program.

When the secret "*VP*"[4] Program, the code name of the PNE Program, was launched in 1971, the RO Division of the AEB was reorganized to conduct this R&D program. The RO Division had already existed since the establishment of the AEB in 1961, and was responsible for the PELINDUNA project - a local R&D program for a new nuclear power reactor concept. The PELINDUNA project was terminated in 1969 in favour of the uranium enrichment project that had better commercial potential. The initial PNE program team consisted of a

Figure 4: The windowless Kentron Circle building where an estimated average of 150 people worked on the Nuclear weapons program from 1980 to 1989.

[4] Abbreviation for *Vreedsame Plofstof* - Afrikaans for "Peaceful Explosive".

small group of native South African nuclear scientists and engineers of the RO Division. In addition to its own staff, the Division was assisted by a few people seconded from other divisions of the AEB.

The RO Division consisted of the following nine groups (Steyn, Van der Walt and Van Loggerenberg 2003:38):

The Nuclear Engineering Group
This group was responsible for the study of civil applications of nuclear explosives in South Africa. They were also responsible for the modelling of underground nuclear explosions and the design of placement and containment technology.

The Theoretical Reactor Physics Group
This group was responsible for the development of computer programs for the design of explosive devices. This included neutron data, criticality studies and explosive yield calculations.

The Theoretical Nuclear Physics Group
This group was responsible for the theoretical prediction of pre-detonation probabilities and material properties at extremely high temperatures and pressures. They were also responsible for the theoretical design of possible future thermo-nuclear devices.

The Experimental Reactor Physics Group
This group was responsible for the construction and operation of the critical facility and fast pulse reactor. They were also responsible for measurements and data acquisition at these facilities and at the planned fully instrumented underground nuclear test explosion.

The Reactor Engineering Group
This group was responsible for the engineering design, manufacture and assembly of nuclear explosive devices. They were also responsible for the experimental measurement of materials properties at very high temperatures and pressures.

The Electronic Engineering Group
This group was responsible for the design, acquisition and manufacture of all electronic equipment required for the program.

The Process Metallurgy Group
This group was responsible for the conversion of enriched uranium from the gaseous to the metallic form.

The Physical Metallurgy Group
This group was responsible for the manufacture of all metallic components, including the enriched uranium components, for the program.

The Nuclear Chemistry Group
This group was responsible for the design and development of production facilities for thermo-nuclear materials.

When the PNE program was terminated in 1980 by the AEB and the Nuclear Weapons Program was started by Armscor, a small group of key personnel from the RO Division was transferred to Kentron Circle. This newly established nuclear weapons facility of Kentron (Pty) Ltd, an affiliated company of the Armscor group, was located west of Pretoria at the Elandsfontein Vehicle Test Range. The rest of the personnel of the RO Division remained at the AEB and was redeployed in civilian nuclear reactor development projects.

The initial Circle team consisted of two groups: those that were transferred from the AEB and those that were transferred from Kentron. During the following years the team grew as new employees were appointed or transferred from Kentron and other Armscor divisions. When the Nuclear Weapons Program was terminated in 1989, most of the NEWP personnel were retained to dismantle the nuclear devices and facilities. The NEWP personnel were only a small fraction (1%) of Armscor's workforce of 26,248 people in 1989. In that year a major reduction in personnel occurred throughout the armaments industry, initially reducing its workforce to 21,387 and later to 15,210. In an effort to retain and utilize its technology and skills base, Armscor's R&D and manufacturing facilities were transferred to Denel (Ltd), a new commercial state enterprise[5]. The former nuclear weapons facility, Kentron Circle, now renamed Advena, was also commercialised and transferred to Denel in 1992. The conversion appeared promising at first (Buys, 1993) but in the longer term it was not successful and the facility was closed down in 1993. The remaining personnel were transferred to Denel or retrenched. The employment history is shown graphically in Figure 6.

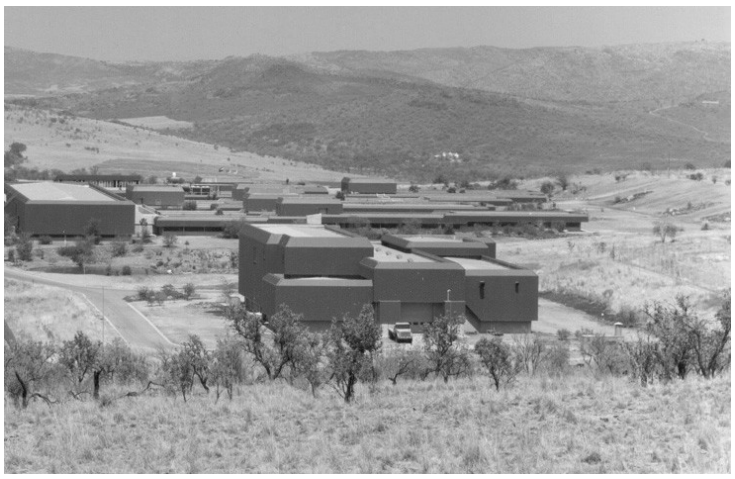

Figure 5: The Advena buildings at Elandsfontein where an estimated 200 people worked on the Nuclear Weapons Program from 1988 to 1993.

[5] Denel (Pty) Ltd was established as a state-owned industrial company under the Ministry of Public Enterprises on April 1, 1992. It inherited most of Armscor's production and research facilities, and more than 15 000 employees.

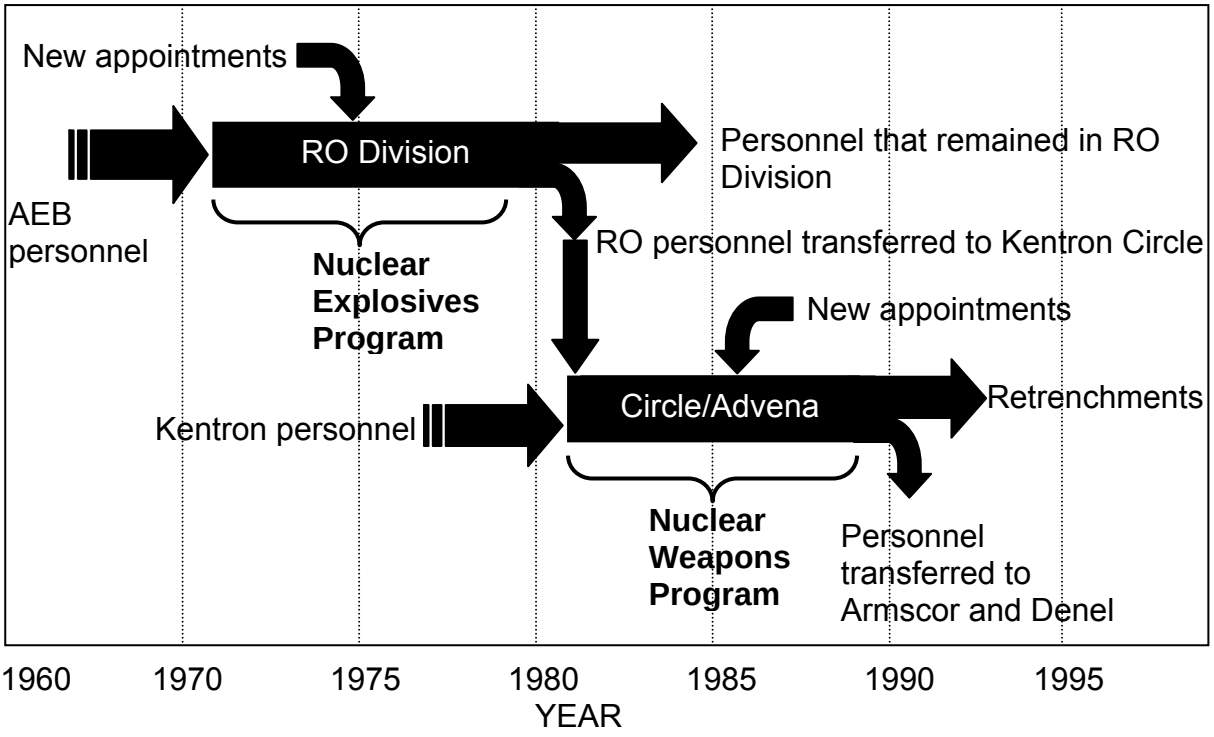

Figure 6: The employment history of the NEWP.

In September 1989, immediately after Mr F W de Klerk assumed office as State President, he instituted the process to negotiate a new democratic future for the country and halted the nuclear weapons program. The dismantlement of the weapons and associated production equipment was done between 1989 and 1991. South Africa acceded to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) as a non-nuclear weapon state in 1991. In a 24 March 1993 speech, President de Klerk revealed that South Africa had produced nuclear weapons and International Atomic Energy Agency (IAEA) inspectors subsequently verified the completeness of its nuclear dismantlement. South Africa joined the Zangger Committee in 1994 and the Nuclear Suppliers Group in 1995. South Africa was instrumental in winning indefinite extension of the NPT in 1995, and played a leading role in the successful conclusion of the 2000 NPT Review Conference.

1.4 Research problem

Until now nothing was known about the fate of South Africa's former NEWP personnel and many questions have remained unanswered. How many people were retrenched? Did they receive special retrenchment benefits? An incident that indicated that there were some problems with the retrenchment of former NEWP personnel occurred in March 1994 when a group of 16 threatened to reveal secret information “to the highest bidder” unless their retrenchment benefits were improved. In response, Armscor obtained a court injunction barring them from revealing any sensitive information. Has this dispute left a group of disgruntled former NEWP personnel? Some individuals and companies in South Africa are known to have been

part of the A Q Khan nuclear black market[6]. Has any former South African NEWP personnel been involved in illegal nuclear trade or gone to work for other countries? This research project attempts to answer these and other such questions.

The problem statement for this research project is as follows:

> *What has been the potential proliferation risk posed by South Africa's former NEWP personnel after the termination of the program in 1991?*

1.5 Rationale for the study

The fate of all former NEWP personnel globally remains a major non-proliferation concern. Such personnel has specialized knowledge and skills that are of interest to potential proliferators. The recruitment or soliciting of information from them by coercive or other means, e.g., by agents of other states or terrorist groups, is a potential problem that former nuclear weapons states and the international community should address. It is therefore important that research be conducted into this issue. There is currently no existing theory or models for assessment of the proliferation risk posed by former NEWP personnel.

South Africa offers a unique opportunity for such research, as it is the only country to date that had nuclear weapons and has since destroyed it and completely dismantled its program. This research study therefore has two goals:

1. To investigate the fate of South Africa's former NEWP personnel.
2. To develop a theoretical framework and model for assessment of the proliferation risk posed by former NEWP personnel.

1.6 Research objectives and research questions

This research project was aimed at answering the following research questions about South Africa's former NEWP personnel:

- What happened to the former NEWP personnel when the program was terminated? What career options were open to them and what choices did they make?
- Were any of the personnel retrenched when the NEWP was terminated? If so, did they receive any compensation and what were their perceptions regarding the "fairness" of the compensation received?
- What were the feelings of the personnel about the termination of the program? Were there any disgruntled people and what were the reasons for this?
- What was the skills profile of the former NEWP personnel? Did any have unique or specialized knowledge and skills that were so specific to the program that it was made "obsolete" by the termination?
- Were any personnel retrained after the termination? If so, who offered this training and who paid for it?

[6] Wisser and Geiges, two foreign nationals with permanent South African residency, were arrested in 2004 and charged with efforts to procure gas centrifuge equipment used for uranium enrichment for Libya. Both have long associations with the company Krisch Engineering, which, according to a state witness, imported equipment for South Africa's nuclear program in the 1980s.

- Were the personnel "debriefed" and sensitized to the need for maintaining secrecy about the knowledge they possessed regarding nuclear explosives/weapons technology? Were they given any guidelines in this regard?
- Has any of the personnel been approached by foreign agents with nuclear or armaments related job offers outside South Africa? Has any of the personnel emigrated or taken temporary positions overseas?

As already mentioned, this study was limited to personnel that were employed by the *RO* Division of the *AEB* and *Kentron Circle/Advena*, as these were the only personnel directly involved in explosives/weapons work. Although other personnel were indirectly involved in the program, these were not included in this study.

1.7 Key attributes of the desired theory and derived models or methods

This project is about risk management. It attempts to find a theory-based model supported by empirical evidence that can be used to assess the potential proliferation risk posed by former NEWP personnel after the termination of such programs. This model should enable managers and other stakeholders to assess the risk inherent in a specific situation and provide guidelines for effective risk management.

2. THEORETICAL FRAMEWORK

2.1 Literature review

A preliminary survey of published literature was done to determine what research has already been done on this topic or in this field, and what findings have been made thus far.

2.2 Past research studies

Many aspects of South Africa's former NEWP have been extensively researched. This research has focused on a number of issues:

- Historic research has been undertaken by Hibbs (1993), Howlett & Simpson (1993), Zondi (1993), Van der Westhuizen & Le Roux (1997) and Steyn, van der Walt & van Loggerenberg (2003).

- The dismantlement and verification process has been reported on by researchers such as Hibbs (1993), Stumpf (1996) and Von Baeckmann, Dillon & Perricos (1995).

- The conversion of South Africa’s former nuclear weapons facilities to conventional uses was investigated by Buys (1993).

- Strategic studies, with the focus on decision-making processes, were conducted by Muller (1996), de Villiers, Jardine & Reiss (1993) and Liberman (2001).

- Non-proliferation issues were investigated by Albright (1993)(1994a)(1994b), Fischer (1990)(1994), Pabian (1995), Reiss (1995), Sagan (1997), and Spector & Smith (1990).

- Research relating to former NEWP personnel in other countries has focused on two issues: health and non-proliferation concerns.

The health issue has been primarily a USA concern. An example is the case of former workers of the Iowa Army Ammunition Plant (IAAP) near Burlington. University of Iowa College of Public Health researchers have mailed nearly 10,000 surveys to former workers at the Iowa Plant to gather more details on workers' occupational histories at the plant (University of Iowa News Services, 2002). From 1945 through 1975, workers on Line 1 assembled and disassembled nuclear weapons for the U.S. Atomic Energy Commission. Evidence suggests that a large number of plant employees may have had significant exposures to hazardous agents such as asbestos, beryllium, radiation and explosives. The research will be used to determine former workers' eligibility for free medical screenings.

The non-proliferation issue relating to former NEWP personnel has focused primarily on Russia's former nuclear weapons facilities located in its ten closed 'nuclear cities'. Of the three-quarter of a million people who lived in these closed cities, 125,000 worked in the nuclear weapons enterprises (Princeton Environmental Institute, 2000). The cancellation and closure of these facilities in the 1980's resulted in hardship for the former NEWP personnel and their families. The United States was so worried about Russian scientists' leaving to help aspiring nuclear powers that it agreed to provide money to their employers to switch to non-nuclear ventures. The US Department of Energy has pledged as much as $30 million in assistance through 1999 to start up new businesses in the hope that the enterprises would be able to attract hundreds of millions more in Western investment (Princeton Environmental Institute, 2000). Two US programs – the Initiatives for Proliferation Prevention (IPP) and the Nuclear Cities Initiative (NCI) – collectively known as the Global Initiatives for Proliferation Prevention (GIPP), try to create non-weapons work for former Soviet WMD experts by convincing U.S. companies to establish joint ventures in the former Soviet Union which would employ these workers. See also report by Tikhonov (2001).

2.3 Need for research and theoretical development

It appears from the open literature that apart from the Russian case, no research has been done to date regarding the fate of former NEWP personnel in other countries. There has also been no theoretical development of any risk-assessment model of the proliferation risk posed by former NEWP personnel.

Notwithstanding the fact that South Africa's former NEWP has been extensively researched, no research has been conducted on the fate of the personnel that were

involved. A need therefore existed for such research in order to better understand the potential proliferation risk posed by former NEWP personnel.

2.4 Towards a NEWP personnel risk-management theory

As stated in the rationale for this study, the fate of former NEWP personnel remains a major non-proliferation concern as such personnel has specialized knowledge and skills that are of interest to nuclear proliferators. This potential for supporting proliferation will only be realized once recruitment or soliciting of information from them by agents of other states or terrorist groups takes place. For this to happen, a number of conditions must be met. It is proposed that these are the following:

- Information about the identity and whereabouts of former NEWP personnel must be available.
- Former NEWP personnel must possess technical knowledge of nuclear explosives/weapons designs and production processes.
- Some of these persons must be a) willing or b) coerced into divulging the information sought. The transfer could be transferred orally, by documents, or by performing work.

Information about the identity and whereabouts of former NEWP personnel is only of concern in cases where the transfer of information is by force or solicited. This information might not be feely available and attempts might even be made to keep it secret, but it probably has to be accepted that any reasonably effective intelligence agency should be able to obtain this information. Nevertheless, keeping the identity and whereabouts of former NEWP personnel secret could be a 'first-line-of-defence'. The risk of solicitation of information from former NEWP personnel will be increased if they should work in foreign countries, especially in foreign nuclear or armaments industries.

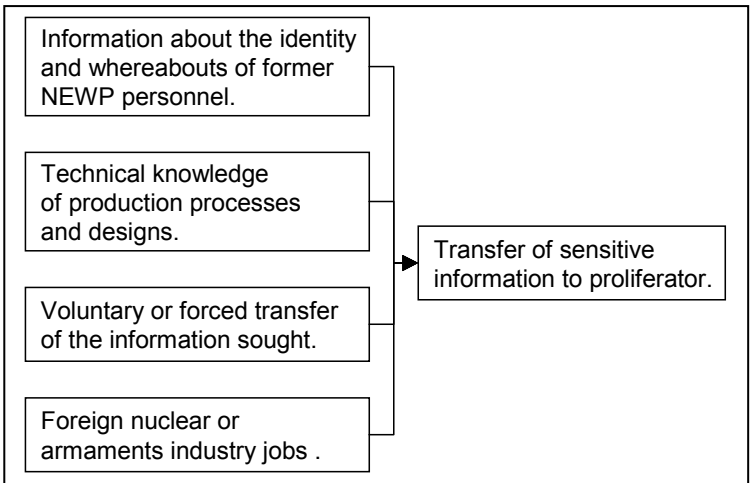

Figure 7: Information Transfer Risk Sub-model

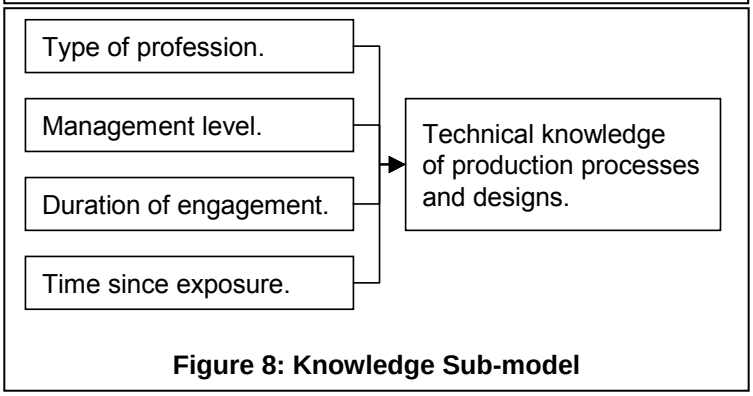

Figure 8: Knowledge Sub-model

A common view might be that all former NEWP personnel have information or knowledge that is of value to proliferators. This is unlikely to be the case. Proliferators are primarily interested in technical details of production processes and designs of nuclear explosives and warheads. This is the type of information that would be protected by national secrecy acts and non-proliferation legislation, and regulations issued in terms of such legislation, where these exists (See Appendix 7.5 for a summary of South Africa's secrecy and non-proliferation legislation) and other Weapons of Mass Destruction (WMD) control regimes. Not all former NEWP personnel have information or knowledge about the technical details of production processes and designs of nuclear explosives and warheads. It is therefore proposed that former NEWP personnel be classified according to the extent of their technical knowledge by the type of profession or position they occupied in the program.

It is proposed that the most knowledgeable persons in order of technical knowledge would be engineers, scientists and then other technical staff. Many former NEWP personnel were involved in administrative tasks or had only limited access to technical details. These were personnel such as non-technical professionals, administrative staff, security officials and other support staff. Another factor that plays a role in this regard is the management level of the person. The more senior and the wider the management responsibility of the person, the more extensive would be the person's knowledge base.

It is proposed that the basic determinant of the types and levels of the job positions of former NEWP personnel (and all employees in general) is their highest educational qualifications. It is therefore hypothesised that:

> *H1: There is an association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel.*

The duration of engagement with the program is also likely to play a role in the extent of a person's knowledge. The longer a person's involvement, the more knowledge would be accumulated. However, the effect of duration of exposure would probably tend to level off after a few years. The information and knowledge of former NEWP personnel will also diminish as time passes. Not only will their memories fade, but also the technology will become outdated and will eventually be obsolete. However, this would not necessarily be true for states or groups that are only interested in acquiring a nuclear weapons capability irrespective of whether it is based on modern or outdated technology.

The risk of former NEWP personnel supporting proliferation will only be realized once relevant information is divulged to a proliferator. This transfer of information or knowledge could either be voluntarily or by some form of coercion.

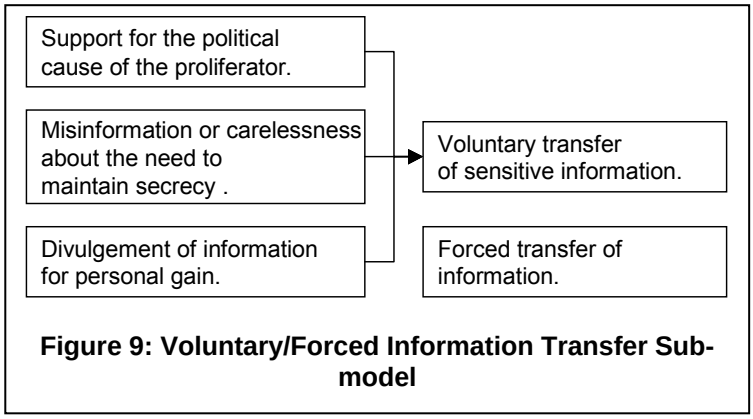

Figure 9: Voluntary/Forced Information Transfer Sub-model

Voluntary divulgement could take place where individuals either support the political cause of the proliferator, are misinformed or careless about the need to maintain secrecy, or for personal gain.

Personnel employed in NEWP's would have been carefully selected and have passed strict security clearances. In general, it could therefore be expected that these are persons of above-average integrity. During their term of engagement in the NEWP they would also have become accustomed to maintaining secrecy about their work. However, this situation could change once the NEWP is terminated. Former NEWP personnel could feel that the need for secrecy no longer exists. This will depend to a large extent on whether the personnel were "debriefed" and sensitized to the need for maintaining continuing secrecy, and what guidelines on secrecy they received when they left the NEWP.

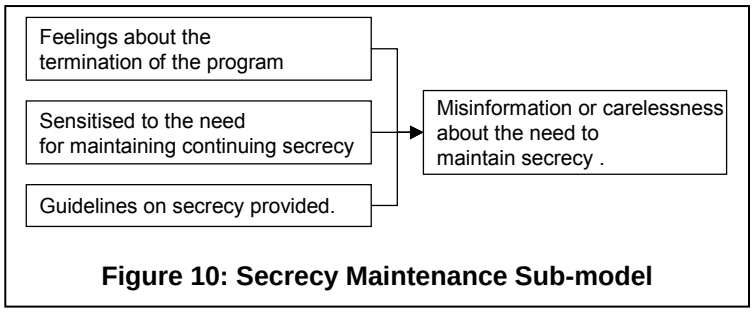

Figure 10: Secrecy Maintenance Sub-model

The feelings of former employees about the termination of the program could also influence the individual's motivation to maintain secrecy. If the individual felt that the government should not have terminated the NEWP, he/she might not be in support of non-proliferation and be less motivated to maintain secrecy. Most former employees probably experienced a sense of loss when the NEWP was terminated. They were proud about working in the NEWP and found it hard to do "ordinary" work again. There might even be a longing to work in a NEWP again. Others were probably less sentimental about the program. For them working in a NEWP was just a job. As long as they were given another job or found other employment or were fairly compensated, they probably didn't care much about the termination of the program. Personnel that were well informed and understood the circumstances that led to the termination probably agreed that it was the right thing to do and supported the government's decision to terminate the program. Such persons are likely to be supporters of non-proliferation and be motivated to maintain secrecy.

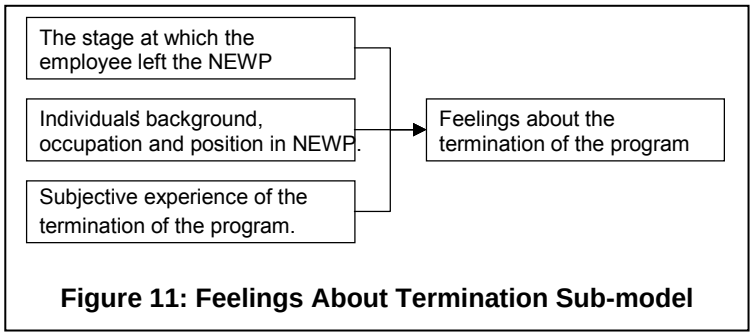

Figure 11: Feelings About Termination Sub-model

The stage, at which an employee left the NEWP, whether it was before or after the termination of the program, probably played a major role in the person's feelings about the termination. Personnel that left before the termination probably did so voluntarily and under 'normal' circumstances, e.g., resignation, transfer or retirement. They probably didn't care very much about the termination, as they were otherwise employed or in retirement at the time of the termination.

It is proposed that the temptation to sell information or his/her services for money is heightened when the person has suffered financially as a consequence of the termination of the NEWP. A more serious problem would be where former employees had grudges against the organization when they left.

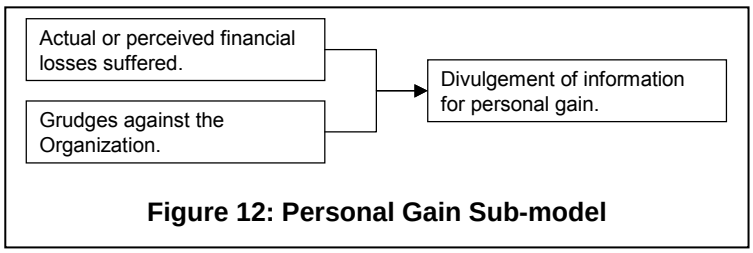

Figure 12: Personal Gain Sub-model

The actual or perceived losses suffered will depend to some extent on the circumstances under which the person left the NEWP. If the person left voluntarily, i.e. by resignation, transfer or promotion within the group or normal retirement, it is less likely to result in a disgruntled former employee. On the other hand, forced severance of employment through retrenchment, dismissal or early retirement could have the opposite effect. In the latter case the perceived fairness of the severance package would of course have an influence on the outcome. It is therefore hypothesised that:

> *H2: There is an association between the degree of satisfaction/dissatisfaction and the mode of termination of employment of former NEWP personnel.*

Personnel that resigned or went into normal retirement would most likely have done so with a favourable new career in mind or already lined up. On the other hand, those that were retrenched or retired early, might not be ready to take up a new career and would be more likely to be under-employed (drop in income) or un-employed. It is therefore hypothesised that:

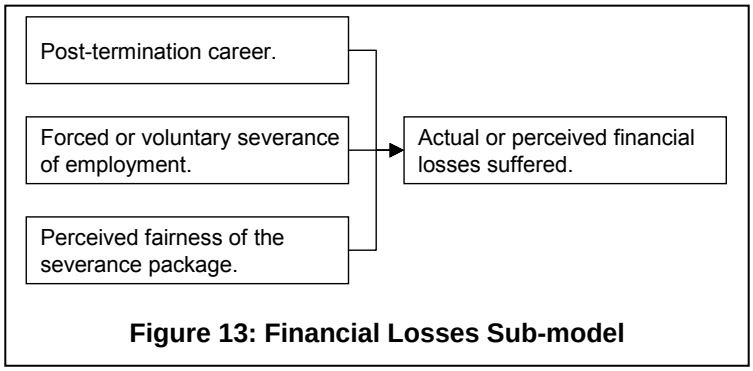

Figure 13: Financial Losses Sub-model

> *H3: There is an association between the type of post-termination employment and mode of termination of employment of former NEWP personnel.*

The actual losses suffered will depend on the person's post-termination career. It is expected that those that were immediately employed by another firm or transferred within the enterprise group are least likely to have suffered any loss of income.

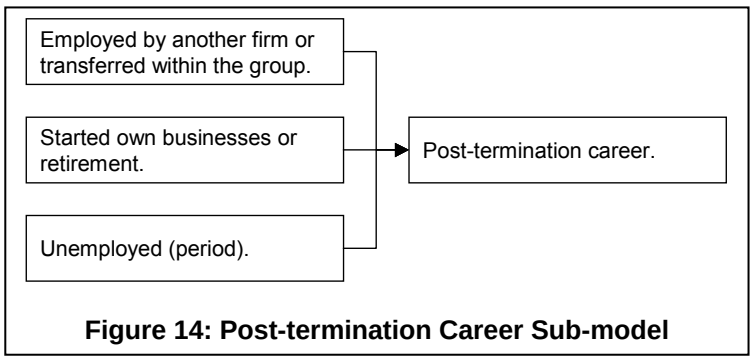

Figure 14: Post-termination Career Sub-model

The incomes of those that started their own businesses or that went into retirement were more vulnerable, and the ones that were most likely to have suffered financially are those that became unemployed after their employment was terminated. It is therefore hypothesised that:

> *H4: There is an association between income and the type of employment of former NEWP personnel after leaving the program.*

The length of the period they were unemployed would of course increase their loss of income. It is proposed that persons that were able to find jobs that where related to their previous ones would be less likely to have suffered a decrease in income. Persons whose new jobs were completely unrelated, or where they used only their basic skills and professional training in their new jobs, would be more likely to have experienced a decrease in income. It is therefore also hypothesised that:

> *H5: There is an association between the income of former NEWP personnel after leaving the program and the relatedness of their new jobs to their previous ones.*

The duration of engagement in the program and the type of profession or position they occupied in the program can also have an influence on the person's post-termination career. Persons that acquired unique or specialized knowledge and skills, that were so specific to the NEWP that it was made "obsolete" by the termination of the program, would feel deprived of an opportunity to practice their trade, especially as it was so highly valued during the course of the program. They might also find it difficult to find another job that is as paying as the one they had.

Personnel that were able to use some of the knowledge and skills acquired during the NEWP, in their new jobs, and personnel that were retrained to enable them to pursue a new career would be more likely to find favourable employment. Their job experiences prior to joining the NEWP could also be to their advantage in finding favourable employment. The period and industry sectors where they were formerly employed in are important factors in this regard. Other important factors that would play a role in their ability to find favourable employment

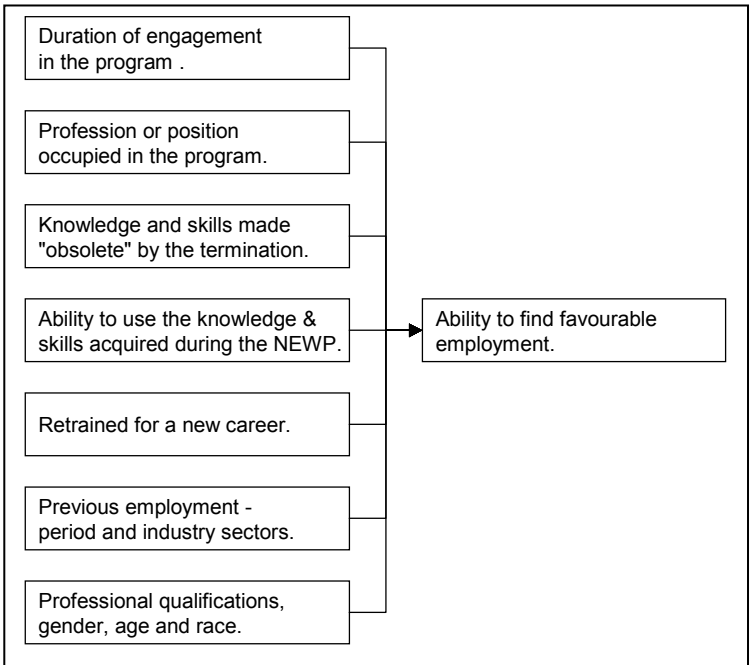

Figure 15: Favourable Employment Sub-model

are their professional qualifications, gender, age and race. In post-apartheid South Africa unemployed white middle-aged men found it particularly difficult to find jobs comparable to what they had before.

The foregoing argumentation and deduction of the Risk Assessment Sub-models as shown in Figures 7 to 15 were combined to form the complete *Former NEWP Personnel Risk Assessment Model* shown in Figure 16. This model forms the theoretical framework for this study.

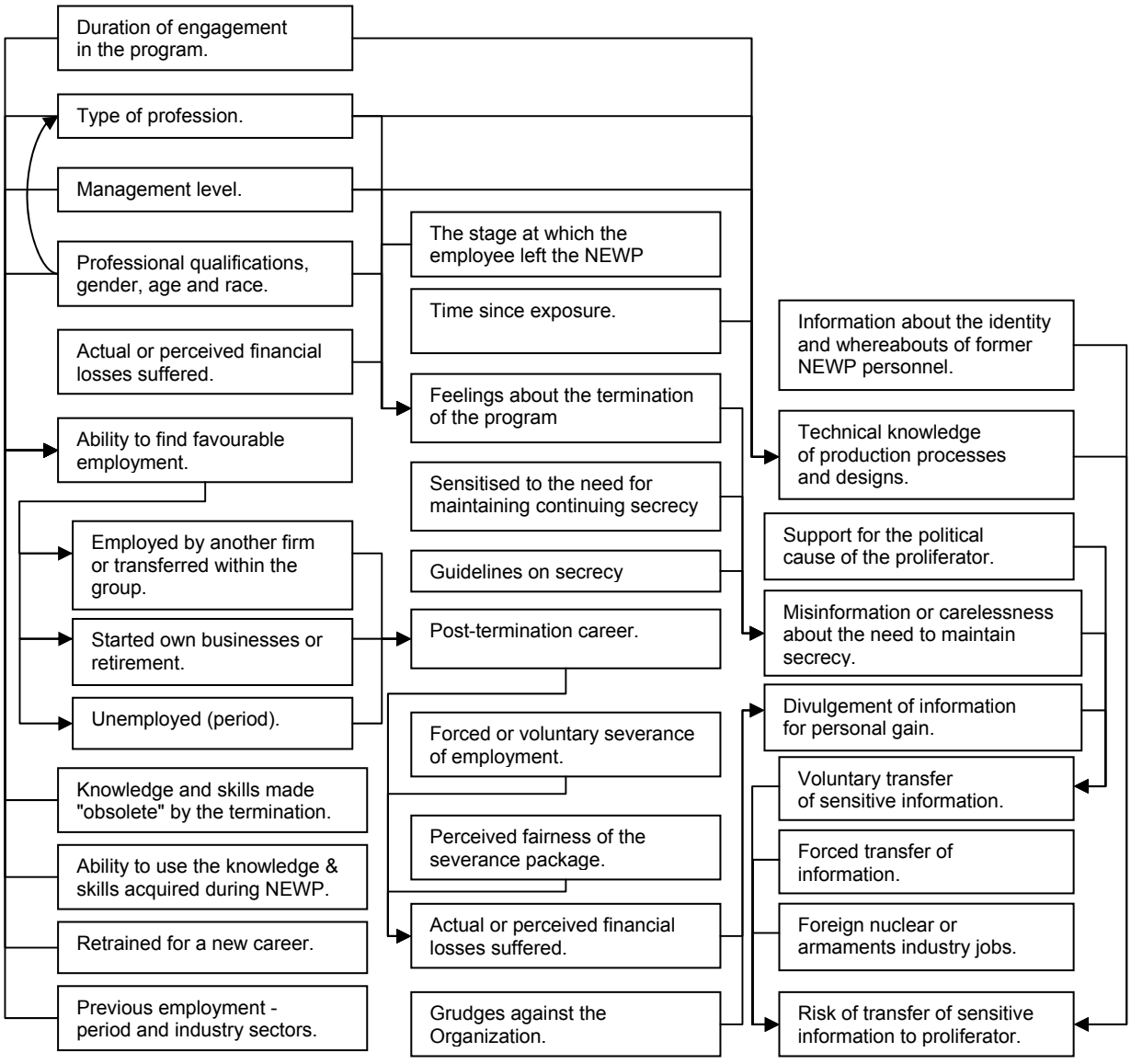

Figure 16: Former NEWP Personnel Risk Assessment Model

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Research strategy and design

As there are currently no existing theories or models for assessment of the proliferation risk posed by former NEWP personnel, this is a theory-building study aimed at development of such a theory and assessment model. The proposed model as developed in the preceding section will be tested using empirical data from the South African case study. This research study is therefore an exploratory and hypothesis testing theory-based empirical study. The relevance of this study is practical and has societal relevance. Its ultimate aim is to contribute to the non-proliferation of weapons of mass destruction by providing a risk assessment model of the proliferation risk posed by former NEWP personnel.

The data acquisition approach and strategy for this case study research were to collect primary data by conducting interviews with key former managers of the NEWP and to do a survey of the personnel involved. Data analysis was performed by descriptive and inferential statistical analysis, including correlation analysis and hypothesis testing. The generalisability of this study to other countries is limited by the fact that this is a single-case study. However, it represents a *critical test of a significant theory* (Yin (2003:41).

3.2 Interviews

The interviews with selected former managers aimed at gaining information on the policies and programs utilized for the relocation or retrenchment of the former NEWP personnel.

3.3 Survey design

A survey questionnaire, based on the research objectives and theoretical framework (Risk Assessment Model), was designed and used for the survey of the former NEWP personnel. The survey questionnaire contained twenty-two questions grouped into five parts as shown in Table 1. The complete survey questionnaire is attached to this report as Appendix 7.2.

Table 1: The structure of the survey questionnaire

PART 1: PERSONAL INFORMATION
1.1 Date of birth
1.2 Gender
1.3 Highest qualification
PART 2: CAREER PRIOR TO JOINING THE NEWP
2.1 Period employed before joining the NEWP
2.2 Industries employed in before joining the NEWP
PART 3: CAREER AT THE NEWP
3.1 Period employed in the NEWP
3.2 Job position in the NEWP

3.3 Profession or occupation during the NEWP

PART 4: TERMINATION OF EMPLOYMENT
4.1 Circumstances under which the person left the NEWP.
4.2 Was the person retrenched?
  4.2.1 Did the person receive a retrenchment package?
  4.2.2 Did the person consider the package as “fair”?
4.3 Did the person have unique or specialized knowledge and skills that were made "obsolete" by the termination of the NEWP?
4.4 What were the person’s feelings about the termination of the program?
4.5 Did the person have a grudge against the organisation when he/she left?
4.6 Was the person retrained after the termination of the project?
4.7 Who offered this training and who paid for it?
4.8 Was the person "debriefed" and sensitized to the need for maintaining secrecy?
4.9 What guidelines on secrecy were given?

PART 5: POST-TERMINATION CAREER
5.1 What happened to the person immediately after leaving the NEWP?
5.2 To what extent was the person able to use the knowledge and skills he/she acquired during the NEWP in his/her next job?
5.3 What was the effect of leaving the NEWP on the person’s monthly income?
5.4 Did the person receive foreign nuclear or armaments related job offers?
5.5 Did the person work overseas since leaving the NEWP?

The linkage between the research objectives and the survey questions is shown in Table 2.

Table 2: The linkage between the research questions and the survey questions

Research questions (See Section 1.5)	**Survey questions (See Appendix 7.2)**
What happened to the former NEWP personnel when the program was terminated?	5.1 What happened to the person immediately after leaving the NEWP?
What career options were open to them and what choices did they make?	5.2 To what extent was the person able to use the knowledge and skills he/she acquired during the NEWP in his/her next job? 5.3 What was the effect of leaving the NEWP on the person’s monthly income?
Were any of the personnel retrenched when the NEWP was terminated?	4.1 Circumstances under which the person left the NEWP. 4.2 Was the person retrenched?
If so, did they receive any compensation and what were their perceptions regarding the "fairness" of the compensation received?	4.2.1 Did the person receive a retrenchment package? 4.2.2 Did the person consider the package as “fair”?
What were the feelings of the personnel about the termination of the program?	4.4 What were the person’s feelings about the termination of the program?
Were there any disgruntled people and what were the reasons for this?	4.5 Did the person have a grudge against the organisation when he/she left?
What was the skills profile of the former NEWP personnel?	1.3 Highest qualification 2.1 Period employed before joining the NEWP 2.2 Industries employed in before joining the NEWP 3.1 Period employed in the NEWP 3.2 Job position in the NEWP 3.3 Profession or occupation during the NEWP
Did any have unique or specialized knowledge and skills that were so specific to the program that it was made "obsolete" by the termination?	4.3 Did the person have unique or specialized knowledge and skills that were made "obsolete" by the termination of the

		NEWP?
Were any personnel retrained after the termination?	4.6	Was the person retrained after the termination of the project?
If so, who offered this training and who paid for it?	4.7	Who offered this training and who paid for it?
Were the personnel "debriefed" and sensitized to the need for maintaining secrecy about the technical knowledge they possessed regarding nuclear explosives/weapons technology?	4.8	Was the person "debriefed" and sensitized to the need for maintaining secrecy?
Were they given any guidelines in this regard?	4.9	What guidelines on secrecy were given?
Has any of the personnel been approached by foreign agents with nuclear or armaments related job offers outside South Africa?	5.4	Did the person receive foreign nuclear or armaments related job offers?
Has any of the personnel emigrated or taken temporary positions overseas?	5.5	Did the person work overseas since leaving the NEWP?

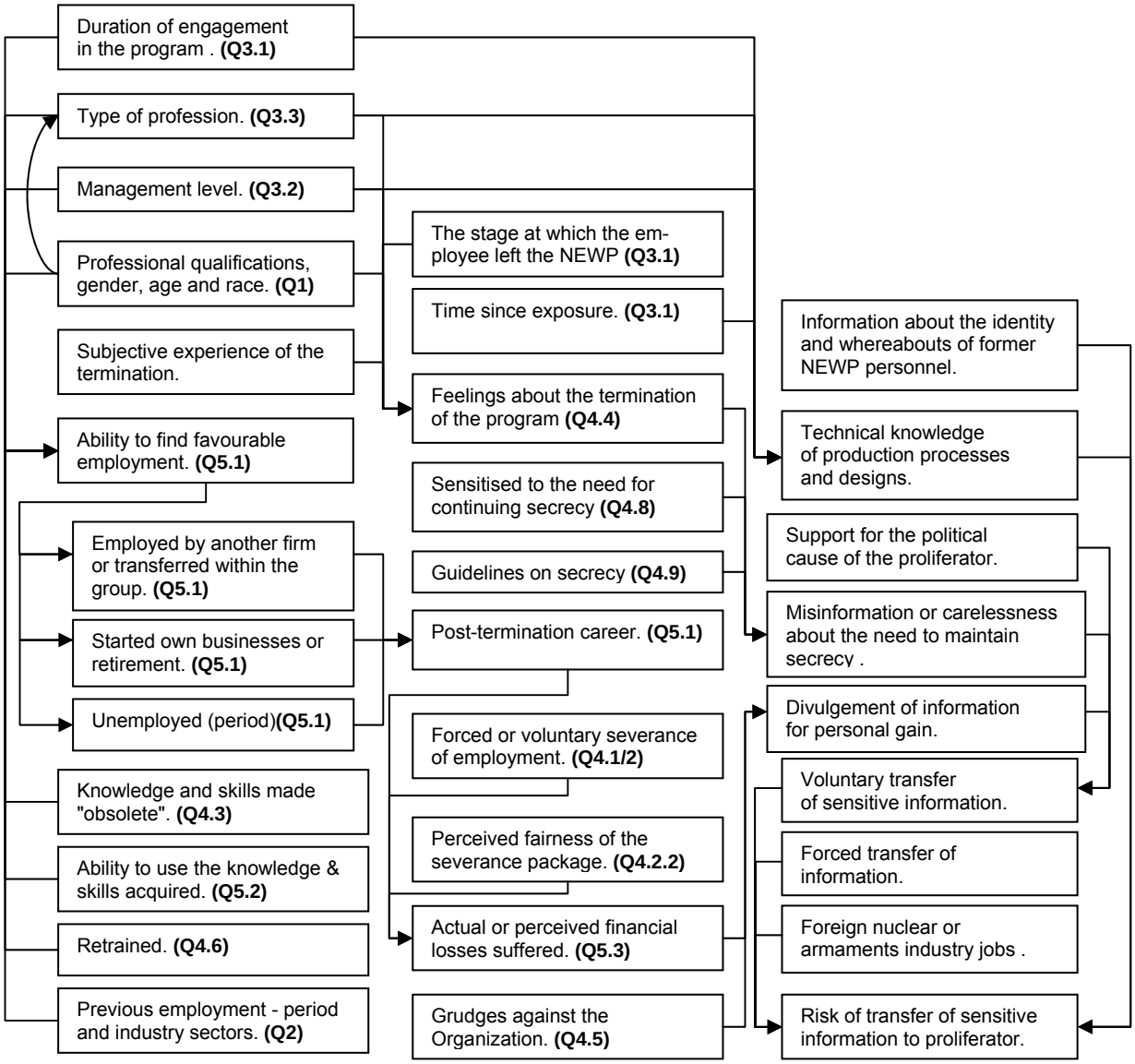

Figure 17: The linkage between the Risk Assessment Model and the survey questions.

The completed survey questionnaires are classified CONFIDENTIAL and the identity of respondents will not be disclosed. The results of the survey was presented and interpreted by using standard descriptive and inferential statistical methods. The research population consisted of the approximately 400 personnel that were employed by RO and Kentron Circle/Advena and the survey sample consisted of 255 individuals for whom information could be obtained. This was more than adequate for a representative sample, especially as a response rate of close to 50% was achieved.

4. DATA GATHERING AND ANALYSIS

4.1 Research Project Approval

This research study and the survey questionnaire were approved by the Research Ethics Committee of the Faculty of Engineering, Build-Environment and Information Technology of the University of Pretoria on March 10, 2004 (Copy of approval attached – Appendix 7.1).

4.2 Data and information gathered

4.2.1 Survey response

Of the 295 names in the survey frame, 23 had no contact information or the information was wrong or outdated. 272 survey questionnaires were therefore sent to the former NEWP personnel by e-mail, fax or post on 26 March 2004. Of these, 14 were returned by network servers because of wrong e-mail addresses. Of the 258 questionnaires that were delivered, 125 were completed and returned by June 30, 2004, giving a response rate of 48.4%. Table 3 summarizes the survey statistics.

Table 3: Survey response statistics

	RO Personnel	Circle/Advena Personnel	Total
Questionnaire completed and returned	25	100	125
Not sent - no address	4	19	23
Sent by e-mail – non response	34	73	107
Sent by fax – non response	0	24	24
Posted – non response	0	2	2
Returned – wrong e-mail address	3	11	14
Total	66	229	295

Seven RO personnel that had joined the division after 1980 responded to the survey. They had not been involved in the PNE Program (although they were apparently informed about the RO Division's former involvement in this program). They were therefore not former NEWP personnel and their entries were removed from the database leaving a total of 118 respondents. Table 4 shows a summary of the

survey design and response statistics.

Table 4: Summary of the survey design and response

Research population	All former South African NEWP personnel. Estimated at approximately 400 individuals.
Sample frame	255 former South African NEWP personnel for who contact details could be obtained.
Survey response	125 respondents completed and returned the questionnaires by June 30, 2004.
Survey sample	118 former NEWP personnel.

The major groupings of respondents are shown in Table 5. The categories are best understood by reference to the employment history of the NEWP (see Figure 6).

Table 5: The composition of the survey sample

Category of respondents	Number	Percentage
RO personnel that joined the division before 1971.	7	5.9%
RO personnel that joined during the PNE program (1971-1980) and remained at RO after 1980.	11	9.3%
RO personnel transferred to Circle in 1981.	16	13.6%
Circle/Advena personnel that joined during the Nuclear Weapons Program (1981-1989).	81	68.6%
Circle/Advena personnel that joined after the termination of the Nuclear Weapons Program (1989).	3	2.5%
Total:	118	100%

4.2.2 The goodness-of-fit between the sample and population distributions

The only variable distribution that could be determined for the population frame was gender (by inspection of the titles and first names of the individuals). Gender distribution was therefore used to perform a Chi-squared goodness-of-fit test to determine whether the sample values 'fit' the population distribution. The null and alternate hypotheses are defined as:

H_0: There is no difference in the gender distributions of the sample and population.
H_1: There is a difference in the gender distributions of the sample and population.

Table 6: Relationship between population frame and sample frequency breakdowns for gender: Chi-squared goodness-of-fit test

Gender	Population	Pop%	Sample	Sample%
Male	242	81%	109	87%
Female	55	19%	16	13%
Total	297	100%	125	100%
ChiSq = 2.709, df = 1, P = 0.09978				

Table 6 shows the relationship between population frame and sample frequency breakdowns for gender. The P-value for the test is 9.978%, which is more than 5%. Consequently, H_0 cannot be rejected and there is thus no significant difference between the sample and population distributions, suggesting that the sample is representative of the population, giving credence to the survey results.

4.2.3 Effective sample size and margin of error

The sample size obtained in this survey was 118. This was a non-probability sample as the respondents were self-selected. This is not the best sampling method in terms of producing a representative sample and has a design effect (d) of 2.00. For the purpose of estimating the margin of error of variables, the effective sample size is the sample size divided by the design effect. The effective sample size (e) for the survey is thus only 59. Margin of error estimates of proportions (p) are calculated using the following simple formula:

$$\text{Margin of error} = 2\sqrt{p(1-p)/e}$$

The largest margin of error is therefore 13%, in the case of proportions of 50%. In such cases the confidence interval ranges from 37% to 63%. The margin of error declines for smaller or larger proportions (i.e. 7.8% for proportion of 10% or 90%). Although the accuracy of the survey results are therefore not very high, it is still adequate for the purpose of this research project where the objective is not to get extremely accurate figures but rather patterns and correlations between variables.

4.3 Data analysis

This section presents the initial data analysis. In the first part the data is summarized, using descriptive measures and graphs to provide an overall picture of the data. This is followed by bivariate analyses of association tests between variables. In this section, the goal is to explore the data. In the following section the correlations will be tested for significance, in other words generalised to the research population, using hypothesis tests.

4.3.1 Employment history of NEWP personnel

The South African NEWP personnel were relatively young people when they joined the program. Their mean age was 29 years and 8 months. Half of them were younger than 27 years and 10 months. Figure 18 shows the frequency distribution and descriptive statistics of the age distribution of the survey sample. The mean period of engagement in the NEWP was 7 years and 6 months. Figure 19 shows the frequency distribution and descriptive statistics of the engagement period of the survey sample. The mean age of the NEWP personnel when they left the program was 37 years and 2 months. Figure 20 shows the frequency distribution and descriptive statistics of the age-at-departure distribution of the survey sample.

The survey sample data for the NEWP employment history in terms of appointment rates, departure rates and annual staff complement is shown in Figure 21. The maximum staff complements for the PNE and Nuclear Weapons Programs can be estimated by multiplying the survey data by the Population-to-Sample Ration. The estimated maximum staff complement of the PNE Program is 80 (23x400/115) and for the Nuclear Weapons Program it is 223 (64x400/115). Both programs reached their maximum staff complements in their respective termination years, i.e. 1980 for the PNE Program and 1989 for the Nuclear Weapons Program.

Mean	29.69421
Standard Error	0.619315
Median	27.83333
Mode	28.83333
Standard Deviation	6.727483
Sample Variance	45.25903
Kurtosis	1.23678
Skewness	1.154864
Range	33.5
Minimum	20.08333
Maximum	53.58333
Sum	3503.917
Count	118
Largest(1)	53.58333
Smallest(1)	20.08333
Confidence Level(95.0%)	1.226521

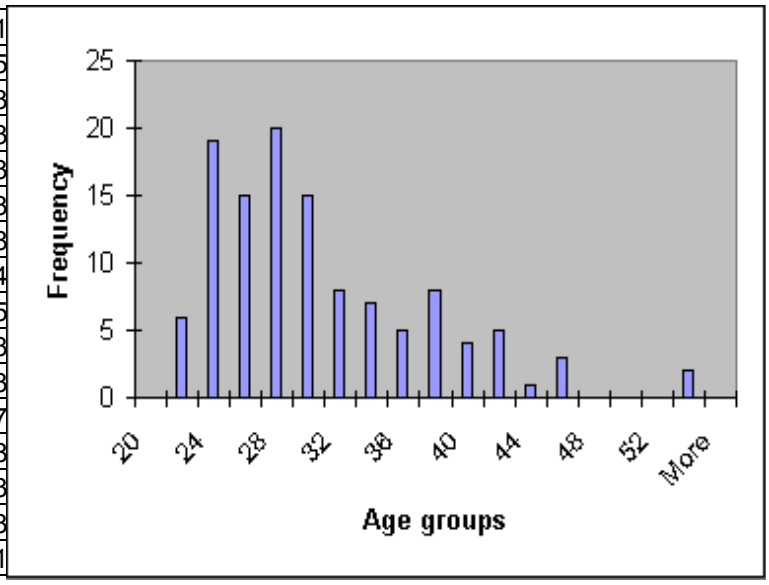

Figure 18: The age distribution of the personnel on joining the NEWP.

Mean	7.485119
Standard Error	0.483129
Median	5.916667
Mode	5.916667
Standard Deviation	5.112954
Sample Variance	26.14229
Kurtosis	-0.14954
Skewness	0.911926
Range	19
Minimum	1
Maximum	20
Sum	838.3333
Count	112
Largest(1)	20
Smallest(1)	1
Confidence Level(95.0%)	0.957351

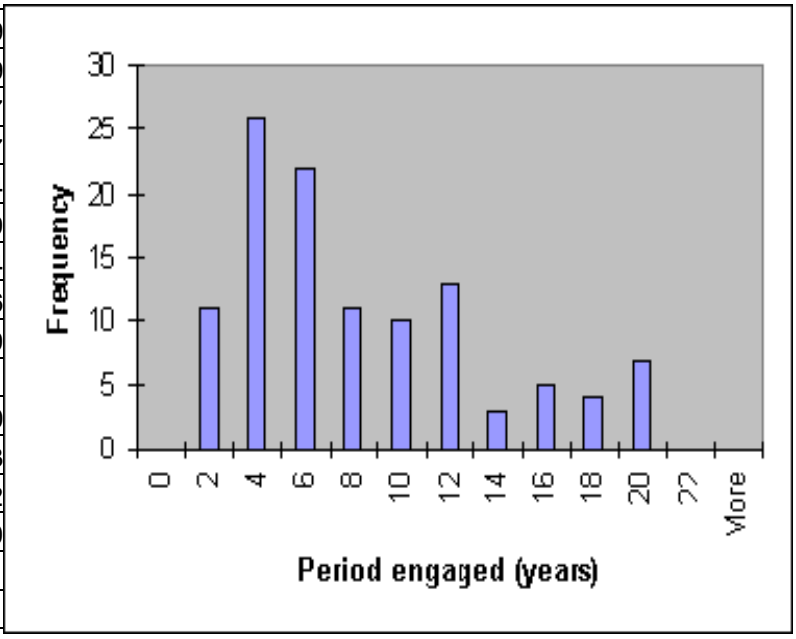

Figure 19: The period of engagement distribution of the NEWP personnel.

Mean	37.17039
Standard Error	0.753304
Median	36.45833
Mode	33.83333
Standard Deviation	7.972224
Sample Variance	63.55635
Kurtosis	-0.25604
Skewness	0.552685
Range	37
Minimum	23.66667
Maximum	60.66667
Sum	4163.083
Count	112
Largest(1)	60.66667
Smallest(1)	23.66667
Confidence Level(95.0%)	1.492722

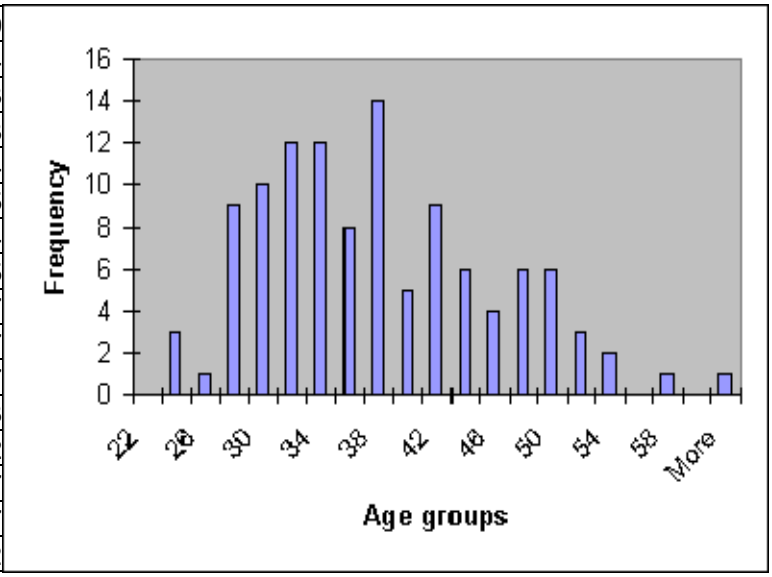

Figure 20: The age distribution of the personnel on leaving the NEWP.

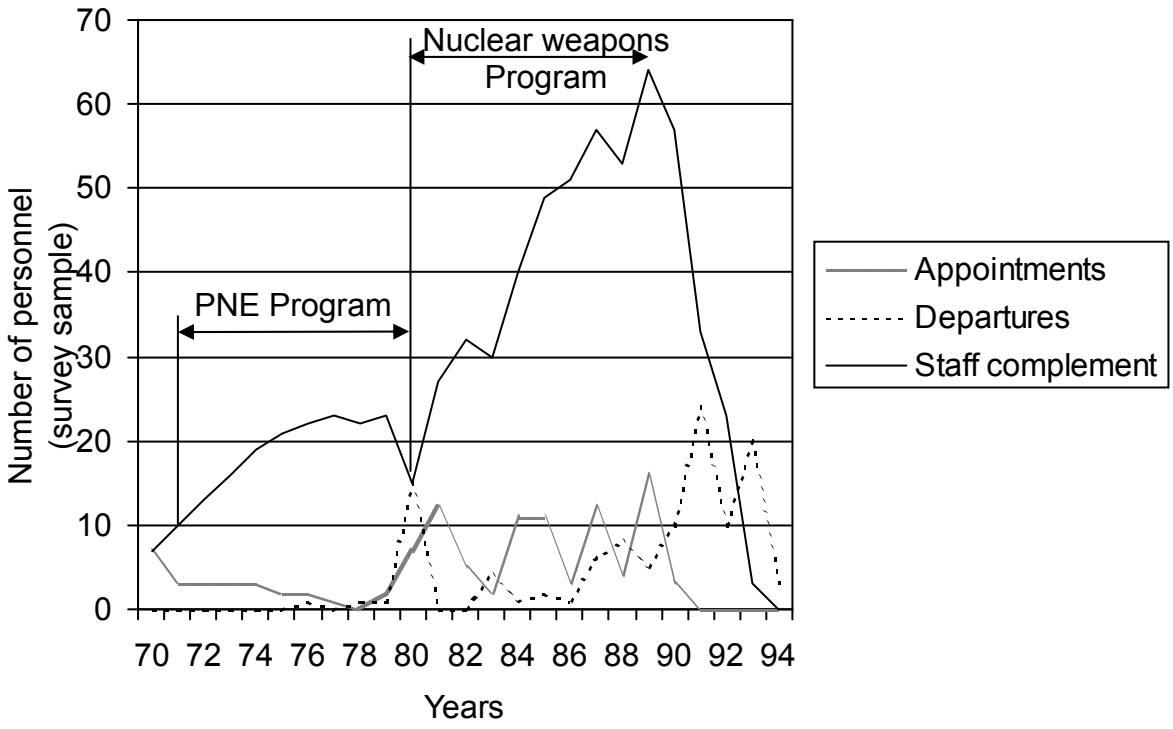

Figure 21: History of appointments, departures and staff complement.

4.3.2 Skills profile of the NEWP personnel

Most (86%, margin of error = ±9%) of the respondents were male. A more accurate estimate is that obtained from the population frame (by inspection of the titles and

first names of the individuals). The gender distribution as estimated from the population frame was 81% males (Margin of error = ±6.4%). The PNE Program personnel at the RO Division had a higher percentage of males (94%) that the nuclear weapons personnel at Circle/Advena (78%).

Figure 22 shows the educational level of the respondents. As expected, the educational level of the NEWP personnel was high. Most (87%) were educated at the tertiary level, 53% were graduates with 25% having master's degrees and 11% doctoral degrees. A large group (35%) had diplomas from Technical Colleges. These were mostly in Mechanical Engineering (36.6%) and Electrical & Electronic Engineering (26.8%).

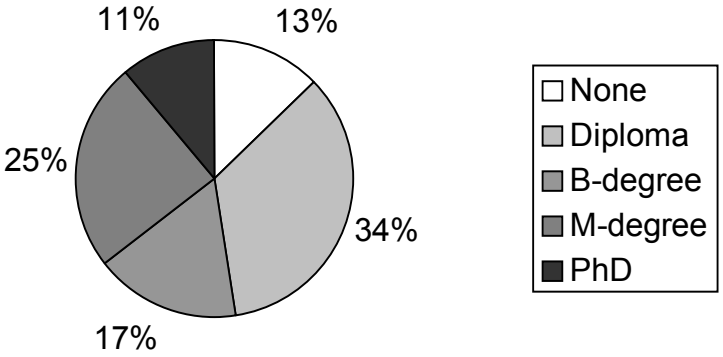

Figure 22: Tertiary educational level of NEWP personnel

Figure 23 shows the breakdown in terms of professional background of the respondents. The majority was trained in engineering, technology and the natural sciences. A surprisingly large group (11%) was trained in the human sciences and art. These included disciplines such as Law, Strategic Studies & International Politics, Social Work, Industrial Psychology, Teaching, Video production, Photography and Graphic Art. The 'Other' group included disciplines such as Library & Information Science, Operational Research, Industrial Engineering and Artisans. The majority of graduates were engineers (53%), consisting of Mechanical Engineers (24%), Electrical/Electronic Engineers (19%), Nuclear Engineers (3%), Metallurgical Engineers (3%), Chemical Engineers (2%) and Industrial Engineers (2%).

The composition in terms of professional background of the RO Division personnel was very similar to that of the Circle/Advena personnel. The only significant differences are in the high percentage of physicists at the RO Division (19.4%) versus the low percentage (4.4%) at Circle/Advena. On the other hand, Circle/Advena had a high percentage of electrical and electronic engineers (25.0%) versus a low percentage (5.6%) at the RO Division. These differences are due to the different requirements of the PNE Program versus the Nuclear Weapons Program. The nuclear physics design of nuclear explosive devices was a major task during the PNE Program, and this required a substantial input from nuclear physicists. The weaponization effort at Circle concentrated mainly on the safety, security and

reliability of the nuclear weapons. This required a substantial input from electrical and electronic engineers who were responsible for the design and development of the safing, arming and command-and-control systems of the nuclear warheads.

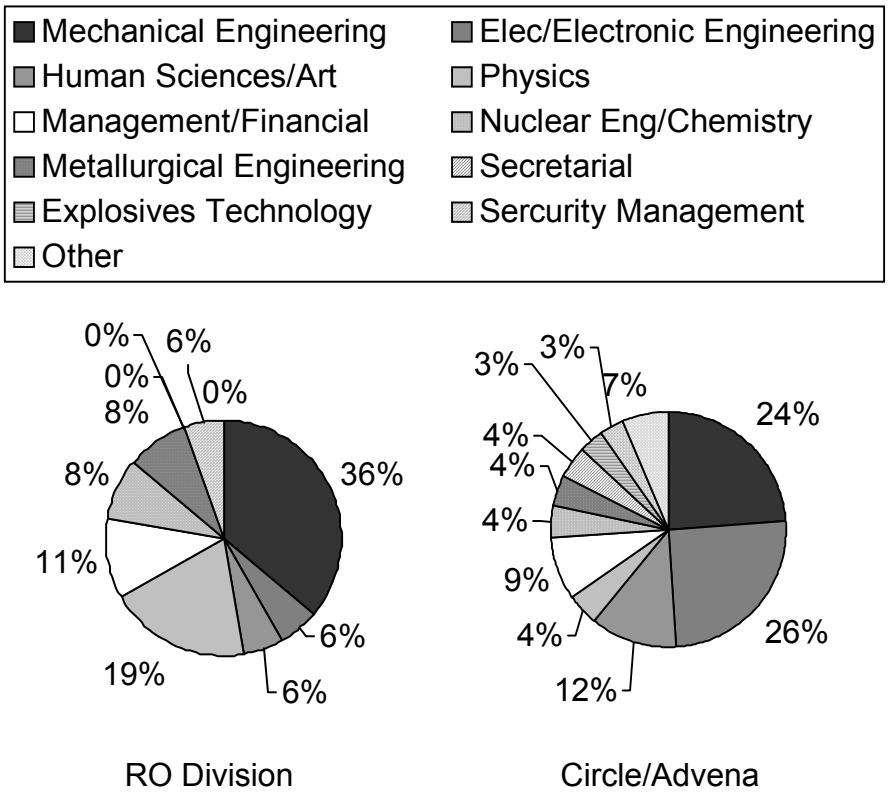

Figure 23: Professional backgrounds of the NEWP personnel

4.3.3 Previous employment history of the NEWP personnel

Figure 24 shows the frequency distribution and descriptive statistics of the period the survey sample group was employed before joining the NEWP. The multi-modal distribution is indicative of three subgroups in the population. The first subgroup consisted of young people that started their careers in the NEWP ($Mode_1$ = 0 years). Many of these had been undergraduate bursars of the AEB and Kentron and were therefore contractually bound to work for their employers after completing their studies. The second subgroup consisted of people that joined the NEWP after resigning from their initial employer (Median = 7 years). Seven years seems to be a typical period for most employees to work for one employer before seeking another job (See also Figure 19). The third sub-group was a group of senior personnel that had extensive work experience in other organizations before joining the NEWP ($Mode_3$ = 16 years).

Mean	8.08547
Standard Error	0.610061
Median	7
Mode	0
Standard Deviation	6.598815
Sample Variance	43.54436
Kurtosis	1.406456
Skewness	1.139826
Range	32
Minimum	0
Maximum	32
Sum	946
Count	117
Largest(1)	32
Smallest(1)	0
Confidence Level(95.0%)	1.208301

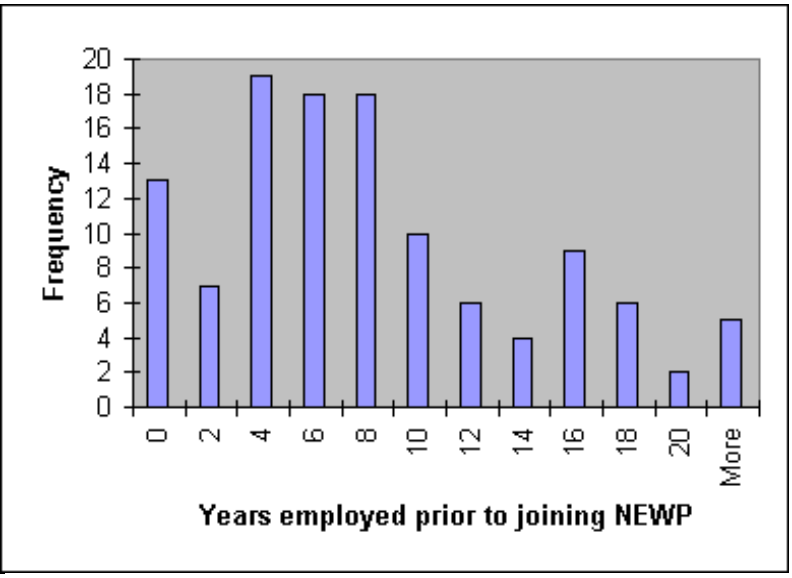

Figure 24: The distribution of the period the personnel were employed before joining the NEWP.

The industrial sectors the personnel worked in before joining the NEWP are shown in Figure 25. Most (74.5%) of the personnel came from governmental or semi-governmental organisations such as the Defence Industry (mostly from Armscor), the Nuclear Industry (mostly from the AEB), the Civil Service, Statutory Bodies (Parastatals such as the Council for Scientific and Industrial Research (CSIR)) and the Defence Force. Only 25.5% came from the Private Sector or were self-employed.

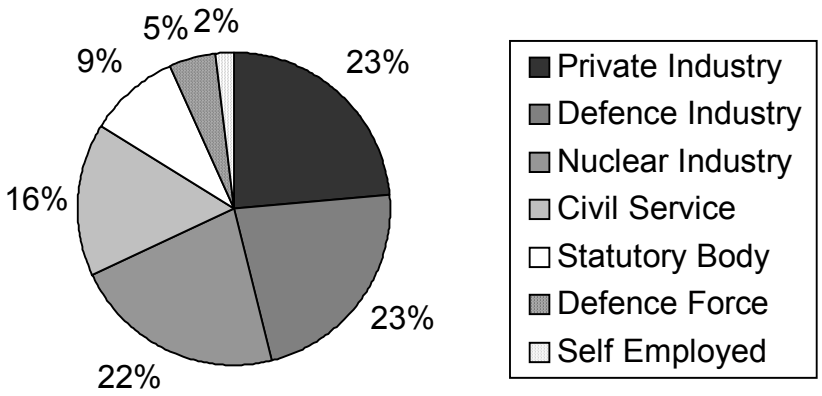

Figure 25: The industrial sectors the personnel worked in before joining the NEWP

Some of the previous employers that the respondents indicated are listed in Table 7.

Table 7: Previous employers

INDUSTRIAL SECTOR	EMPLOYERS
Private Industry	Mining Steelmaking Banking
Defence Industry	Kentron (Armscor)
Nuclear Industry	Atomic Energy Board
Civil Service	Dept of Education Police Service Correctional Service
Statutory Bodies	Council for Scientific and Industrial Research Iron and Steel Corporation of South Africa Universities South African Airways Technikon Pretoria
Defence Force	South African Defence Force
Self Employed	Farming

4.3.4 Job positions of the NEWP personnel

Figure 26 shows the distribution of job positions of the respondents. A surprisingly high percentage (33%) of the respondents indicated that they held management positions in the NEWP. This could indicate a 'top heavy' organisational structure but is more likely the result of respondents reporting their last positions held in the organisation. It is thus not a true refection of the organisational structure at a specific instance.

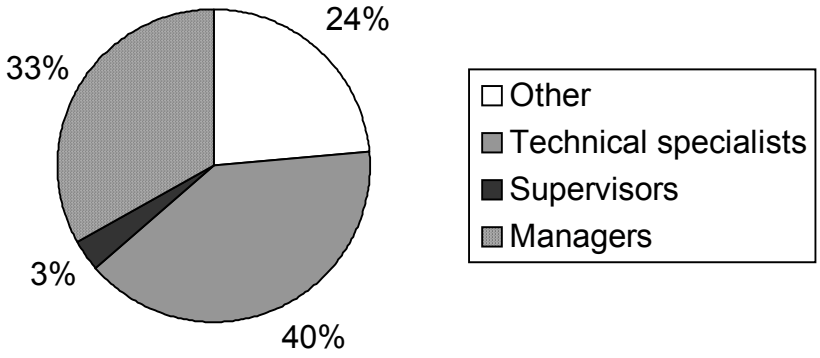

Figure 26: Job positions of the NEWP personnel

Figure 27 shows the distribution of professions or occupations of the respondents. The distributions corresponds with the professional backgrounds of the two groups

(see Figure 23) The major difference between the two groups is the high percentage of scientists at the RO Division (20.5%) versus the low percentage (7.7%) at Circle/Advena. This difference is due to the different requirements of the PNE Program versus the Nuclear Weapons Program as mentioned before. Circle/Advena had administrative and support staff whereas the RO Division apparently had none (no respondents to the survey indicated that they were in this category). This difference is due to the different organisational types. The RO Division was a division of the AEB located at the National Nuclear Research Centre at Pelindaba. The Division was therefore able to make use of the services of the Administrative and Support Divisions of the AEB. The Circle/Advena Plant of Kentron was located at the Elandsfontein Vehicle Test Range west of Pretoria, approximately 25 km from Kentron's main facility at Irene, south of Pretoria. The Circle/Advena plant therefore had to be more self-reliant necessitating their own administrative and support staff.

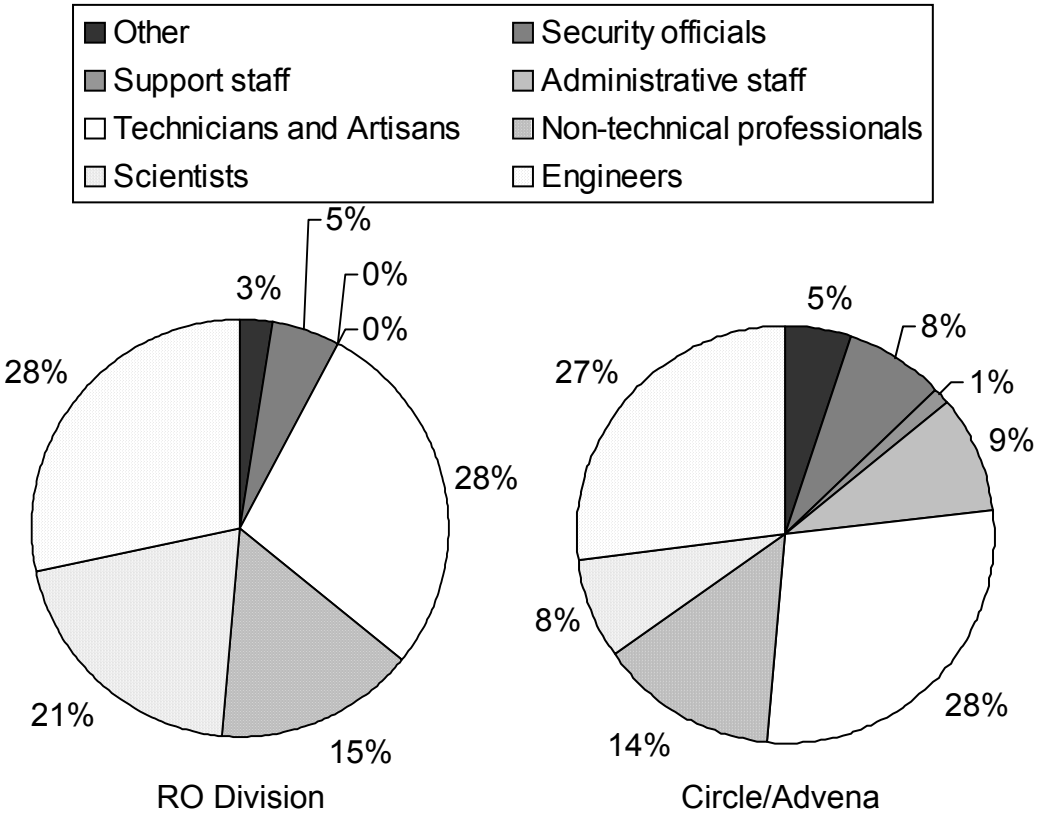

Figure 27: Professions or occupations of the NEWP personnel.

Some of the professions or occupations reported in the 'other' category were the following: Executive Manager, Plating Assistant, Tracer in drawing office, Video Photographer and Artist.

4.3.5 Termination of employment of the NEWP personnel

Figure 28 shows the modes of termination of employment of the NEWP personnel. The history of the termination of employment by mode is shown in Figure 29. The largest group (38%) were those that were retrenched after the termination of the

Nuclear Weapons Program. Some (2.5%) took early retirement (a form of retrenchment).

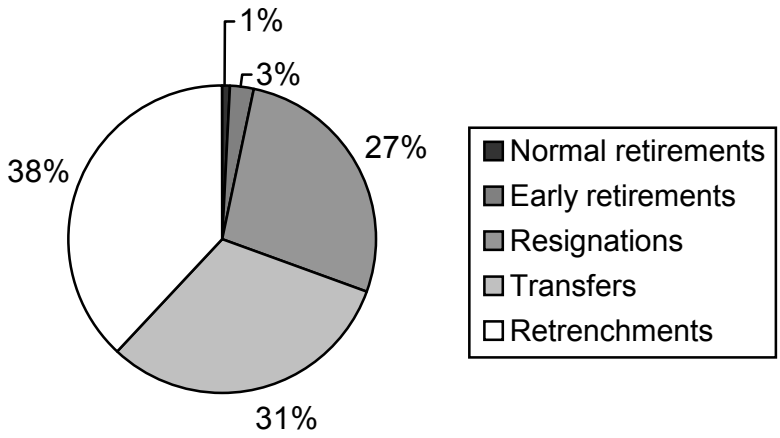

Figure 28: The modes of termination of employment of the NEWP personnel

When the Nuclear Weapons Program was terminated in 1989, the personnel were not immediately redundant. The nuclear warheads had to be dismantled and the HEU recast and returned to the AEC. Many of the project personnel were retained to perform these tasks. It was also decided to convert the facility to civilian and non-nuclear armaments research and development work. It was only when the defence industry embarked on a general downsizing, as a consequence of the sharp cutback in defence spending by the government, that the Advena personnel were affected. The first major retrenchments took place in 1991, two years after the termination. The last group of retrenchments were in 1993 when the facility was finally closed down.

All the personnel that were retrenched received retrenchment packages. Those that were retrenched prior to the split between Armscor and Denel in April 1992 received the standard Armscor retrenchment package of one week's remuneration (based on basic salary including transport allowance, housing subsidy and annual bonus, but excluding any company contributions to medical aid scheme and pension fund) for every completed year of service (Armscor 2007). After Advena became part of Denel in 1992, the retrenchment packages were the same as those offered to other armaments industry workers in the Denel group. At the time of the retrenchment of the last Advena personnel, the retrenchment policy of Denel (effective April 1993 to August 1994) was two weeks remuneration for every year's completed service, with a maximum package not exceeding six months salary (Denel 2007).

The mean period of engagement of the NEWP personnel was 7.5 years (Figure 19). The average retrenchment package was therefore 7 week's or less than two month's salary for those retrenched before 1992 and 14 week's or less than four month's salary for those retrenched after 1992. The median period of unemployment for the retrenched personnel was 6 months (See Figure 31). Most retrenched personnel therefore suffered a financial setback. It is therefore not surprising that almost half

(47.8%) of those that were retrenched viewed the retrenchment packages they received as unfair.

Furthermore, they considered themselves a special case and expected to be treated differently from the other armaments industry workers. The government had provided funds to Advena for the wrapping-up of the program. This funding was spent on the dismantlement and conversion actions, but many of the personnel were under the impression that it was earmarked for bettering their retrenchment packages. When this didn't happen, a group of Advena personnel took Denel to court claiming unfair labour practices. In March 1994, 16 former NEWP personnel announced that, unless they were paid substantial retrenchment packages (amounting to over US$1million), they would reveal information about the programme to the highest bidder. In turn, Armscor took legal action to silence the group, threatening to prosecute them in terms of the secrecy laws if they should make any disclosures. Subsequently, the threats were dropped, and little more was heard from this group. During private interviews with some members of this group they stated that the treat was a bluff, made as part of their negotiating tactics, but they did not seriously contemplate revealing any classified information. They were, however, extremely dissatisfied with the retrenchment packages they were offered.

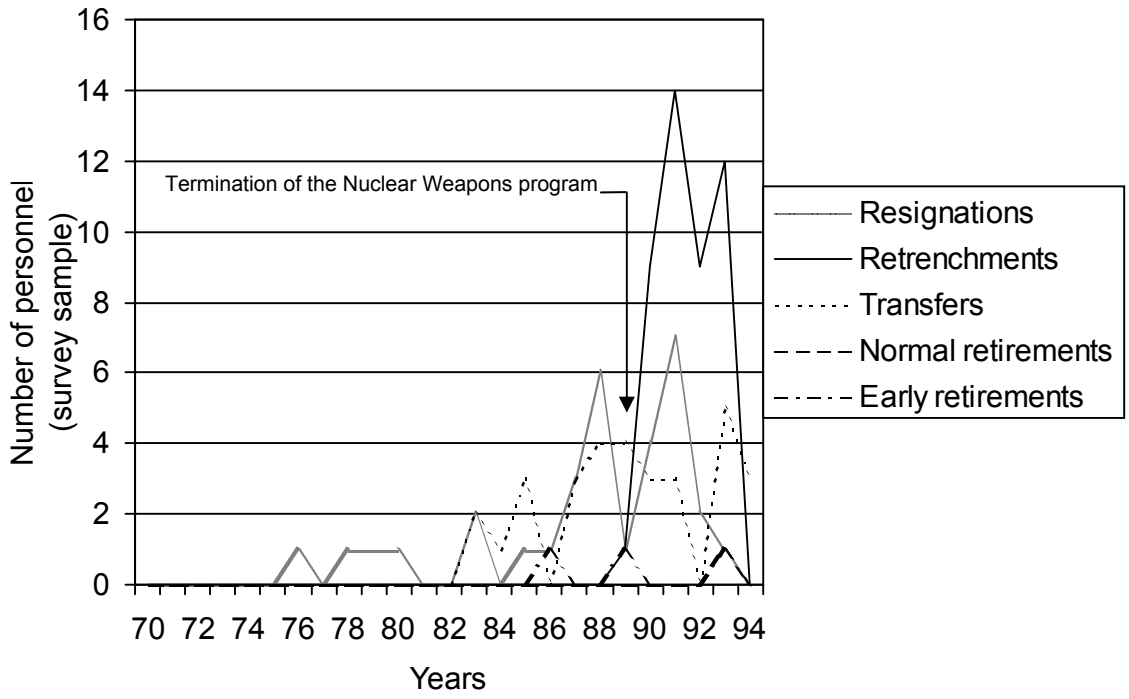

Figure 29: History of the modes of termination of employment of the NEWP personnel

One of the arguments offered in support of the view that Nuclear Weapons Program personnel deserves special compensation, is that they have acquired unique or specialized knowledge and skills that were so specific to the nuclear explosives/weapons program that it was made "obsolete" by the termination of the

program. However, only about a quarter (25.9%) of the respondents indicated that they had acquired such knowledge or skills.

4.3.6 Feelings of the NEWP personnel about the termination of the program

The former NEWP personnel were asked to indicate their feelings about the termination of the program. They were offered four alternative views, but could mark more than one. The majority (65.8%) experienced a sense of loss. They were proud about working in the NEWP and found it hard to do “ordinary” work again. About half (51.3%) was glad that the program was terminated. They agreed that it was the right thing to do in the circumstances the country was in at the time. A minority (13.7%) felt that the government should not have terminated the program and that South Africa should have remained a nuclear weapons state. Very few (6%) considered working in the NEWP as just a job, and as long as they had another job or were fairly compensated, they didn’t care about the termination.

A small fraction (8.5%) of the former NEWP personnel indicated that they had a grudge against the organization when they left. Some of the RO Division’s personnel were aggrieved about their pension payouts, e.g. that they received only their retirement fund contributions plus 4%. Advena personnel mentioned other grievances, e.g. that they had not been promoted as promised, that they were mislead about the reasons for termination of the Advena activities, that commercialization projects were stopped prematurely, that their retrenchments were unnecessary, that they were not offered other jobs in the Denel group, that they couldn't find other jobs, that their retrenchment package calculations and the procedure was incorrect, that some were retrenched while others continued with commercial work.

Some (6%) of the former NEWP personnel indicated that they were unhappy when they left and gave a variety of reasons why they were unhappy. Some of the reasons given were:

- that they couldn't find jobs due to the affirmative action policy of the government,
- that they were sad to break things down,
- one mentioned that his salary dropped by 50%,
- others thought that the space program should have been maintained,
- that the project had been a waste of money,
- that they were not informed of the termination by management but got the news in the media,
- that due to the secrecy of their work they had “gaps” in their CV’s, and
- that Armscor settled later with other Nuclear Weapons Program personnel but they were retrenched immediately after termination of the Program.

However, none indicated that they had a grudge against the organization.

Only 15.6% of the retrenched personnel indicated that they were retrained. Advena paid for the retraining of some (9.5%) of the retrenched personnel. These were trained by e.g. an estate agency, a marketing organisation, a computer company and others. Some (5%) of the retrenched personnel were retrained by their new employers. A few (2%) paid for their own retraining. Some (5%) of the transferred personnel were retrained by their employer, e.g. the AEC.

4.3.7 Secrecy consciousness of the former NEWP personnel

Most (67%) of the former NEWP personnel indicated that they were "debriefed" and sensitised to the need for maintaining secrecy about aspects of the nuclear explosives/weapons project after the termination of the project. Of those that were not debriefed, some were senior personnel who set their own guidelines, others left or were transferred before the termination and were not debriefed afterwards.

The majority (55.1%) of the personnel reported that the guideline on secrecy that they received was that everything remains top secret and that they may disclose nothing about the project. Others (19.5%) indicated that the guideline was that only the technical details of nuclear explosives/weapons designs and production processes remains classified and may not be disclosed, while a small group (5.1%) indicated that in addition to the technical details, the identity of former colleagues may not be disclosed.

There was, however, a lot of uncertainty and contradictory views about what guidelines on secrecy should be adhered to. Many of the personnel reported that they cannot remember of a specific briefing or of any specific guidelines given, but assumed that everything remains top secret. Others indicated that they simply used common sense or the “need to know” principle. Some of those that reported that the guideline was that everything should remain top secret were surprised when information about the project was later made public. Others reported that everybody was briefed that all information must remain classified, even if the history of the program should be made public. One person was told to deny all knowledge of the project, and asked to sign a form to this effect three years after the termination. Others believe that information already in the public domain can be considered as declassified. One person’s view was that secrecy was only to be maintained as long as the NPT had not been signed by the government. Another person reported that he couldn’t remember because “I have tried to blot out my memory”. One reported that: “I talk freely but nobody is very interested”. Another respondent talks but doesn't give details.

4.3.8 Post-termination careers of the former NEWP personnel

The fate of the personnel immediately after termination of their employment in the NEWP is shown in Figure 30. They can be categorised in three major groups:
- Those that were transferred to another position within the AEB or Denel groups (32%);
- Those that were immediately employed by another firm (35%); and
- Those that became temporarily unemployed (26%).

Only a few individuals started their own businesses (4%) or went into retirement (3%).

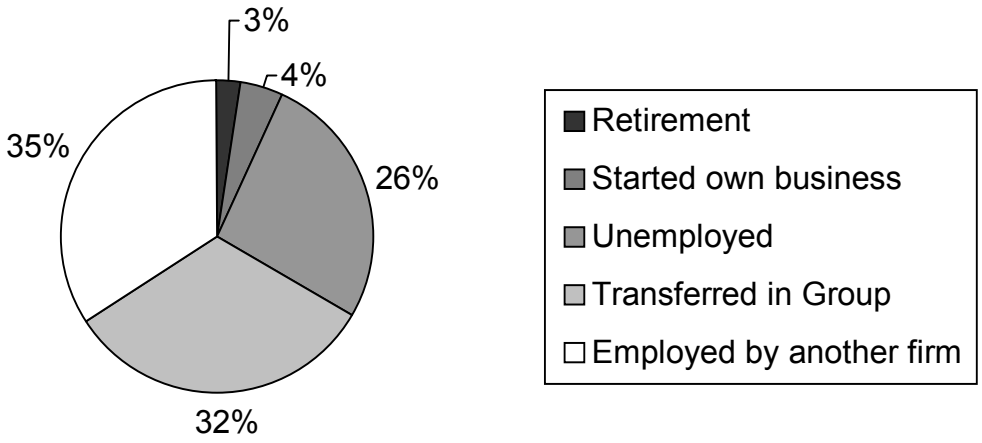

Figure 30: Fate of the personnel immediately after termination of their employment in the NEWP.

Those that became temporarily unemployed after termination of their employment in the NEWP are of special concern. Figure 31 shows the frequency distribution and descriptive statistics of the period they were unemployed. The median period of unemployment was 6 months. Of the temporarily unemployed 71% were employed after one year, and after two year 84% were employed. There were however a small group (13%) that were still unemployed after four years.

Mean	21.4516
Standard Error	6.51167
Median	6
Mode	12
Standard Deviation	36.2554
Sample Variance	1314.46
Kurtosis	6.9663
Skewness	2.70459
Range	149
Minimum	1
Maximum	150
Sum	665
Count	31
Largest(1)	150
Smallest(1)	1
Confidence Level(95.0%)	13.2986

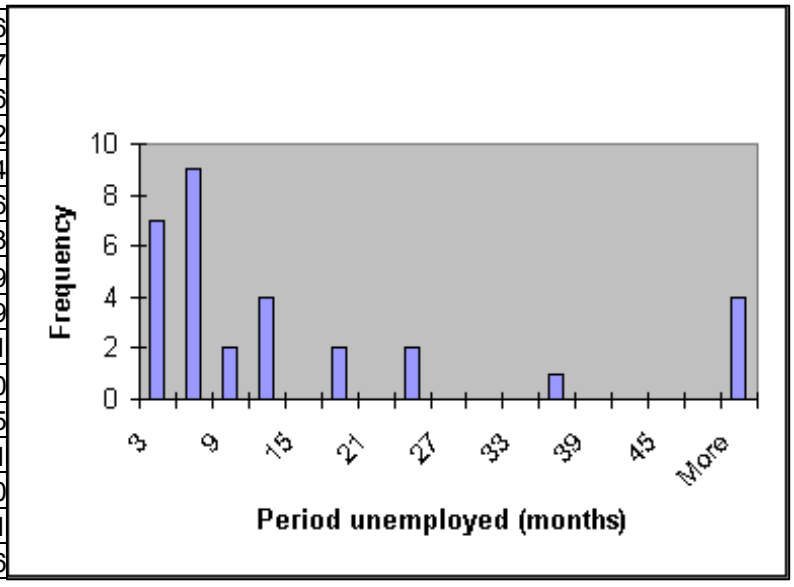

Figure 31: The distribution of the unemployment period for the personnel in the survey sample that was temporarily unemployed after termination of their employment in the NEWP.

The personnel were asked to indicate to what extent they were able to use the knowledge and skills they acquired in the NEWP in their next jobs. A quarter (25%) of the respondents indicated that their new jobs were directly related to their previous experience and that the knowledge & skills gained during the NEWP were very valuable in their next job. The largest fraction (37.5%) indicated that their new jobs were "somewhat related to my previous experience" and that the knowledge & skills gained were of some value. Another group (23.2%) indicated that the experience gained during the NEWP was not of much value and only their basic skills and professional training were of any value in their new jobs. A small group (14.3%) indicated that their new jobs were completely unrelated and their knowledge & skills gained during the NEWP were not used at all.

The largest fraction (44%) of the respondents indicated that their monthly income decreased after termination of their employment in the NEWP. The income of a third (33.6%) of the respondents was unchanged, while only 22.4% reported that their income increased immediately after they left the NEWP.

The personnel were asked whether they had received nuclear or armaments related job offers outside South Africa after they left the NEWP. Only four respondents (3.4%) indicated that they had received such offers. One respondent reported that he was approached overseas with such a job offer, but did not report the incident at the time. Another respondent reported that he knew of a person that "had a contact in Syria". A case was also reported of a former AEB employee with knowledge of the PNE Program that defected to the USA in the late 1970s. He was granted permanent residence in the USA after informing the US Intelligence Community of the South African PNE Program.

Quite a few (11.2%) had worked overseas since they left the NEWP. However, these percentages should be considered with caution. There was only one person with an overseas address in the sample frame. It is therefore possible that many of the former NEWP personnel are still overseas and therefore not represented in the survey. In an attempt to gain some information in this regard, the personnel surveyed were asked whether they were aware of any former colleagues who have worked overseas since leaving the NEWP. The names of nine individuals were reported. Of these, three were accounted for as they were respondents in the survey. When the six additional overseas workers are included in the survey sample, the percentage of former NEWP personnel that had worked overseas since they left the NEWP increases to 16.4%.

4.4 Association analysis

In this section cause-effect relationships will be investigated by means of association and correlation analyses between variables. Hypotheses tests will be used to test the observed associations and correlations for statistical significance. Only when a hypothesis test has given a statistically significant result can a conclusion be extended beyond the sample data to the research population.

4.4.1 Association between income and post-termination employment

The sample data indicates a strong association between income and the type of employment of former NEWP personnel after leaving the program. As shown in Table 8, the income of most (78%) of those that joined another firm increased or was unchanged. The income of most (58%) of those that were transferred was unchanged, and the income declined of the majority (84%) of those that became unemployed, retired or started their own businesses.

The following hypothesis was tested by means of the Chi-squared test of association:

> *H4: There is an association between income and the type of employment of former NEWP personnel after leaving the program.*

The Chi-squared test of association shows that the null hypothesis can be rejected (P = 1.88E-09) and the association is a highly significant result. There is therefore a proven association between income and the type of employment of former NEWP personnel after leaving the program.

Table 8: Cross tabulation of income and post-termination employment: Chi-squared test for significance.

Post-termination income	Post-termination employment[7]			
	Another firm	Transferred	Unemployed, retired or own business	All
Increased	17 (43%)	6 (16%)	3 (8%)	26 (22%)
Unchanged	14 (35%)	22 (58%)	3 (8%)	39 (34%)
Decreased	9 (23%)	10 (26%)	32 (84%)	51 (44%)
All	40 (100%)	38 (100%)	38 (100%)	116 (100%)
ChiSqr = 46.56, df = 4, P = 1.88E-09				

4.4.2 Association between income and the relatedness of new and previous jobs

The sample data does not indicate a clear association between the income of former NEWP personnel after leaving the program and the relatedness of their new jobs to their previous ones. As shown in Table 9, the income decreased of the majority (57%) of the personnel whose new jobs were completely unrelated or only used their basic skills and professional training in their new jobs. Of those whose new jobs were somewhat related, the income of the majority (50%) were unchanged, of 29% it decreased and of 21% it increased. However, of those whose new jobs were directly related, the income of the majority (39%) also decreased and of 21% it increased.

[7] Some categories were combined in the Chi-squared tests to ensure that no expected frequencies are less than 5. The p-value for this test is unreliable if any of the expected frequencies are less than 5 (Page and Meyer 2000:174).

There is therefore no proven association between the income of former NEWP personnel after leaving the program and the relatedness of their new jobs to their previous ones.

Table 9: Cross tabulation of income and post-termination employment.

Post-termination income	Relatedness of new and previous jobs			
	Unrelated and use of basic skills only	Somewhat related	Directly related	All
Increased	11 (26%)	9 (21%)	6 (21%)	26 (23%)
Unchanged	7 (17%)	21 (50%)	11 (39%)	39 (35%)
Decreased	24 (57%)	12 (29%)	11 (39%)	47 (42%)
All	42 (100%)	42 (100%)	28 (100%)	112 (100%)

4.4.3 Association between post-termination employment and mode of termination

The sample data indicates a strong and direct association between the type of post-termination employment and mode of termination of employment of former NEWP personnel. As shown in Table 10, almost all (90%) of those that resigned joined another firm or started their own businesses. Only a few (10%) of those that resigned were unemployed or went into retirement. The majority (63%) of those that were retrenched or retired were unemployed or went into retirement, and only a third (33%) immediately joined another firm or started their own businesses.

Table 10: Cross tabulation of post-termination employment and mode of termination: Chi-squared test for significance.

Post-termination employment	Mode of termination of employment			
	Resigned	Retrenched & retired	Transferred	All
Firm & Own	28 (90%)	16 (33%)	1 (3%)	45 (38%)
Unemployed & retirement	3 (10%)	31 (63%)	0 (0%)	34 (29%)
Transferred	0 (0%)	2 (4%)	36 (97%)	38 (32%)
All	31 (100%)	49 (100%)	37 (100%)	117 (100%)
ChiSqr = 139, df = 4, P = 4.6E-29				

4.4.4 Association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel

The following hypothesis was tested by means of the Chi-squared test of association:

H3: There is an association between the type of post-termination employment and mode of termination of employment of former NEWP personnel.

The Chi-squared test of association shows that the null hypothesis can be rejected (P = 4.6E-29) and the association is a highly significant result. There is therefore a proven association between the type of post-termination employment and mode of termination of employment of former NEWP personnel.

The sample data indicates a strong and direct association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel. As shown in Table 11, most (56%) of the graduated personnel occupied management positions. Most (73%) of those with diplomas were supervisors or technical specialists. The majority (87%) of those that had no tertiary qualifications were employed in other positions.

The following hypothesis was tested by means of the Chi-squared test of association:

H1: There is an association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel.

The Chi-squared test of association shows that the null hypothesis can be rejected (P = 2.9E-13) and the association is a highly significant result. There is therefore a proven association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel.

Table 11: Cross tabulation of job position and highest tertiary qualification of personnel: Chi-squared test for significance.

	Highest tertiary qualification			
Job position	None	Diploma	Graduated	All
Management	0 (0%)	4 (10%)	35 (56%)	39 (33%)
Supervisors & Technical specialists	2 (13%)	30 (73%)	19 (31%)	51 (43%)
Other	13 (87%)	7 (17%)	8 (13%)	28 (24%)
All	15 (100%)	41 (100%)	62 (100%)	118 (100%)
ChiSqr = 64.7, df = 4, P = 2.9E-13				

4.4.5 Satisfaction Index

A composite *Satisfaction Index* was computed for each respondent using a set of indicators of satisfaction/dissatisfaction as shown in Figure 32. This index is an indicator of the level of satisfaction/dissatisfaction of the former NEWP personnel after they left the program. Multipliers (Xs) are assigned to each response and the Satisfaction Index is computed as the product of the Xs of all seven indicators. A multiplier of more than 1 indicates an increase in satisfaction, whereas a value below one is an indication of dissatisfaction. For example, if a respondent indicated that

his/her income increased after leaving the NEWP, the multiplier is 1.5. If the respondent's income decreased the multiplier is 0.5, and if the income was unchanged, the multiplier is 1. The multipliers are shown in the boxes for each indicator in Figure 32, and the value of the multiplier for the period unemployed is shown in Figure 33.

Since the Chi-squared test of association that will be used for hypotheses testing is appropriate only for discrete dependent variables, the Satisfaction Index was transformed into an ordinal discrete variable by grouping the index values into the following four categories:

Category	Range of Satisfaction Index values
Very dissatisfied	<0.5
Dissatisfied	0.5 – 1.0
Satisfied	1.0 – 1.5
Very satisfied	>1.5

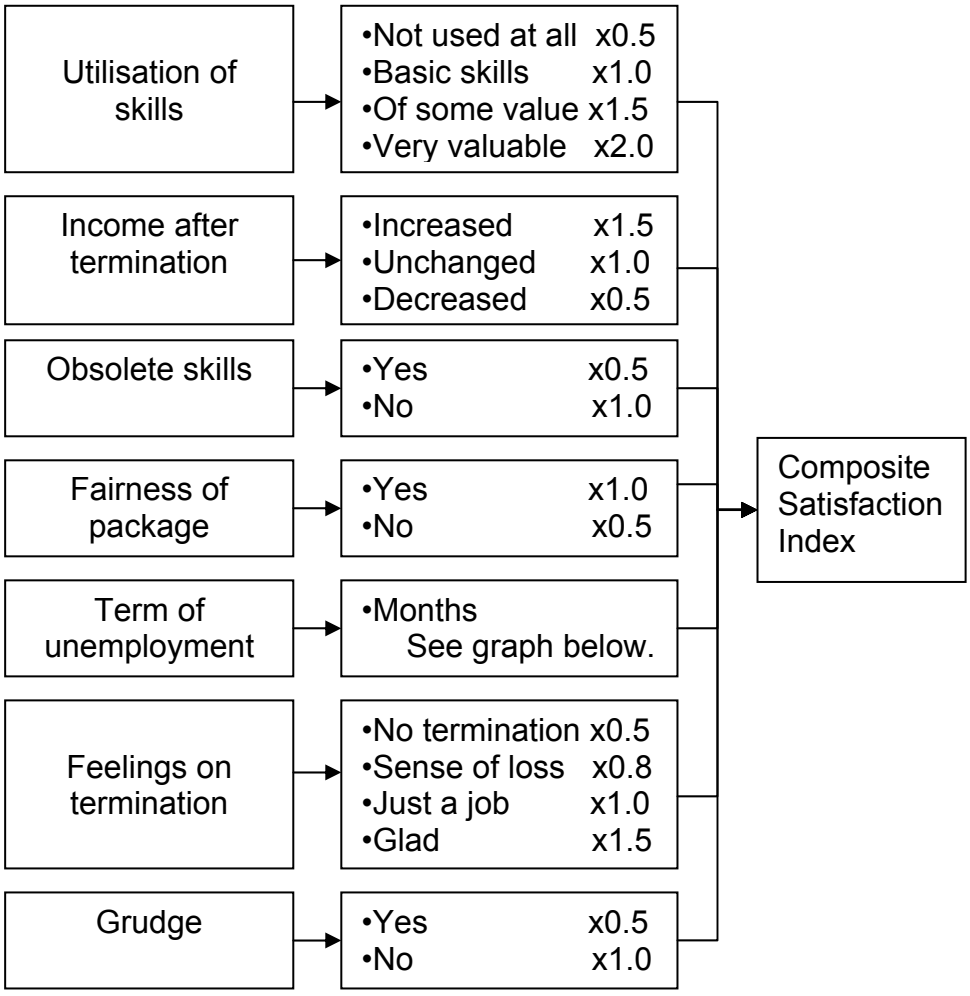

Figure 32: Composite Satisfaction Index.

Figure 33: Satisfaction Index multiplier for period unemployed.

4.4.6 Association between modes of termination of employment and satisfaction

The following hypothesis was tested by means of the Chi-squared test of association:

> *H2: There is an association between the degree of satisfaction/dissatisfaction and the mode of termination of employment of former NEWP personnel.*

The sample data indicates a strong and direct association between the degree of satisfaction/dissatisfaction and the mode of termination of employment of former NEWP personnel. As shown in Table 12, most (89%) of the personnel that were retrenched were either dissatisfied (18%) or very dissatisfied (71%). Most (63%) of the personnel that resigned were either satisfied (22%) or very satisfied (41%). Half (49%) of those that were transferred were either dissatisfied (27%) or very dissatisfied (22%).

The Chi-squared test of association shows that the null hypothesis can be rejected (P = 1.1E-6) and the association is a highly significant result. There is therefore a proven association between the degree of satisfaction/dissatisfaction and the mode of termination of employment of former NEWP personnel.

Table 12: Cross tabulation of satisfaction/dissatisfaction and mode of termination: Chi-squared test for significance.

Satisfaction/ Dissatisfaction	Mode of termination of employment			
	Resigned	Retrenched	Transferred	All
Very dissatisfied	6 (19%)	32 (71%)	8 (22%)	46 (41%)
Dissatisfied	6 (19%)	18 (18%)	10 (27%)	24 (21%)
Satisfied	7 (22%)	0 (0%)	9 (24%)	16 (14%)
Very satisfied	13 (41%)	11 (11%)	10 (27%)	28 (25%)
All	32 (100%)	45 (100%)	37 (100%)	114 (100%)
ChiSqr = 35.68, df = 5, P = 1.1E-6				

4.4.7 Associations between period of unemployment and the age, period employed and qualifications of the unemployed former NEWP personnel

In this section the associations between the period of unemployment and the age, period employed and qualifications of the unemployed former NEWP personnel are investigated. The Pearson correlation coefficients in the following table are all less than 0.3 indicating very weak positive linear correlations between the variables. No meaningful association between the period of unemployment and these variables are therefore demonstrated by the sample data.

Independent variable	Pearson correlation coefficient
Age at termination of employment	0.3
Period employed in NEWP	0.17
Qualifications	0.119

4.5 New hypotheses, theories, models or methods

Five research hypotheses were tested in this research. There were no surprises as most of the hypotheses were supported by the empirical evidence as shown in Table 13. The only hypothesis that was not supported was *H5*.

Table 13: Research hypotheses

H1: There is an association between the job positions occupied in the NEWP and the highest tertiary qualifications of former NEWP personnel. (P16) (p44)	Strong association: Generally the graduated personnel occupied management positions and of those with diplomas were supervisors or technical specialists. (p<1%)
H2: There is an association between the degree of satisfaction/dissatisfaction and the mode of termination of employment of former NEWP personnel. (P18) (p47)	Strong association: Generally those that were retrenched were dissatisfied. Some of those that were transferred were dissatisfied and only those that resigned were satisfied. (p<1%)
H3: There is an association between the type of post-termination employment and mode of termination of employment of former NEWP personnel. (P18) *(p43)*	Strong association: Generally those that resigned joined another firm or started their own businesses. Those that were retrenched or retired were unemployed. (p<1%)
H4: There is an association between income and the type of employment of former NEWP personnel after leaving the program. (p19) (P42)	Strong association: Generally the income of those that joined another firm increased. The income of those that were transferred was unchanged, and the income of those that became unemployed, retired or started their own businesses declined. (p<1%)

H5: There is an association between the income of former NEWP personnel after leaving the program and the relatedness of their new jobs to their previous ones.(p19)	No association was found between their income after leaving the program and the relatedness of their new jobs to their previous ones.

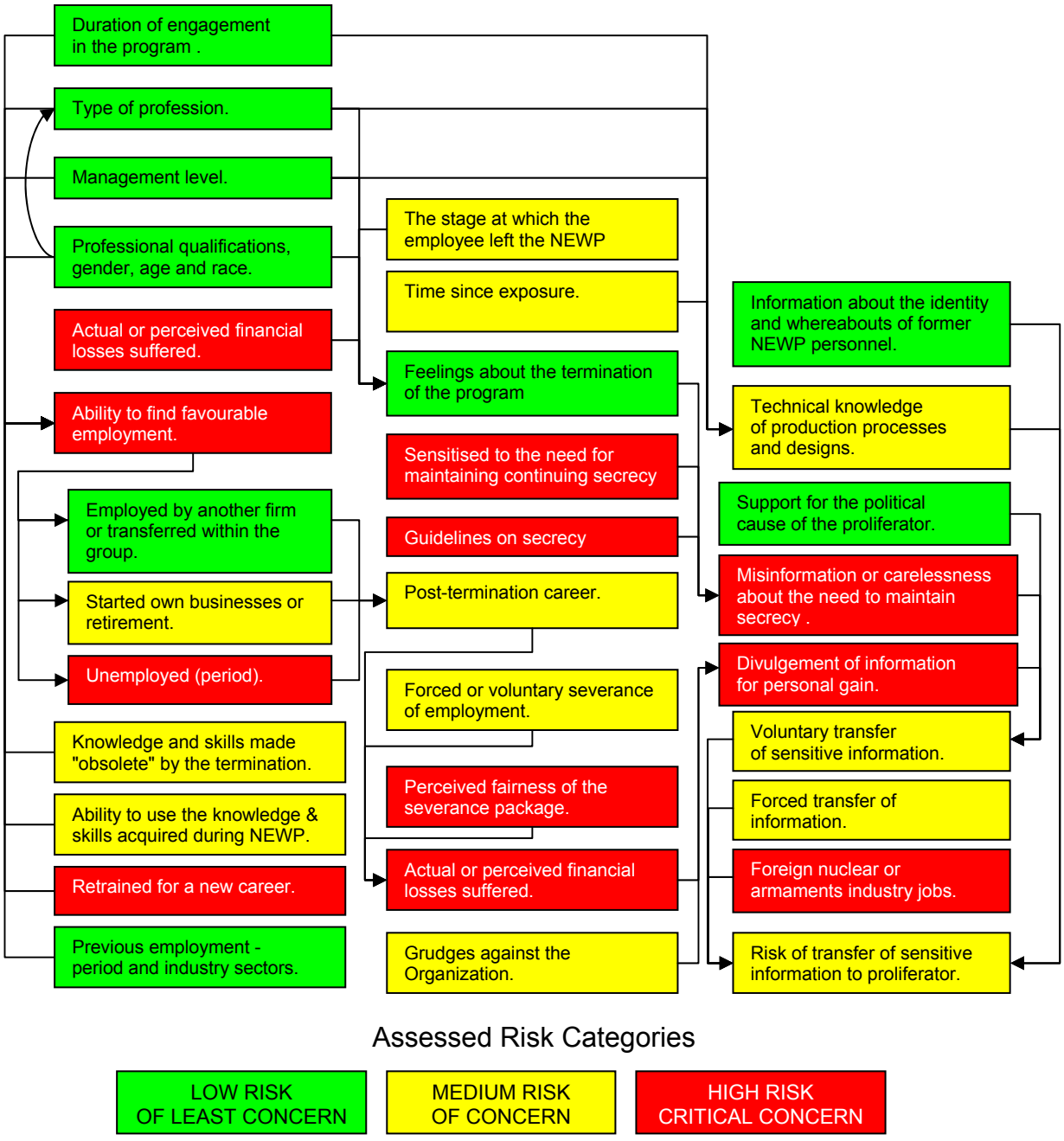

Figure 34: Risk Assessment Model for South Africa's former NEWP personnel

The Risk Assessment Model (Fig 16) was populated with the assessed risk levels indicated with colour codes, as shown in Fig 34, for South Africa's former NEWP

personnel. The high risk issues of critical concern in this case can be reduced to only two matters:

a. Retrenchment related unemployment and financial hardship.

A high proliferation risk profile existed as a consequence of the dominant mode of termination of employment (retrenchment) and the financial compensation received. Most (89%) of the personnel that were retrenched were either dissatisfied (18%) or very dissatisfied (71%). Almost half (47.8%) of those that were retrenched viewed the retrenchment packages they received as unfair, some were extremely dissatisfied and a small fraction had a grudge against the organization. They considered themselves a special case and expected to be treated differently from other armaments industry workers.

The monthly income of 44% of all personnel decreased after termination of their employment in the NEWP and the majority (63%) of those that were retrenched or retired were temporary unemployed. The income declined of the majority (84%) of those that became unemployed, retired or started their own businesses. The median period of unemployment was 6 months. 29% were still employed after one year, 16% after two year and 13% after four years.

Only 37.5% of the personnel indicated that their new jobs were “somewhat related to my previous experience” and that the knowledge & skills gained in the NEWP were of some value. There was therefore clearly a need for retraining. However, only 15.6% of the retrenched personnel indicated that they were retrained.

b. Lack of clear and uniform secrecy guidelines.

Most (67%) of the former NEWP personnel indicated that they were "debriefed" and sensitized to the need for maintaining secrecy about aspects of the nuclear explosives/weapons project after the termination of the project. There was, however, a lot of uncertainty and contradictory views about what guidelines on secrecy should be adhered to.

Given the high proliferation risk profile of South Africa’s former NEWP personnel, it is surprising that to the best of our knowledge none of them became involved in activities of proliferation concern. The only incident that has come to light is that of South African Johan Meyer’s involvement with the AQ Khan network (His accomplices Wisser and Geiges were German and Swiss nationals respectively). Meyer was not a NEWP employee as defined in this study, but was indirectly involved in the program as a former UCOR employee that resigned in 1980, started his own business and became a subcontractor to UCOR supplying process piping for their enrichment plants.

Some insight into the restraints to engage in actions of proliferation concern by former NEWP personnel can be deducted from this case study. These are the following:

- South Africa has a comprehensive set of legislation related to Nuclear Non-Proliferation (See Appendix 7.4), making any actions of proliferation concern criminal offences.

- The NEWP personnel all had Top Secret security clearances. Although it does not provide absolute assurances, one has to appreciate that these are individuals of above-average integrity. They were also accustomed to working with highly classified information and “keeping secrets”.

- They were ideologically aligned with western values and views about issues such as communism, terrorism, religion and culture. Most (51.3%) agreed that terminating the program was the right thing to do in the circumstances the country was in at the time. They had no political agenda to support others acquire nuclear weapons.

- Only about a quarter (25.9%) indicated that they had acquired unique or specialized knowledge and skills that were specific to the nuclear explosives/weapons program. Individuals only received the minimum information to enable them to do their work in accordance with a strict “need-to-know” policy.

- Although 16.4% had worked overseas since they left the NEWP, only 3.4% indicated that they had received nuclear or armaments related job offers outside South Africa after they left the NEWP. These jobs were probably not of proliferation concern, although the exact nature thereof was not investigated.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Research results

The problem statement for this research project was the following:

> *What has been the potential proliferation risk posed by South Africa's former NEWP personnel after the termination of the program in 1991?*

The finding of this study is that the potential proliferation risk posed by South Africa's former NEWP personnel after the termination of the program in 1991 was moderate to high. The risk assessment model developed in this study indicates that although the majority of former NEWP personnel did not pose a proliferation risk, there were a minority that did.
The risk related predominantly to two matters:

1. Retrenchment related unemployment and financial hardship.
2. Lack of clear and uniform secrecy guidelines.

The generalisability of this study is limited by the fact that this is a single-case study.

5.2 Recommendations

This case has found that NEWP personnel see themselves as a special case and expect special retrenchment packages when retrenched. This expectation is not unreasonable given the unique circumstances of their employment and the termination of their employment. The amount of compensation that would be perceived as fair will depend on the specific circumstances. Factors that should be taken into consideration are whether they had already received special remuneration when employed and what their prospects are of finding satisfactory employment in the immediate future. This case study found that there were grounds for such special compensation in the case of South Africa's former NEWP personnel.

It is also important that personnel receive clear and uniform secrecy guidelines. They must be "debriefed" and sensitized to the need for maintaining secrecy about aspects of the nuclear explosives/weapons project after the termination of the project. There should not be any uncertainty and contradictory views about what guidelines on secrecy should be adhered to. These guidelines should be included in any retrenchment agreement.

This case study has highlighted the need for Restraint of Trade Agreements for retrenched personnel when terminating nuclear weapons programs rather than relying only on secrecy laws and standard retrenchment packages. If this was done in the case of South Africa's former NEWP personnel the proliferation risk would have been substantially lowered. The agreement should spell our clearly what restraints are imposed on the former employee. An example of such an agreement is provided in Appendix 7.5.

The retrenchment package should not be viewed as restraint compensation is this would amount to paying someone to not break the law. The motivation would be to compensate the personnel for potential loss of income as suffered by the majority of South Africa's former NEWP personnel.

6. REFERENCES

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7. APPENDIXES

7.1 Research Project Approval

7.2 Survey questionnaire

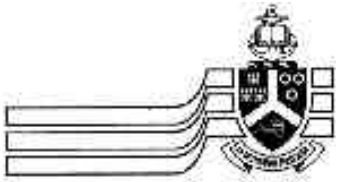
7.3 Chronology of South Africa's Nuclear Program

7.4 South African Legislation related to Nuclear Non-Proliferation

7.5 Restraint of Trade Agreement

7.6 Personal information of researcher

Appendix 7.1 Research Project Approval



Reference number: E/EBIT/01/2004 10 March 2004

Prof AJ Buys
Department of Engineering and Technology Management
UNIVERSITY OF PRETORIA

Dear Prof Buys,

YOUR RECENT APPLICATION TO THE FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

1. I hereby wish to inform you that the research project titled " Investigation of the fate of South Africa's past Nuclear Weapons Programme (NWP) personnel " has been approved by the Committee.

   This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Codes of Research Ethics of the University of Pretoria, if action is taken beyond the approved proposal.

2. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of any member of the Faculty Committee who will deal with the matter.

3. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof. J.J. Hanekom
Chairman: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Appendix 7.2 Survey questionnaire

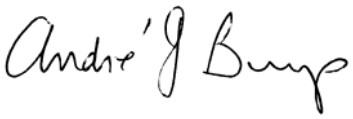
A PLOUGHSHARES FUND RESEARCH PROJECT

INVESTIGATION OF THE FATE OF SOUTH AFRICA'S FORMER NUCLEAR EXPLOSIVES/WEAPONS PROGRAM PERSONNEL

QUESTIONNAIRE

CONFIDENTIALITY UNDERTAKING

Participation in this project is voluntary. The identity of former nuclear explosives/weapons programme personnel will not be disclosed to third parties. Questionnaires are numbered for control and follow-up purposes. Only the chief researcher has access to the names and reference numbers of individuals. The findings of this survey will be made public but will contain only descriptive and inferential statistics. No individual responses will be disclosed.



Prof. André Buys (Chief researcher)
Department of Engineering and Technology Management
University of Pretoria
Phone: 012-420-2829
E-mail: ajbuys@up.ac.za

This research project is supported by the University of Pretoria and the Ploughshares Fund in the USA. The Ploughshares Fund is a public grant-making foundation that supports organizations and individuals working to stop the spread of weapons of war, from nuclear arms to landmines and build regional security.

www.ploughshares.org

Introduction and background

To date, nine countries - Britain, France, China, India, Israel, Pakistan, Russia, South Africa, and the United States - are known to have acquired Nuclear weapons. Of these, South Africa remains the only one that has subsequently dismantled its program. Another four countries - Iran, Iraq, Libya, and North Korea – had active Nuclear Weapons Programs that has been terminated or are currently under consideration for termination. However, the security situation facing many countries such as South Korea, Japan, Taiwan, Algeria, and Yugoslavia continues to raise concerns that they may decide to seek Nuclear weapons in the future. Many terrorist organizations are suspected of currently seeking Nuclear weapons technology.

The fate of the former Nuclear Weapons Program personnel of nuclear and near-Nuclear weapons states is a global non-proliferation concern. Such personnel has specialized knowledge and skills that are of interest to potential proliferators. It is therefore important that research be conducted into this issue. South Africa offers a unique opportunity for such research, as it is the only Nuclear weapons state to date that has terminated and completely dismantled its program.

This study is limited to personnel that were formerly employed by the RO Division of the AEB, Kentron Circle and Advena. This research investigates the fate of South Africa's former nuclear explosives/weapons program personnel. This knowledge will contribute to our understanding of the potential proliferation risk posed by former nuclear explosives/weapons program personnel. This insight will be valuable for the development of appropriate policies and programs to minimize the proliferation risk. This research will be of benefit to governments and international bodies such as the International Atomic Energy Agency, non-governmental organizations and the non-proliferation community at large.

Respondents should be able to complete this questionnaire in a few minutes. It is important to achieve a high response rate for reliable statistical analyses to be performed. Hence, you are kindly requested to please complete the questionnaire and return it to the researcher. Instructions for returning completed questionnaires are found at the end of the questionnaire.

Prof. André Buys 26 March 2004

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

- Do not write your name or other identification on the questionnaire.
- Only enter your personal reference number on page 3.
- If you intend returning the completed questionnaire by e-mail, open the file in MS Word, type your responses in the text boxes next to the questions, save the file and attach it to your e-mail message.
- If you intend returning a hard copy, print the file and complete by hand.

PART 1: PERSONAL INFORMATION

		Month	Year
1.1	Date of birth		

1.2 Gender ☐ Male ☐ Female

1.3 Highest qualification

Diploma ☐ B-degree ☐ M-degree ☐ D-degree ☐

Field of study (e.g. Mechanical Engineering)

PART 2: CAREER PRIOR TO JOINING RO/CIRCLE/ADVENA

2.1 How long were you employed before joining RO/Circle/Advena? ☐ Years

2.2 In which industries?

☐ Nuclear industry (e.g. AEC) ☐ Statutory body (e.g. CSIR)

☐ Defence industry (e.g. Armscor) ☐ Private industry

☐ Defence Force ☐ Self-employed

☐ Civil Service Other:

PART 3: CAREER AT RO/CIRCLE/ADVENA

			Month	Year
3.1	Period employed at RO/Circle/Advena	From:		
		To:		

3.2 Nature of position at RO/Circle/Advena:

☐ Management ☐ Technical specialist / expert

☐ Supervisor ☐ Other

3.3 Profession or occupation at RO/Circle/Advena:

☐	Engineer	☐	Scientist
☐	Technician or artisan	☐	Non-technical professional (e.g. finance, human resources)
☐	Administrative (e.g. clerk, secretary)	☐	Security official
☐	Support staff (e.g. cleaner, driver, gardener)	Other:	☐

PART 4: TERMINATION OF EMPLOYMENT

4.1 Under what circumstances did you leave RO/Circle/Advena?

☐	Resignation	☐	Transfer within group
☐	Retrenchment	☐	Normal retirement
☐	Dismissal	☐	Early retirement

4.2 Retrenchment (Skip this question if you were not retrenched)

4.2.1 Did you receive a retrenchment package? Yes ☐ No ☐

4.2.2 Did you consider the package as “fair”? Yes ☐ No ☐

4.3 Did you have unique or specialized knowledge and skills that were so specific to the nuclear explosives/ weapons program that it was made "obsolete" by the termination of the program? Yes ☐ No ☐

4.4 Which of the following statements describes your feelings about the termination of the program? (You may mark more than one.)

☐ The government should not have terminated the program. South Africa should have remained a Nuclear weapons state.

☐ As long as I had a job or were fairly compensated, I didn’t care. Working at RO/Circle/Advena was just a job to me.

☐ I experienced a sense of loss. I was proud about working at RO/Circle/Advena and found it hard to do “ordinary” work again.

☐ I was glad the program was terminated. It was the right thing to do in the circumstances the country was in at the time.

4.5 Did you have a grudge against the organisation when you left? Yes ☐ No ☐

What were the reasons for your grudge? (Voluntary information)

4.6 Were you retrained after the termination of the project? Yes ☐ No ☐

4.7 If you were retrained, who offered this training and who paid for it?

Trained by ☐ Paid by ☐

4.8 Were you "debriefed" and sensitised to the need for maintaining secrecy about aspects of the nuclear explosives/weapons project? Yes ☐ No ☐

4.9 Indicated what guidelines on secrecy you received, if any.

☐ Everything remains top secret. I may disclose nothing.

☐ Only the technical details of nuclear explosives/weapons design and production processes remains classified and may not be disclosed.

☐ The identity of former colleagues may not be disclosed.

Any other guidelines:

PART 5: POST-TERMINATION CAREER

5.1 What happened to you immediately after you left RO/Circle/Advena?

☐ Employed by another firm ☐ Transferred within group

☐ Started own business ☐ Went into retirement

☐ Unemployed→Period unemployed: ☐ months.

5.2 To what extent were you able to use the knowledge and skills you acquired at RO/Circle/Advena in your next job?

☐ My new job was completely unrelated to my previous experience. Knowledge & skills gained at RO/Circle/Advena were not used at all.

☐ Only my basic skills and professional training were of value in my new job. Experience gained at RO/Circle/Advena was not of much value.

☐ My new job was somewhat related to my previous experience. Knowledge & skills gained at RO/Circle/Advena were of some value.

☐ My new job was directly related to my previous experience. Knowledge & skills gained at Circle/Advena were very valuable.

5.3 What was the effect of leaving RO/Circle/Advena on your monthly income?

☐ Increased ☐ Unchanged ☐ Decreased

5.4 Have you received nuclear or armaments related job offers outside South Africa? Yes ☐ No ☐

5.5 Have you worked overseas since you left RO/Circle/Advena? Yes ☐ No ☐

5.6 If you are aware of any former colleagues who have worked overseas since leaving RO/Circle/Advena, please give details: (Voluntary information)

INSTRUCTIONS FOR RETURNING THE COMPLETED QUESTIONNAIRE

By e-mail: Attach the file to e-mail and send to: ajbuys@up.ac.za.
By fax: Send the completed questionnaire by fax to tel.: (012) 362-5307.
By mail: Post the completed questionnaire to:
Prof. A. J. Buys
Department of Engineering and Technology Management
University of Pretoria
PRETORIA 0002
By hand: Deliver the completed questionnaire to:
Prof. A. J. Buys, Room 4-9, Engineering II Building
University of Pretoria Campus
Lynnwood Road, Hatfield, Pretoria

Appendix 7.3 Chronology of South Africa's Nuclear Program

PHASE 1 (1915-1966) - MAJOR URANIUM SUPPLIER TO USA AND UK NUCLEAR WEAPONS PROGRAMS

DATES	MAJOR MILESTONES
1915	Discovery of radioactive minerals in South Africa by Dr A. W. Rogers.
1923	Discovery of uranium-bearing ore in South African gold mines by R. A. Cooper.
1944 - 1945	Supply of South African uranium ore to the USA and UK as part of the WWII nuclear bomb program - the "Manhattan project". The extraction of the uranium from the ore was done overseas. (The nuclear bomb attacks on Hiroshima and Nagasaki were on 6 and 9 August 1945.)
1946	South Africa decides to undertake local extract of the uranium from the gold mine dumps. Development of extraction technology commenced.
1952	First local production of uranium at the West Rand Consolidated gold mine.
1952 - 1959	South Africa became a major supplier of uranium for the USA and UK Nuclear weapons stockpile.
1957	South Africa and the United States signed a 20-year agreement under the Eisenhower Administration's Atoms for Peace programme. This agreement covered the purchase of a research reactor from the USA and the enriched uranium needed to run it.
1959	Uranium production reaches a peak of 6 400 tons produced by 27 mines and 17 treatment plants. The requirements from the West's Nuclear Weapons Programs started dropping after this date.
1959 to date	South Africa remains one of the major uranium producers in the world. Production declined to 3200 tons by 1974 but increased again after that. South Africa possesses the second largest uranium reserves in the Western world - uranium reserves in Namibia and South Africa amounts to approximately 17 per cent of the world total.
1966	US Government uranium purchase contracts ended.

PHASE 2(1946-1982) - THE CIVILIAN NUCLEAR ENERGY PROGRAM

DATES	MAJOR MILESTONES
1946	Establishment of the CSIR and start of a local nuclear research programme.
1948	Establishment of the South African AEB (AEB) to control the civilian nuclear programme.
1955	First locally designed and constructed 16 MeV cyclotron nuclear research accelerator in operation.
1956	South Africa is one of the founder members of the International Atomic Energy Agency (IALA) ~d represents Africa on the Board of Governors.
1957	Agreements signed with the USA and UK for the joint development of nuclear technology for civilian application.
1961	A new method for uranium enrichment invented by Dr Grant of the AEB

	initiated a secret research and development program to investigate the commercial feasibility of his invention. (Uranium has to be "enriched" before it can be used in nuclear power stations.)
1961	Establishment of the AEB 's National Nuclear Research Centre at Pelindaba, west of Pretoria.
1962	Start of an independent local research and development programme for a new nuclear power reactor concept - the PELINDUNA programme - at Pelindaba.
1963	South Africa signs the Partial Test Ban Treaty (PTBT) prohibiting nuclear tests in the atmosphere.
1963	Van der Graaff nuclear research accelerator in operation at Pelindaba.
1965	South Africa's first nuclear reactor - the SAFARI-1 research reactor - in operation. The enriched uranium fuel was supplied by the USA.
1965	First uranium enrichment achieved in a laboratory at Pelindaba.
1967	The indigenously built PELINDUNA critical facility completed.
1969	Termination of PELINDUNA reactor development project in favour of the uranium enrichment project that had better commercial potential.
20 July 1970	Public announcement that South African scientists had developed a new and unique uranium enrichment process.
1970	Establishment of the Uranium Enrichment Corporation (UCOR) for the commercial enrichment of uranium. Construction of the pilot enrichment plant - Y-Plant - starts at Valindaba.
1971	Escom invites tenders for a nuclear power station in the West Cape.
1974	USA informs SA that they will no longer supply nuclear fuel for the SAFARI-1 research reactor, effectively terminating the 1957 agreement. The programme for local production of fuel started.
August 1976	Escom signs contract with the French-based consortium Framatome for the construction of the Koeberg nuclear power station.
1976	South Africa expelled from the Board of Governors of the IAFA.
1977	UCOR' 5 pilot uranium enrichment plant (Y-plant) began producing enriched uranium for the Safari research reactor and later also for the Koeberg nuclear power station. This plant also produced highly enriched uranium (HEU).
1982	UCOR and AEB merge to form the Atomic Energy Corporation (AEC). Construction of the commercial uranium enrichment plant - Z-Plant - starts at Valindaba.
1984	Koeberg- 1 nuclear power station in operation.
1985	Koeberg-2 nuclear power station in operation. The commercial uranium enrichment plant (Z-Plant) started producing fuel for the Koeberg power station.
1985 to the present.	The civilian nuclear energy program continues under the auspices of the AEC. The main activities are in the fields of radioisotope production for medical and industrial use and new uranium enrichment technology (the Z-plant was closed in 1995).

PHASE 3(1965-1980) - PNE PROGRAM

DATES	MAJOR MILESTONES
1965 - 1968	The high-profile American PLOUGHSHARE program for the peaceful use of nuclear explosives creates much interest internationally. South African scientists participate in international conferences on the peaceful use of nuclear explosives.
1969	The AEB established an internal committee to investigate the economic and technical aspects of using PNE for mining and civil construction (e.g. dams and harbours).
1971	A program team, consisting of only native South African nuclear scientists and engineers, appointed to conduct the secret PNE Program.
1971 - 1977	Research, design and development of PNE. Preparations for scientific underground testing of PNE. (South Africa had signed the Partial Test Ban Treaty (PTBT) in 1963 prohibiting nuclear tests in the atmosphere.)
1973 - 1977	Development of the VASTRAP Underground Nuclear Test Site in the Kalahari Desert, north of Upington. Two test shafts were completed.
1977	Y-Plant began producing highly enriched uranium (HEU).
August 1977	Discovery of nuclear test site by Soviet and USA surveillance satellites. The test shafts were sealed and the terrain temporary vacated. Termination of the program for scientific underground testing of PNE.
1979	Completion of the first nuclear explosive.
1980	Termination of PNE Program by the AEB. Key personnel and equipment transferred to Armscor.

PHASE 4(1977-1989) - THE NUCLEAR WEAPONS PROGRAM

DATES	MAJOR MILESTONES
1976 - 1977	Turning point in SA's security situation as Soviet and Cuban military intervention in Angolan civil war escalates. The Government appoints a team to investigate the strategic and technical aspects of using the PNE' technology as a military deterrent.
4 Nov. 1977	UN Security Council Resolution 418 (mandatory arms embargo) adopted at the 2046th meeting. The Security Council, "gravely concerned that South Africa is at the threshold of producing Nuclear weapons,... decides that all States shall refrain from any co-operation with South Africa in the manufacture and development of Nuclear weapons.
1978	Nuclear deterrent strategy adopted by Government. Top secret Nuclear Weapons Program launched. The program team consisted of only native South African scientists and engineers.
22 Sept. 1979	US Vela satellite detected a light flash similar to that from an atmospheric nuclear explosion in the South Atlantic. An US scientific inquiry found that the signal was probably not from a nuclear explosion. They considered it more likely that the signal was a consequence of the impact of a small meteoroid on the satellite. If this were a nuclear test, South Africa was not involved.
1978 -	Development of threat dependant 3-phase nuclear deterrent strategy:

1986	Threat: Political isolation but no major military threat. Phase 1 Strategy of uncertainty - the nuclear capability would be neither acknowledged nor denied. Threat: Escalating military threat. Phase 2 Covert notification - covert announcement of Nuclear weapons capability to Western governments to persuade them to come to SA's assistance. Threat: Major military treat. Phase 3 Overt deterrent - Public announcement of Nuclear weapons capability, followed by an underground explosion if required to demonstrate capability. To ensure that the deterrent strategy would be credible, fully operational Nuclear weapons were developed and manufactured. The actual use of these Nuclear weapons against an enemy was however never part of the strategy as this was considered a suicidal action.
1980	Construction of Armscor's Kentron Circle Nuclear weapons facility at the Elandsfontein Vehicle Test Range west of Pretoria.
1982	Production of first nuclear weapon (unguided aircraft bomb) at Kentron Circle. The AEC's first PNE was transferred to Armscor and retained as an underground demonstration device as part of the deterrent strategy.
1981 - 1989	Development and production of a total of seven nuclear warheads for locally designed aircraft-launched guided weapons and for underground testing. Simultaneously, a Nuclear weapons technology research project (theoretical studies and limited experimental work but no actual development of prototypes) was undertaken. This project looked at advanced types of nuclear explosives and delivery systems.
1986-1987	Major armed conflict in Angola prompts SA to prepare to move to phases 2 and 3 of the deterrent strategy. The nuclear test site is reactivated and one test shaft is cleared for possible use. Kentron Circle was renamed Advena and additional facilities were constructed.
1988	Cessation of hostilities in Angola leading to the withdrawal of Cuban and SA troops and independence of Namibia.
1989	Government approves the termination of the Nuclear Weapons Program as the foreign military threat has disappeared.

PHASE 5(1990-1997) - THE POST NUCLEAR WEAPONS ERA

DATES	MAJOR MILESTONES
1990	Closure of the Y-Plant, used for the production of HEU.
1990 - 1991	Dismantling of the nuclear warheads. The HEU was returned to the AEC.
1991	On 10 July 199 1, South Africa acceded to the Nuclear Non-Proliferation Treaty (NPT). The safeguards agreement entered into force on 16

	September 1991. On 30 October 1991 South Africa submitted a complete inventory of all nuclear materials and facilities to the IAFA.
1992 - 1993	Destruction of nuclear warhead components and all related documentation.
24 March 1993	Announcement of the dismantling of South Africa's Nuclear Weapons Program to a joint session of Parliament.
2-12 June 1993	Public backfilling of nuclear test shafts.
23 June 1993	Parliament passes the *Non-proliferation of Weapons of Mass Destruction Act (Act 87 of]993).* The aim of this act is to prevent the proliferation and development of Weapons of Mass Destruction (Nuclear, Biological and Chemical Weapons) and eliminate such weapons. This act established the SA Council for the Non-proliferation of Weapons of Mass Destruction to control and manage matters relating to the proliferation of such weapons in the Republic.
1994	SA became a member of the Zangger Committee, which endeavours to control certain nuclear material and equipment.
3 April 1995	SA became a subscribing member of the Nuclear Suppliers Group (NSG). This Group endeavours to control nuclear related dual-use equipment, materials and technology
11 April 1996	Pelindaba Agreement - Africa Nuclear Free Zone and Test Ban Treaty -signed. Will be ratified after 28 signatures of OAU countries and five nuclear powers.
24 Sept. 1996	SA signed the Comprehensive Nuclear Test Ban Treaty. This treaty was signed by all 40 nuclear potential states, except India that refused to sign.

Appendix 7.4 South African Legislation related to Nuclear Non-Proliferation

Extracted and reproduced from:
http://www.thedti.gov.za/nonproliferation/pdf/Annexure3toGuidelinesICP.pdf

The control, including safety measures, over goods, services and technology related to Nuclear Non-Proliferation are addressed in various Acts, Regulations and Notices.

1. Weapons of Mass Destruction

The Non-Proliferation of Weapons of Mass Destruction Act, 1993 (Act No. 87 of 1993) as amended in 1995, 1996 and 2005 and supported by the following supporting Regulations and Notices:

(a) **The Missile Technology Control Regime Equipment and Technology** are declared as controlled goods in terms of Section 13 of the Non-Proliferation Act. Notice No. 311 dated 11 April 2007, replaces Notice No. 429 dated 10 April 2002.

(b) **The Nuclear Dual-use Goods and related items of the Nuclear Suppliers Group** are declared as controlled goods in terms of Section 13 of the Non-Proliferation Act under Regulation R.1790, dated 14 October 1994, replaced by Government Notice No. 430 dated 10 April 2002. A Notice on the control of nuclear related stable isotope separation technology and equipment that could be used in Uranium isotope separation has been promulgated on 11 April 2007, Notice No. 310.

(c) **"Catch-All",** Regulation R. 75, dated 29 January 2004 - enables the NPC to declare goods, that are mentioned in the controlled lists but do not comply fully with the specifications mentioned, to be controlled if there is a reasonable suspicion that it may be applied in a WMD programme.

(d) **The Wassenaar Arrangement** list of Dual-Use Goods, Technologies and Munitions was promulgated in Government Gazette No. 26372 dated 28 May 2004 under the National Conventional Arms Control Act, 2002 (Act No. 41 of 2002).

2. Nuclear materials

(a) The nuclear materials controlled under the Nuclear Energy Act, 1999 (Act No. 46 of 1999) are listed in Government Notice No. 740 dated 16 April 1994 and are those items listed in the **Zangger** list of items. The possession, use, disposal and processing of nuclear material and especially designed or prepared (EDP) items are controlled by the Department of Minerals and Energy (DME) in terms of the Nuclear Energy Act, 1999 (Act No. 46 of 1999) and its supporting Regulations and Notices.

(b) Dual-use nuclear-related items are controlled in terms of the Non-Proliferation of Weapons of Mass Destruction Act, 1993 (Act No. 87 of 1993).

(c) National Nuclear Regulator Act, 1999 (Act No. 47 of 1999).

(d) Hazardous Substances Act, 1973 (Act No. 15 of 1973); This act covers radioactive materials outside a nuclear installation, they are classified as Group IV hazardous substances.

3. Other relevant legislation

Note: (This list is not an exhaustive list and there may be more Acts that may be relevant. The Acts may also have been amended. Visit http://www.gov.za/documents)

(a) Aviation Act, 1962 (Act No. 74 of 1962)

(b) Criminal Law Second Amendment Act, 1992 (Act No. 126 of 1992)

(c) Cross-Border Road Transport Act, 1998 (Act No. 4 of 1998)

(d) Customs and Excise Act, 1964 (Act No. 91 of 1964)

(e) Defence Act, 2002 (Act No. 42 of 2002)

(f) Explosives Act, 2003 (Act No. 15 of 2003)

(g) Interception and Monitoring Prohibition Act, 1992 (Act No. 127 of 1992)

(h) Internal Security Act, 1982 (Act No. 74 of 1982)

(i) International Trade Administration Act, 2002 (Act No. 71 of 2002)

(j) Maritime Zones Act, 1994 (Act No. 15 of 1994)

(k) National Conventional Arms Control Act, 2002 (Act No. 41 of 2002)

(l) National Environmental Management Act, 1998 (Act No. 107 of 1998)

(m) National Road Traffic Act, 1996 (Act No. 93 of 1996)

(n) Protection of Constitutional Democracy against Terrorist and Related Activities Act, 2004 (Act No. 33 of 2004)

(o) Protection of Information Act, 1982 (Act No. 84 of 1982)

(p) Regulation of Foreign Military Assistance Act, 1998 (Act No. 15 of 1998)

(q) Space Affairs Act, 1993 (Act No. 84 of 1993)

Appendix 7.5 Restraint of Trade Agreement

RESTRAINT OF TRADE AGREEMENT

between

……

and

……

1 In this agreement, unless a contrary intention clearly appears:

1.1	"business"	means the South African nuclear weapons program, including all the organisations, employees, agents and suppliers directly or indirectly involved therein at any time.
1.2	"controlled activity"	means the development, production, acquisition, stockpiling, maintenance or transit of any nuclear weapon.
1.3	“controlled goods”	means goods which may contribute to the design, development, production, deployment, maintenance or use of nuclear weapons.
1.4	"the covenanter"	means …..
1.5	"person"	includes any individual, group, organisation, company, close corporation, partnership, business, concern, undertaking, enterprise or any other instance having a legal personality;
1.6	“nuclear weapon”	means any weapon designed to kill or harm people, animals or plants through the effects of a nuclear explosion, and includes a delivery system exclusively designed, adapted or intended to deliver such weapons.

2 The covenanter hereby undertakes that he will for an indefinite period, either alone or jointly or together with any other person:

2.1 not be interested or engaged in any capacity whatsoever, including, but without prejudice to the generality of the foregoing, as trustee, proprietor, shareholder, member, manager, director, adviser, consultant, partner, employee, financier or agent in or for any person which is directly or indirectly engaged, interested or concerned in a

controlled activity in the Republic of South Africa or in any other state or territory outside the Republic.

2.2 not engage in the import, export, re-export, transit and use of controlled goods, unless authorised by the South African Council for Non-Proliferation of Weapons of Mass Destruction and subject to a permit issued by the said Council.

2.3 not disclose any technical or trade secrets and/or confidential information relating to the design, development, manufacture, maintenance, import, export, re-export, transit, supply or storage of nuclear weapons and controlled goods, including (but not be limited to) all and whatever information relating to the business and its suppliers.

3 The covenanter acknowledges and agrees that the restraints imposed upon him in terms of this agreement are reasonable as to subject matter and period and are necessarily required for the non-proliferation of nuclear weapons.

THUS DONE AND SIGNED AT …… ON ……..

_____

COMPANY

_____

COVENANTER

Appendix 7.6 Personal information of researcher

Name: Prof. André J Buys

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0002
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Academic record: B.Eng. (Mechanical Engineering), University of Pretoria (1969)
M.Sc. (Nuclear Engineering), University of Cape Town (1970)
D.Eng. (Nuclear Engineering), University of Pretoria (1976)

Work history :
- 1971 - Research engineer at the AEB (AEB).
- 1976 - Head of the Nuclear Engineering Sub-Division at AEB.
- 1981 - Plant Manager of the Kentron Circle Nuclear weapons Facility, an affiliated company of the Armaments Corporation of South Africa (Ltd) (Armscor).
- 1987 - Managing Director of Milistan Pty. (Ltd), an affiliated company of Armscor.
- 1990 - General Manager: Planning of the Armscor group.
- 1998 - Director of the Institute for Technological Innovation, University of Pretoria
- 2002 - Professor in the Department of Engineering and Technology Management, University of Pretoria.

