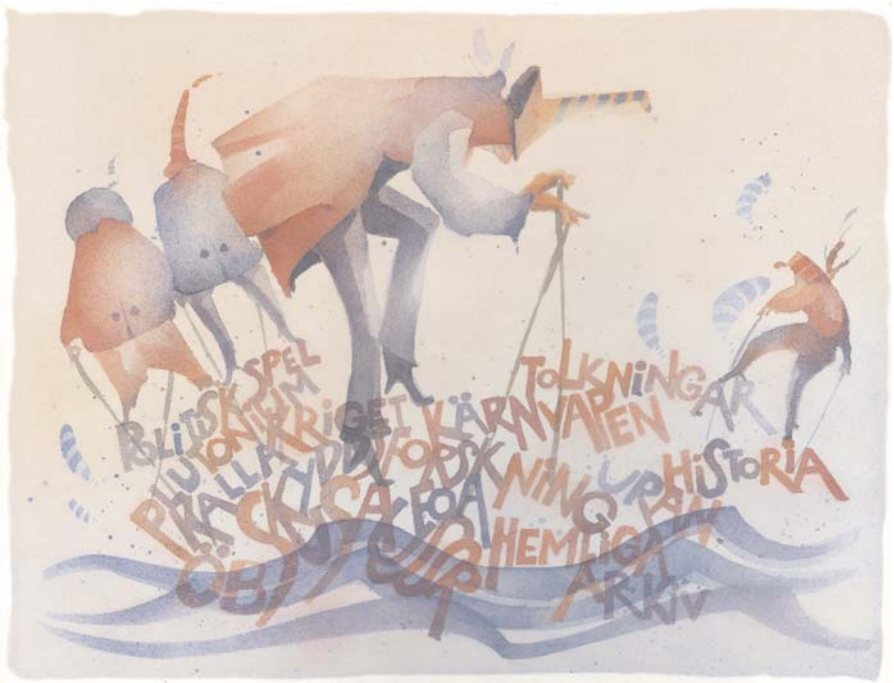
SKI Report 01:33

Research

Sweden and the Bomb

The Swedish Plans to Acquire Nuclear Weapons, 1945–1972



Dr Thomas Jonter
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SKI's perspective

Background

In the year 1998 Sweden, together with the rest of the states in the European Union and Euratom signed the Additional Protocol to the Safeguard Agreement with the International Atomic Energy Agency, IAEA. The Additional Protocol gives the Agency extended complimentary access to areas and buildings and rights to take environmental samples within a state. The process of ratification is going on with the intention that the protocol should be implemented simultaneously in all member states. In ratifying the agreement in May 2000, Sweden changed its Act on Nuclear Activities and passed a new law regarding inspections. The present estimate is that the protocol could be implemented by the end of 2002 after ratification in all EU states.

Aim

When the Additional Protocol is implemented, Sweden is to be "mapped" by the IAEA, scrutinising all nuclear activities, present as well as future plans. In the light of this, SKI has chosen to go one step further, letting Dr Thomas Jonter of the Department of History at Uppsala University investigate Sweden's past activities in the area of nuclear weapons research in a political perspective. Dr Jonter has studied the Swedish National Defence Research Institute's (FOA) activities in this area up until today. Dr Jonter has previously done similar work for SKI and this report is based on archives that are no longer classified.

Since Sweden had plans in the nuclear weapons area it is important to show to the IAEA that all such activities have stopped. This is the main objective with this report.

Results

Dr Jonter has made a survey of available sources in the archives of FOA. The survey has a political and structural character rather than technical and the conclusions and views put forward in this report are his own and is not necessarily the view of SKI. SKI's conclusion from this report is that the issue of Sweden's nuclear ambitions is thoroughly elucidated showing that Sweden's research in the area is ended.

Continued efforts in this area of research

Dr Jonter will, on a contract from SKI, describe his research and present a model that the IAEA can use in its investigation of a state's nuclear activities. Additionally, Dr Jonter will on his own part analyse the political assessments made whether or not the Swedish defence should have been equipped with nuclear weapons.

Effect on SKI's activities

This report, which is a translated and revised version of the Swedish report (SKI Report 01:5), will be submitted as a part of the Swedish State Declaration according to the Additional Protocol. With this research done, SKI is able to show that Sweden's ambitions in the field of producing nuclear weapons research is over.

Project information

Dr Kåre Jansson has been responsible for the project at SKI.

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SKI Project Number 00084

Contents

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The former associate professor Anders Fröman at the Swedish National Defence Research Institute (FOA) has also read the report. His comments have in many respects shed light on many technical misunderstandings in the first draft. Even though he does not agree on all my conclusions, especially so concerning the analysis of the so-called protection research of FOA, I really appreciate his helpful attitude.

The comments of emeritus professor Nils Göran Sjöstrand, at the Department of Reactor Physics at Chalmers University of Technology have been of much value for the revised and English version of this report.

Finally I would like to pay my gratitude to SKI who financially supported this investigation and at the same time emphasise that the conclusions of this report are mine only.

Summary

This study analyses the Swedish nuclear weapons research since 1945 carried out by the Swedish National Defence Research Establishment (FOA). The most important aspect of this research was dealing with protection in broad terms against nuclear weapons attacks. However, another aspect was also important from early on – to conduct research aiming at a possible production of nuclear weapons. FOA performed an extended research up to 1968, when the Swedish government signed the Non-Proliferation Treaty (NPT), which meant the end of these production plans. Up to this date, five main investigations about the technical conditions were made, 1948, 1953, 1955, 1957 and 1965, which all together expanded the Swedish know-how to produce a bomb.

The Swedish plans to procure nuclear weapons were not an issue in the debate until the mid-50's. The reason for this was simple, prior to 1954 the plans were secretly held within a small group of involved politicians, military and researchers. The change of this procedure did take place when the Swedish Supreme Commander in a public defence report in 1954 favoured a Swedish Nuclear weapons option.

In 1958 FOA had reached a technical level that allowed the parliament to make a decision. Two programs were proposed – the L-programme (the Loading Programme), to be used if the parliament would say yes to a production of nuclear weapons, and the S-programme (the Protection Programme), if the parliament would say no. The debate on the issue had now created problems for the Social Democratic Government. The Prime Minister, Tage Erlander, who had earlier defended a procurement of nuclear weapons, was now forced to reach a compromise. The compromise was presented to the parliament in a creative manner that meant that only the S-programme would be allowed. The government argued that the technical level did allow a 'freedom of action' up to at least the beginning of the 60's when Sweden was mature to make a decision on the issue. During this period of 'wait and see' FOA was not allowed to conduct research directed towards producing nuclear weapons. On the other hand, it was stated that it was impossible to make a clear-cut line between protection and construction research within a freedom of action. The parliament accepted the government's recommendation.

Was then protection research the only research that was performed? The question has been under debate in the media and also the issue for one government investigation. Former classified FOA documents have now been released and enabled this study. The conclusion of this report is that FOA went further in its efforts to make technical and economical estimations than the defined S-programme allowed, at least in a couple of instances. The findings in this report support the assumption that it was a political game that made the Swedish government to introduce the term protection research to escape criticism, while in practical terms construction research was performed in order to obtain technical and economical estimations for a possible production.

A second finding of this report is that Sweden reached latent capacity to produce nuclear weapons in 1955. This is at least two years earlier than what is normally accepted in the international literature on nuclear proliferation. For example, in Stephen M Meyer's classical study *The Dynamics of Nuclear Proliferation*, Sweden is said to have reached latent capacity in 1957. Meyer's study refers to another study in this respect. An analysis of the declassified documents from FOA concludes that this is at least two years to late.

A third aim of this report is to analyse the de-commissioning of the nuclear weapons research after the NPT was signed in 1968.

The fourth aim is to investigate how much plutonium, natural and depleted uranium and heavy water FOA had at its disposal within the research programme. The result of this investigation is given in appendix 2.

Sammanfattning

I denna undersökning har Försvarets forskningsanstalts (FOA) kärnvapenforskning sedan 1945 analyserats. Sverige hade sedan slutet av 40-talet planer på att skaffa egna kärnvapen. En omfattande forskning på området bedrevs vid FOA fram till 1968, då Sverige undertecknade avtalet om icke-spridning av kärnvapen, vilket innebar att planerna övergavs. Under denna tid gjordes fem stora utredningar om de tekniska förutsättningarna för en tillverkning – 1948, 1953, 1955, 1957 och slutligen 1965 – som steg för steg flyttade fram den svenska kunskapsnivån på kärnvapenområdet.

Frågan om svenska kärnvapen blev inte ett debattämne förrän i mitten av 50-talet. Innan dess var det enbart en liten krets av politiker, militärer och forskare som intresserat sig för en eventuell anskaffning. När väl FOA:s forskning nått den nivå att ett beslut i frågan kunde tas, togs två program fram – L-programmet (laddningsprogrammet), vilket kunde genomföras om riksdagen sade ja, och S-programmet (skyddsprogrammet), om riksdagen sade nej. Detta skedde 1958 och riksdagen gick till beslut i juli samma år. Mot bakgrund av att frågan började splittra landet och riksdagen – detta gällde i synnerhet socialdemokratin, där till och med regeringen var splittrad – lades en proposition fram i vilken enbart skyddsforskning skulle få bedrivas. I propositionen hävdades att ett rådrum hade uppstått eftersom den tekniska nivån tillät minst ett par års forskning innan ett avgörande beslut kunde tas. Den skyddsforskning som skulle få utföras fick inte ske i direkt syfte att få fram underlag för en framställning av kärnvapen. Riksdagen antog propositionen.

Var det då skyddsforskning som bedrevs? Frågan har genom åren debatterats i media och varit föremål för en statlig utredning.

Denna studie har kommit fram till att FOA överskred gränsen för vad som fick göras inom ramen för denna skyddsforskning åtminstone vid ett par tillfällen. Det mesta talar för att det var ett politiskt spel som fick den socialdemokratiska regeringen att lansera skyddsforskningen.

Den andra huvudfrågan handlar om att mot bakgrund av den vetenskapliga diskussionen om kärnvapenspridning (nuclear proliferation) sätta in Sveriges forskning på området i ett internationellt sammanhang. I denna diskussion har Sverige ansetts vara ett vetenskapligt och kärnenergitekniskt avancerat land som avstod från att tillverka kärnvapen trots att de tekniska förutsättningarna ansågs finnas. I den internationella diskussionen har det varit allmänt vedertaget att Sverige uppnådde en latent förmåga att påbörja konkreta förberedelser för kärnvapentillverkning i slutet av 50-talet. Exempelvis anger Stephen M Meyer i sin klassiska studie *The Dynamics of Nuclear Proliferation* att detta skedde 1957. I den här undersökningen har jag funnit att mycket talar för att detta skedde redan 1955. Det är två år tidigare än vad som brukar anges i den internationella litteraturen om kärnvapenspridning.

Den tredje huvudfrågan gäller att följa upp hur kärnvapenverksamheten avvecklades efter Sveriges undertecknande av avtalet om icke-spridning av kärnvapen 1968 (eller, om man så vill, hur den svenska skyddsforskningen utformades efter det att avtalet ingicks).

Den fjärde huvudfrågan hade till uppgift att besvara hur mycket plutonium, uran (naturligt och utarmat) samt tungt vatten FOA har haft till sitt förfogande inom ramen för den bedrivna forskningen. Resultaten redovisats i bilaga 2.

1. The aims of the report and the issues it deals with

This study was carried out as part of a project at the Swedish Nuclear Power Inspectorate (Statens Kärnkraftinspektion, SKI), begun in 1998, to make a historical review of Swedish nuclear weapons research during the period 1945-2000. SKI is the body responsible for ensuring that Sweden complies with the international treaty on non-proliferation of nuclear weapons, ratified in 1970. By carrying out independent scientific reviews of Swedish nuclear energy and weapons policy, Sweden reinforces its international credibility in the area of non-proliferation.

This ambition became even stronger in 1998, when Sweden signed an Additional Protocol to the safeguard agreement. By signing this Additional Protocol, the Swedish government undertook not only to report on current nuclear activity but also to declare proposed future activity. But SKI has decided to go one step further and include what took place in the past. Although the additional protocol does not compel member states to carry out such historical reviews, SKI has chosen to openly report on Swedish nuclear weapons research since 1945.

A report that mainly analyses Swedish-American nuclear energy collaboration between 1945 and 1995 has already been published. The report also contained a list of archives with documentation of nuclear material development in Sweden, the growth of international inspections and the legislation that has applied in the nuclear energy field since 1945.[1]

What is nuclear weapons research? What do we mean when we say that a country has a nuclear weapons programme? How can the capability of a state to produce nuclear weapons be determined? And why do certain states which have reached a given level of scientific and technical knowledge choose to produce nuclear weapons, whilst other nations with a comparable level of knowledge do not?

There are no self-evident answers to these questions, but they must nevertheless be answered in order to analyse the activity of FOA (*Försvarets Forskningsanstalt, Swedish National Defence Research Institute*) in the nuclear weapons field.

FOA began nuclear weapons research as early as 1945. Admittedly, the main aim of the research initiated at that time was to find out how Sweden could best protect itself against a nuclear weapon attack. But from the outset there was interest in FOA investigating the possibilities of manufacturing what was then called an atomic bomb. When, in 1954, the Swedish Supreme Commander advocated Swedish nuclear weapons, this research became the object of political discussions and conflicts.[2] Resistance to these plans began to emerge among the public, in parliament and even among the government, where Prime Minister Tage Erlander had been in favour of acquiring nuclear weapons well into the 1950s.[3] Not only Sweden as a whole, but also the Social

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[1] Jonter, T., *Sverige, USA och kärnenergin. Framväxten av en svensk kärnämneskontroll 1945-1995* (Sweden, the USA and nuclear energy. The emergence of Swedish nuclear materials control 1945-1995), SKI Report 99:21.

[2] *Alltjämt starkt försvar. ÖB-förslaget 1954* (ÖB 54). (Strong Defence Preserved. The Supreme Commander's proposal 1954 (ÖB 54)), *Kontakt med krigsmakten* 1954:9-10.

[3] Erlander, Tage, *1955-1960*, Stockholm 1976, pp 75-101.

Democracy movement, was divided on the issue. For this reason, a bill was drafted which laid down a period for consideration. This meant that Sweden could postpone a decision on the issue. According to the bill, the reason for the consideration period, or freedom of action as it has also been called, was that research had not reached the technical level at which a decision could be taken on the issue.[4]

The bill laid down that, for the time being only protection research could be done, precluding research aimed directly at producing nuclear weapons. Parliament passed the bill in July 1958. But FOA and several of the politicians involved were of the opinion that protection research had been far to narrowly defined for Sweden to be able to live up to the freedom of action that parliament had laid down. It was therefore proposed in the 1960 defence bill that protection research should be extended. It was the government that would define the limits of FOA's nuclear weapons research in directives. Parliament approved the bill.[5]

Did FOA stay within the limits of protection research as regulated by the government? Over the years, this question has been the subject of debate and a government investigation (see Section 1.3). The first aim of this report is to investigate whether or not FOA went beyond the defined limits.

The second aim is to place Sweden's research in the field in an international context against the background of the scientific discussion of nuclear weapons proliferation. In this discussion, Sweden has been regarded as an advanced country scientifically and in terms of nuclear technology, a country that refrained from making nuclear weapons even though it was considered technically capable of doing so. It has been generally accepted in the international discussion that Sweden reached a latent capability (see Section 1.2) to begin concrete preparations for nuclear weapons manufacture at the end of the 1950s. For example, Stephen M Meyer states in his classic study of *The Dynamics of Nuclear Proliferation* that this happened in 1957.[6] Meyer bases this assertion on a paper by Jerome Garris, "Sweden's debate on the proliferation of nuclear weapons".[7] But Garris' dissertation is based not on any review of FOA's nuclear energy activity, but on open sources.

The second aim of this study is to analyse, on the basis of a review of FOA's archives, whether or not this picture is correct.

The third aim is to follow up the way in which the nuclear weapons activity was phased out after Sweden signed the treaty on non-proliferation of nuclear weapons in 1968 (or, to put it another way, how Swedish protection research developed after the agreement had been signed).

The fourth aim is to investigate how much plutonium, uranium (natural and depleted) and heavy water FOA had at its disposal within the framework of the research it conducted.

In order to be able to carry out the study described here, the following questions will be posed:

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4 Bill 1958:110.

5 Bill 1960:1, Annex 6, pp 27 et seq and 292 et seq. Rskr. 1960:4.

6 Meyer, Stephen, *The Dynamics of Nuclear Proliferation*, Chicago 1986, p 41.

7 Ibid, p 207, footnote 3.

1. How was nuclear weapons research organised at FOA from 1945 to 1995 and what were the overall aims of this research during those years?
2. With which companies and research institutions did FOA collaborate in order to obtain information on which to base the development of nuclear weapons? What was the purpose of this collaboration and what was achieved?
3. What nuclear materials, in particular plutonium, did FOA have at its disposal? To what extent did FOA attempt to produce plutonium for military use?
4. When did Sweden achieve latent capability and how far developed was Swedish nuclear weapons research? How advanced was the Swedish capability when the plans to acquire nuclear weapons were finally abandoned?
5. What type of nuclear weapons did FOA intend to equip the Swedish defence forces with? Were any weapon carrier systems planned?
6. How was the protection research defined that was conducted at FOA? Was there any violation in this protection research of the limits set by FOA?
7. What was the nature of nuclear weapons research after Sweden signed the NPT in 1968?
8. What happened to the nuclear materials and the heavy water that FOA previously had at its disposal after design research was phased out?

This study is not based on a review of all documents that relate to nuclear weapons research at FOA. Such an analysis is not possible at present because secrecy still applies to information that must not be made public with regard to the NPT that Sweden signed (and in certain cases where documents still contain information that must not be revealed for reasons of state security). During the autumn of 1998, I began a process of de-classification with the assistance of former associate professor at FOA, Anders Fröman. In addition, the information that formed the basis of the government report on the Swedish nuclear weapons research by Olof Forssberg, Head of the Legal Secretariat at the Department of Defence, was declared no longer secret in 1995.[8] I believe that I have had access to all the material that is relevant to my task. Despite the restrictions that still exist, I consider that the material I have gone through is sufficient to make an analysis of FOA's nuclear weapons research during the years in question.

As with all historical processes, nuclear weapons research at FOA went through various phases. There are good reasons for the period-based approach of this study. The first period studied is 1945-52. It is natural to begin in 1945 since Swedish nuclear weapons research began in that year, soon after the atomic bombs fell on Japan. I set the end of this phase at 1952, because it was in that year that Commander-in-Chief of the Swedish Air Force Bengt Nordenskiöld stated publicly that Sweden should acquire nuclear weapons. This was the first statement on the issue by a senior military officer. It started a debate that took on serious proportions a few years later. The next period, 1953-1959, was chosen because, in 1953, a very important study was undertaken of the technical prospects for Swedish nuclear weapons manufacture. The reason for choosing 1959 as the final year of this phase has to do with the fact that the committee group of the Social Democratic party council issued a report in December of that year which was highly

[8] Forssberg, Olof, *Svensk kärnvapenforskning 1945-1972* (Swedish nuclear weapons research 1945-1972). Stockholm 1987.

influential on the nature of protection research. The period from 1960 to 1967 is a natural choice since it was during those years that the nuclear weapons issue was decided. Finally, the period from 1968 to the present day was chosen in the light of the fact that Sweden signed the NPT in August 1968. After this, FOA's more design-oriented nuclear weapons research was phased out. It can also be said that there was an increasing active Swedish policy opposed to nuclear weapons proliferation, and this also influenced the activities of FOA.

1.1. Theoretical preconditions and definitions

There are of course many models to explain why certain states choose to acquire nuclear weapons.[9] There is no reason to describe them all here, since it is *not* the purpose of my study to analyse the Swedish nuclear weapons issue in its entirety. This study deals only with technical research, and analyses what Sweden achieved in terms of capability and what decision were taken to realise this. A study of the entire issue of Swedish nuclear weapons would also embrace, in addition to the scientific-technical arena, the actions of the Swedish military, the game of domestic politics and an international level on which primarily the nuclear energy policy of USA is taken into consideration.[10] Since the focus of this study is FOA's nuclear weapons research, and the aim is to determine what capability to manufacture nuclear weapons Sweden reached, the theoretical discussion will deal mainly with how this can be assessed and analysed. The starting point is the study *The Dynamics of Nuclear Proliferation* by the American political scientist Stephen M Meyer. I have to a large extent made use of Meyer's model to determine what should be characterised as nuclear weapons programmes and latent capability, which is called "The Technological Basis of Nuclear Proliferation" in Meyer's study; see Appendix 3.

How is it possible to determine that a state has acquired nuclear weapons? The classic indicator is that the country in question has carried out a nuclear test. This was true for the first five nuclear weapons states, but it is a poor indicator nowadays. Considering that knowledge of the technology surrounding nuclear weapons development and the results of other countries' test explosions is so widespread nowadays, a country need not necessarily carry out nuclear tests. It should also be added that one of the two nuclear explosive devices dropped over Japan – the one in which the fissionable substance was uranium – detonated without prior testing. Another example is Israel, which is considered to have produced nuclear weapons without having carried out any nuclear weapons tests.[11]

Since President Eisenhower's global cooperation programme "Atoms for Peace"[12] and its successors, many countries have obtained much of the basic knowhow and resources needed for the manufacture of nuclear weapons. This fact has made the classic indicator

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[9] See for example Oglivie-White, Tanya, "Is there a theory of nuclear proliferation? An analysis of the contemporary debate." *The Nonproliferation Review*, autumn 1996.

[10] Such a study is planned. So far, the US policy has been analysed, see Jonter, T, *Sverige, USA och kärnenergin. Framväxten av en svensk kärnämneskontroll 1945-1995* (Sweden, USA and nuclear energy. The emergence of Swedish nuclear materials control 1945-1995), SKI Report 99:21.

[11] See Cohen, Avner, *Israel and the Bomb*. Columbia University Press: New York, 1998.

[12] USA's support programme for friendly countries from the mid-1950s onward.

useless. The expression currently used is *latent capability* to produce nuclear weapons. The term latent capability means that a country has achieved the ability to start a nuclear weapons programme. Admittedly, different countries will take more or less time to produce the first nuclear explosive device in serial production. This is why we also refer to the degree of nuclear infrastructure for producing nuclear weapons. Against this background, the earlier *desire* to manufacture (interest in manufacturing) nuclear weapons is separated from the *capability*. And it is in fact more important to measure and relate to the *latent capability* than when a state might possibly carry out a nuclear test, since latent capability need not result in the country actually acquiring nuclear weapons. One positive consequence of this changed view is that it made it possible to prevent more and more states acquiring nuclear weapons without denying them the opportunity to develop their nuclear expertise.

In 1982 it was calculated that 35 countries had reached latent capability[13] and even more states are likely to have done so by 2001. But the key question is of course: why do certain states choose to move from latent capability to operational capability, in other words, to produce nuclear weapons? Meyer distinguishes between four steps in the process from decision to finished nuclear explosive devices:

1. A state decides to acquire latent capability to manufacture nuclear weapons;
2. A state has reached latent capability;
3. A state decides to manufacture nuclear weapons;
4. A state possesses nuclear weapons.

According to Meyer, a nation chooses to acquire nuclear weapons after a process that comprises several steps. In that process, economical and political costs are weighed against security policy assessments in which military interests, domestic politics, opinion and international players in the form of the actions of major power and international organisations influence the decision. A state may choose to go from latent capability to the manufacture of nuclear weapons – like Pakistan and India, for instance – or may decide not to do so, like Sweden and Switzerland. When a nation, which has latent capability perceives a threat or a latent threat, it has the following choices, according to Meyer: to begin its own nuclear weapons programme, to increase the degree of nuclear weapons research, to adopt a "wait-and-see" posture while analysing the threat, to seek security guarantees from or enter into alliances with a nuclear weapons state, or to ignore the threat. Naturally the state in question may choose more than one of these options at the same time.

The step from latent capability to deciding to acquire nuclear weapons is subject to a number of factors that can be interpreted as *incentives* or as obstacles in the form of economic and political costs (*disincentives*). An example of an incentive to acquire nuclear weapons might be that this is seen as economically preferable to setting up a costly and less effective conventional defence force. An example of an obstacle, in the form of a political cost, would be that a major power or a group of states might penalise the country in question with export embargoes if it attempted to acquire nuclear weapons.

[13] Meyer 1986, p 3.

One condition for a country choosing to develop a nuclear weapons programme is that it must have reached latent capability. There are researchers who maintain that technological capability alone sooner or later leads to a country acquiring nuclear weapons.[14] Those who support this hypothesis *do not* mean that all countries *achieve* the goal of producing nuclear weapons. But they will try to do so sooner or later. The problem with this hypothesis is that several countries have clearly reached a fairly advanced latent status without going on to produce their own nuclear weapons. For example, Argentina, Brazil, Spain, Australia, Belgium, Canada, Italy, The Netherlands, Sweden and Switzerland have not chosen to produce such weapons. One modification of this theory has maintained that different countries take more or less time to go from latent capability to operational nuclear weapons production. A further modification of the technological imperative has stated that it is the degree of nuclear infrastructure that determines when a state chooses a nuclear weapons option. The economic and psychological obstacles decrease at the same rate as a country develops its latent capability, and finally the state in question chooses to acquire the weapon. If a nation has reached a highly advanced level of nuclear expertise, it is very probable that this will lead to the country in question acquiring its own nuclear explosive devices.

The validity of this hypothesis cannot be tested on Sweden since it might be objected that, at some time in the future, in a given security policy threat situation, Sweden could choose to manufacture its own nuclear weapons. This cannot be proved or disproved (at least not in the present situation). But it might be interesting to analyse how advanced Sweden's infrastructure was up to 1968 when the plans for nuclear weapons were abandoned. In the light of Stephen Meyer's three degrees of latent capability (see Section 1.2), it may be appropriate to characterise in a more concrete way how well developed Sweden's capability was. And against that background such an analysis could serve as a argument which either (to some extent) lends support to or reduces the strength of the technological hypothesis (especially in the sense that, the more advanced a state's nuclear infrastructure, the greater the probability that it will acquire its own nuclear weapons).

1.2. Evaluating the latent capability of a state

How do we know that a country has a nuclear weapons programme? We have already established that nuclear weapons tests are not a necessary condition. Nor is it essential for more or less advanced weapon carrier systems to have been developed since nuclear weapons can be used without sophisticated long-range missiles or large bombers. Far simpler arrangements can be used *de facto* for armaments with nuclear devices.[15]

A state is regarded as having a nuclear weapons programme when the intended programme has been started with a goal to produce at least one nuclear explosive device per year on average for several years. It is immaterial whether the state in question has any plans for a weapon carrier or whether nuclear weapons tests are planned.

In addition, a state is regarded as having achieved latent capability when it has achieved the capability to carry out the above nuclear weapons programme.

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[14] This entire section is based on a discussion conducted by Meyer, p 9 et seq.

[15] Ibid., p 31.

But how can the latent capability of a state be measured in a more concrete sense?

A great deal of resources is needed in order to carry out a complete nuclear weapons programme. Firstly, purely material resources such as steel, concrete and obviously nuclear materials are needed. Secondly, scientific expertise is needed. This means more than simply having sufficiently developed nuclear physics and nuclear chemistry available; the scientific knowledge must extend to other areas such as classical mechanical engineering, thermodynamics, kinetic theory and the metallic properties of uranium and plutonium. Thirdly, a state needs technical *knowhow* and extensive organisational ability to be able to design and run the programme. It will also need a developed ability to be able to maintain and replace parts in an efficiently functioning nuclear weapons programme.[16]

Meyer divides the possible latent capability of states into three categories.

1. For a *state entirely lacking in nuclear infrastructure*, and which decides to produce finished nuclear explosive devices, it would take up to six years from the initial experiments to produce the first nuclear weapon.
2. For a state with a *modest nuclear infrastructure*, the goal of producing the first device could be achieved in two to three years.
3. A state with an *advanced nuclear infrastructure* would be able to produce a finished nuclear explosive device within at most two years. Such a state possesses practically everything that is needed apart from the actual weapons factory. There are two forms of advanced capability: either the state has both a plutonium-producing reactor and a reprocessing plant (or a "hot cell") or it has a uranium enrichment plant. In either case, the country in question has practically all the resources needed to start a nuclear weapons programme.[17]

1.3. The research position

The role of FOA in planning Swedish nuclear weapons has so far not been analysed by research. Admittedly the issue has been touched on in articles and studies, but in a more general way, describing the main aspects of Swedish official policy. The texts were not based on a thorough review of sources relating to the activities of FOA during the relevant period from 1945 up to 1968, when Sweden signed the nuclear weapons non-proliferation treaty.[18] That so little has been done is not due to FOA archive having been

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[16] Ibid.

[17] Ibid. p 37.

[18] See for example Agrell, Willhelm, *Alliansfrihet och atombomber. Kontinuitet och förändring i den svenska försvarsdoktrinen 1945-1982* (Non-alignment and atomic bombs. Continuity and change in the Swedish defence doctrine 1945-1982), Stockholm 1985; Björnerstedt, Rolf, "Sverige i kärnvapenfrågan" (Sweden in the nuclear weapons issue) in *Försvar i nutid*, 1965:5; Cole, Paul M, *Sweden Without the Bomb. The Conduct of a Nuclear Capable Nation Without Nuclear Weapons*, RAND, Santa Monica, CA: MR-460, 1994; Fröman, Anders, "Kärnvapenforskning" (Nuclear weapons research) in *Försvarets forskningsanstalt 1945-1995*, Stockholm 1995, and "FOA och kärnvapen – dokumentation från seminarium 16 november 1993" (FOA and nuclear weapons – documentation from a seminar on 16 November 1993), *FOA VET om försvarsforskning*,1995; Garris, Jerome Henry, *Sweden and the Spread of Nuclear Weapons*, University of Calfornia, Los Angels, Ph. D; Jervas, Gunnar, *Sverige, Norden och kärnvapnen* (Sweden, the Nordic countries and nuclear weapons). FOA

completely closed to research. During the 1980 and 1990s, a considerable number of documents were taken off the secret list. It may well be due to a kind of "archive-blindness" that beset Swedish researchers because they were stuck in the self-image of the Swedish policy of neutrality, as alleged by political scientist Stefan Lindström in an article in the Swedish morning paper Svenska Dagbladet. Sweden's role of disarmament negotiator from the late 1960s onwards seems to have made it indelicate to remind people of the Social Democrats' earlier support for Swedish nuclear weapons.[19]

There is one exception, however. In 1985, journalist Christer Larsson took up the issue in the journal Ny Teknik, in a long multi-part report entitled "Historien om en svensk atombomb 1945-1972" (The story of a Swedish atomic bomb 1945-1972).[20] The articles allege that the Swedish people, parliament and even parts of the government were kept in the dark by a small group of decision-makers. According to Christer Larsson, this inner circle, consisting of members of the government, high-ranking military officers and researchers, forced through a programme which also worked on plutonium production, design research and the manufacture of components for nuclear weapons, despite the fact that this was in conflict with the guidelines drawn up by parliament for the activities of FOA.

Several of the articles describe how the civil and military nuclear energy programmes were coordinated as long ago as 1950 to make a Swedish nuclear weapons programme possible. Step by step, the research-related, technical and financial preconditions were created to enable production to start. In 1965, according to Larsson, all the preconditions existed, meaning that only six more months were needed for the first Swedish nuclear weapon to see the light of day – if parliament said yes.

The only question now is: Is this picture correct?

No, not at all, according to the government report "Svensk kärnvapenforskning 1945-1972" (Swedish nuclear weapons research 1945-1972) headed by Olof Forssberg, Head of the Legal Secretariat at the Department of Defence at the time.[21] In its report, the commission, appointed by the government as a result of the articles in Ny Teknik, dismissed Christer Larsson's articles as an untrue interpretation full of inaccuracies and misinterpretations:

> "My final judgement on FOA's nuclear weapons research in relation to the decisions of the government is that it was conducted in accordance with the regulations of the government, that the government was well informed of the content of the research and that it kept parliament informed about this, and that the conditions laid down by parliament for

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report C 10189-M3, September 1981; Lindström, Stefan, *Hela nationens tacksamhet: svensk forskningspolitik på atomenergiområdet 1945-1956* (The entire nation's gratitude: Swedish research policy in the atomic energy field 1945-1956), Stockholm 1991; Larsson K-E, "Kärnkraftens historia i Sverige" (The history of nuclear power in Sweden), *Kosmos*, 1987; Larsson, Tor, "The Swedish Nuclear and Non-nuclear Postures", *Storia delle relazioni internazionali*, 1998:1.

[19] This is the interpretation of political scientist Stefan Lindström in an article in Svenska Dagbladet, 12 March 2000. See also other contributions relating to the Swedish nuclear weapons programme in Svenska Dagbladet, Thomas Jonter, 19 February 2000 and Hans Weinberger 29 January 2000.

[20] Larsson, Christer, "Historien om en svensk atombomb 1945-1972" (The history of a Swedish Atomic Bomb 1945-1972), *Ny Teknik*, 1985-1986.

[21] Forssberg, Olof, *Svensk kärnvapenforskning 1945-1972* (Swedish nuclear weapons research 1945-1972), Stockholm 1987.

> the use of grants were complied with by the government when drawing up regulations for the research. Their main motive was to acquire such knowledge of nuclear weapons as is required for tactics and protection against them. An important secondary motive up to 1968 was to preserve Sweden's freedom to manufacture its own nuclear weapons. Parliament had accepted that the research included some design aspects, even after the 1958 decision."

Even if Forssberg rejects Larsson's interpretation on practically every point, the government study nevertheless confirms the picture that FOA conducted far-reaching research with a view to producing nuclear weapons.

Olof Forssberg had full access to the FOA archive. The information on which the Forssberg study is based was on the secret list until 4 May 1995. In many respects it amounts to a thorough review of FOA's nuclear weapons research between 1945 and 1972.

I do not intend to deal with all Forssberg's conclusions here; instead I shall concentrate on those points that are important when it comes to answering the questions posed in this report. According to Olof Forssberg, the decision taken by parliament in 1958 does not amount to a "ban on design research". The decision cannot be interpreted as if "it involved an absolute ban on any form of activity that gave results that could be used in a possible design of nuclear weapons." The conclusion reached by the Head of the Legal Secretariat at the Department of Defence was that FOA always kept within the limits of protection research as defined by the government.

Another conclusion is that the collaboration agreement that was signed between FOA and AB Atomenergi (AE) in 1949 was both natural and necessary in view of the paucity of Swedish resources in the nuclear energy field. For that reason, civilian and military research coincided at the initial stage. (Christer Larsson maintained that there was secret collaboration between FOA and AE, the aim of which was that the military direction would govern the civilian direction.)

Another of Forssberg's conclusions that I have investigated in this report is the statement that FOA never used more than 0,5 kg of plutonium in its research activity. That plutonium was not weapons-grade, according to the criteria used by FOA during the period when it was being used. (In Larsson's view, weapons-grade plutonium was used in this research).

2. Research begins: 1945 – 1952

The Swedish National Defence Research Institute (FOA) was established on 1 April 1945. The idea of this was to coordinate Swedish research in the field of military technology and to make it more effective. Previously this work had been the responsibility of FKA (Försvarsväsendets kemiska anstalt, *Armed Forces Chemical Institute*), MFI (Militärfysiska institutet, *Military Physics Institute*) and SUN (Statens uppfinnarnämnd, *The National Inventors' Board*). But the intention was that resources would now be focused and a modern Swedish research institution would emerge. It was the experience of the war, with its huge advances in weapons technology that prompted the creation of this organisation.[22]

According to the instructions, FOA is obliged to monitor scientific development in those areas that may be expected to be significant for the defence of the nation and to conduct research in those fields. The Institute's instruction also includes collaboration with other national or independent research institutions and communicating research information to them. From the outset, the Supreme Commander has played a leading role. The Supreme Commander is empowered to place research assignments with FOA. From 1959 onwards this power has been gradually extended to apply to research assignments issued by other total defence bodies. The Supreme Commander is also entitled to have a representative on the council of FOA.[23]

One of the underlying ideas was to create an organisation which would be free of the command structure of the defence force but which was nonetheless oriented towards its problems. Three departments were created to meet future needs: department 1 (chemistry), department 2 (physics) and department 3 (telecommunications and electronics).[24] As early as the autumn of 1945, there were 150 employees at FOA.[25]

FOA was only just over four months old when the nuclear weapons issue became one of the issues it had to deal with. On 17 August 1945, the Supreme Commander's representative on the council of FOA, Torsten Schmidt, requested "an account of what might currently be known about the atomic bomb."[26] The same day, the Supreme Commander applied to the government for funding for research, design and experimental activity. In the application the Supreme Commander did not specifically mention nuclear weapons, stating simply that the funds applied for were not to be tied to any particular objects of research.[27] More specific research assignments would later be

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[22] Lundquist, Nils-Henrik, "Försvarets forskningsanstalt – organisation i ständig utveckling" (The Swedish National Defence Research Institute - a constantly developing organisation) in *Försvarets forskningsanstalt 1945-1995,* Stockholm 1995, p 7.

[23] Forssberg 1987, p 12.

[24] Lundquist 1995, p 8.

[25] Fröman, Anders, "Kärnvapenforskning" (Nuclear Weapons Research), in *Försvarets forskningsanstalt 1945-1995*, Stockholm 1995, p 162.

[26] Ibid.

[27] Swedish National Defence Research Institute, secretariat, incoming documents 1946 E III a, H 62.

specified by the government. The sum of 1,625 million Swedish crowns (SEK) was requested for this assignment and this was approved by parliament.[28]

The head of the department of physics, Torsten Magnusson, was asked by the council of FOA to investigate what was known about the nuclear devices that had recently been dropped over Hiroshima and Nagasaki. This was the starting gun (unless of course the actual dropping of the bombs over Japan can be seen as the starting gun) for Swedish nuclear weapons research.

November 1945 saw the formation of Atomkommittén ("The Atomic Committee", AK), which was made up of ten experts who would assist the government with studies relating to the planning of the exploitation of nuclear energy. It was mainly the civilian aspect that was to be considered, even if the assignment also included the military aspect. The committee gave advice and made suggestions as to how nuclear energy might best be exploited.[29]

2.1. The first studies see the light of day

During this early period, much of FOA's nuclear weapons research was concerned with obtaining, on a broad front, information about the effect of the new weapon of mass destruction. But even at an early stage there was great interest in investigating the possibilities of acquiring Swedish nuclear weapons. In October 1945 a conference on the subject was held at the Research Institute for Experimental Physics at the Royal Academy of Sciences. The Smyth report from USA (which contains information about the basic design of nuclear weapons and their explosive effect, and which was published soon after the nuclear devices fell over Hiroshima and Nagasaki) was an inevitable subject of discussion at the conference, where people also expressed the wish that studies should be undertaken concerning Swedish nuclear weapons development. Among other things, researchers urged that, the manufacture of heavy water, plutonium and various types of uranium compounds should be investigated.[30]

FOA applied for 450 000 SEK from the government to enable it to carry out the studies proposed at the conference. The Supreme Commander supported this application and added that the sum would only be sufficient for preparatory investigations during the first six months and that further funds would have to be made available "if we are to study in depth this matter, which is of such exceptional importance for the defence of Sweden".[31]

In department 1, the question of uranium production was tackled at an early stage. I October 1945, the Geological Survey of Sweden (SGU) had compiled a list of possible presence of uranium in Sweden. A synthesis group and an analysis group were set up at FOA to conduct further work on the issue. Collaboration was set up with several Swedish companies and research institutions to look into the possibilities of producing uranium (Boliden Gruv AB, Svenska Skifferolje AB, Wargöns AB, The Royal Institute

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[28] Bill 1945:334, p 23 et seq; SU 1945:266; rskr. 545.

[29] Larsson, Karl-Erik, "Kärnkraftens historia i Sverige" (The History of Nuclear Power in Sweden), *Kosmos* 1987.

[30] Olof Forssberg's study (basis), p 5 et seq.

[31] Ibid.

of Technology (KTH), Chalmers University of Technology and the universities of Uppsala and Lund).[32] It was primarily the kolm-type shales of central Sweden that were of interest. In January 1946, the Atomic Committee requested FOA to investigate the potential for Swedish uranium production and for the separation of plutonium from irradiated uranium.[33]

As early as the spring and summer of 1946, a method had been devised for determining the presence of uranium in small amounts. During the autumn, larger-scale analysis was begun on the basis of this method. A third group, the raw materials group, was created alongside the existing units for the work of synthesis and analysis.[34]

In December 1945, the head of department 1, Gustaf Ljunggren, presented a proposal that turned out to lead the way for the entire Swedish nuclear weapons programme. In Ljunggren's opinion, Sweden should do the same as USA – but the other way round. Civilian exploitation of nuclear energy was a "spin-off" of the nuclear weapons programme, in which plutonium production held a central position. Ljunggren's view was: why not take the opposite approach and let the main aim be the generation of nuclear energy, with plutonium production, which made possible the manufacture of nuclear weapons, as a side-effect. What Ljunggren was suggesting was to try and accommodate nuclear weapons production in the framework of civilian nuclear energy generation.[35]

At the end of the same month, Torsten Magnusson completed his study "Rapport angående atombomben, I" (Report on the atomic bomb, I), which in many respects amounted to a summary of what was known at the time in Sweden about the design and operation of nuclear weapons. Magnusson discussed both the manufacture of nuclear weapons and protection against them. In his report, Magnusson maintained that plutonium was preferable to uranium as a fissionable material in the device. [36]

For the fiscal year 1946/47, FOA applied for 3,5 million SEK, and this was approved by parliament.[37] The secret grant application states that the atomic bomb is an urgent research task. The government earmarked 1,21 million SEK of this sum for research into the exploitation of nuclear energy.[38]

Several studies were done at the beginning of 1946, among other things into how to start nuclear fission in a nuclear explosive device (known as the initiation problem) and the production of heavy water.[39] During the same period, a special section was established

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[32] Swedish National Defence Research Institute, Report on the operations at the Swedish National Defence Research Institute department 1. From 1/4 1945 to 30/6 1946 H 188/05.

[33] Larsson, Karl-Erik, "Kärnkraftens historia i Sverige" (The History of Nuclear Power in Sweden), *Kosmos* 1987, p 128 et seq.

[34] Swedish National Defence Research Institute, Report on the operations at the Swedish National Defence Research Institute department 1, during fiscal year 1946-47, together with a proposed program for continued operations H 144/47.

[35] Olof Forssberg's study (basis), p 7.

[36] Ibid.

[37] Bill 1946:120, p 285.

[38] Olof Forssberg's study (basis), p 8.

[39] A memo dated 7 January described various methods of producing heavy water. Lund researcher Lamek Hulthén, who wrote the report, thought that it would be possible to develop Ljungaverket's electrolysis operation to reach a higher level of production. Although the capital cost would be great and it would take a long time to set up the plant, in purely technical terms the problem was solved, so it was claimed.

for nuclear physics investigations at department 2 under Sigvard Eklund. Ten people would be engaged in various technical calculations and tests relating to the exploitation of nuclear energy.[40]

At the end of May, Torsten Magnusson drew up a list of ongoing research projects on the exploitation of nuclear energy and the design and effects of nuclear weapon.[41] He concluded that fifteen studies were being done at FOA. One month later it emerges in a report to the research officer at the defence staff that 27 researchers at department 2 of FOA and 27 outside researchers were engaged in nuclear weapons research.[42]

Ten months had passed since the Supreme Commander commissioned FOA to initiate research in this area. This can truly be described as a flying start for Swedish nuclear weapons research.

During fiscal year 1947/48 there was further expansion of the activity. New services were established and a number of studies were started. A new section in the analysis group was formed in 1947. The main task of the group was to develop different methods for the separation of plutonium and generally to create a bank of knowledge in the field of plutonium chemistry. For this reason, a nuclear chemistry laboratory was set up. A Van de Graff accelerator was taken into service during 1947. The accelerator was used for cross-section measurements, which were important to making more accurate calculations of the various effects of nuclear weapons explosions. This was a big step forward for the operation.[43]

On 26 April 1947, the "Atomic Committee" issued a report that led to the formation of AB Atomenergi (AE) in the same year.[44] The idea was to create a company, which could develop methods and basic material for eventually achieving exploitation of nuclear energy on a larger and more industrial scale. A rewarding collaboration developed between FOA and AE.

In February 1948, the Chief of the Defence Staff commissioned FOA to investigate how the Swedish Defence Forces might make use of nuclear energy. Naturally their interest was primarily in nuclear weapons, but other possibilities were also to be covered. The assignment included time schedules and cost estimations for the manufacture of Swedish nuclear weapons.[45]

Three months later the study was complete. The study was based on the premise that plutonium was preferable to uranium 235 in a possible nuclear explosive device. To produce a nuclear weapon based on U-235 was considered to be a highly complex – and therefore far too costly – process. For this reason a reactor would have to be built which

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[40] Assignments were given to other research institutions. For example, Adolf Eriksson, associate professor at the University of Uppsala, would perform theoretical calculations of neutron diffusion (how the velocity and density of the neutrons is affected), and Lamek Hulthén, researcher at the University of Lund, would calculate the critical mass for a uranium 235 bomb and a plutonium bomb. Swedish National Defence Research Institute, memo no. 3 concerning work on the uranium question, H 42/8509.

[41] Olof Forssberg's study (basis), p 9.

[42] Ibid.

[43] Swedish National Defence Research Institute, "Verksamhetsberättelse för budgetåret 1947/48" (Annual report for fiscal year 1947/48), H 158/48.

[44] Olof Forssberg's study (basis), p 11

[45] Swedish National Defence Research Institute, Incoming documents 1948 E III a, Volume 4, H 35.

would be loaded with natural uranium and with graphite as the moderator. The calculated theoretical yield of the reactor was about 1 kg of plutonium per day. This was considered sufficient for the production of 5-10 nuclear explosive devices a year.

If plutonium production such as that envisaged were to succeed at all, a large reactor would have to be built, the report further maintains. A prerequisite for such a complex construction was that an experimental reactor would first be operated to find out how best to construct the main reactor (it might even be necessary to build an intermediate experimental reactor in order for a project of this magnitude to succeed, according to the authors of the report).[46]

A further prerequisite for the programme outlined was access to nuclear materials, especially uranium, and also the required quantity of graphite.[47] According to the report on the study it would take about eight years, probably longer, to produce a nuclear weapon.[48]

FOA estimated that this programme would cost 450 million SEK, and this did not include the costs of a build-up time of three to four years. The time schedule assumed that the required manpower would be available, that it would be possible to obtain the required nuclear materials, and that the reactors could be built as planned.[49]

2.2. Collaboration between FOA and AE

During the spring and autumn of 1948 a close collaboration began to develop between FOA and AE. The idea was to co-ordinate the relatively scarce research resources that existed in Sweden. A secret memo written in October of that year stated that the work relating to factory-style production of uranium should largely be taken over by AE. FOA should in turn focus its resources on the nuclear chemistry field, which would mean concentrating the activity on producing a reactor for the manufacture of plutonium.[50]

The heads of departments 1 and 2 at FOA worked out a common basis that would be used in the future negotiations with AE about future work at the beginning of 1949. The starting point for FOA was that collaboration should be aimed at the design and effect of nuclear weapons, regardless of whether or not the government and parliament decided on production. The basis states that, as well as such research providing opportunities for protection against nuclear weapons, it could also yield knowledge that could be used in civilian nuclear energy development. Specifically, the tasks of FOA in nuclear energy research would be as follows:

a) to contribute to training and maintaining a cadre of researchers linked to the defence forces, versed in the instruments and methods used in nuclear research;

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[46] Swedish National Defence Research Institute, Outgoing documents 1948 B IV, Volume 4, H 35:2.

[47] High-purity graphite was being tested by ASEA and by Skandinaviska grafitindustriaktiebolaget.

[48] It was estimated that it would take two years to set up the mining and production operation, five to ten years to produce 500 to 1000 tons of uranium at a production capacity of 100 tons per year, and one year to produce bombs ready for use.

[49] Swedish National Defence Research Institute, Outgoing documents 1948 B IV, Volume 4, H 35:2.

[50] Swedish National Defence Research Institute, 8 October 1948, “P. M. rörande medelsbehovet för budgetåret 1949/50 under reservationsanslaget till viss forskningsverksamhet” (Memo concerning the need for funds for fiscal year 1949/50 under the reservation grant to certain research activities), H 186.

b) to promote the building of a uranium reactor in Sweden by making equipment and personnel available for such investigations as are necessary and which would otherwise have been significantly delayed;

c) through close collaboration with AB Atomenergi, to work to ensure that the reactor is operated so that is makes the greatest possible contribution to solving the research tasks that are important for defence;

d) to study the design and effect of the atomic bomb and the possibility of protecting against it;

e) to study radioactive armaments, their effect, and how to detect and protect against them;

f) to follow developments in the field of nuclear energy in order to be able to apply the practical consequences for the defence of Sweden as quickly as possible;

g) to follow developments in the field, both theoretically and practically, with the aim of being able to use atomic bombs and radioactive substances in our defence, provided that they are made available by another power.[51]

AE was in principle of the same opinion as FOA on the question of how collaboration between them should develop. For example, it was decided that FOA would hand over to AE research results and apparatus that could be used for the extraction of uranium.

One of AE's first and important tasks was to get uranium production started. The company's view was that there was very little prospect of importing uranium and for this reason Sweden should concentrate on utilising the low-content shales at Kvarntorp, which contained uranium. There were financial and technical reasons in favour of choosing extraction of kolm from the shales. It was considered that this extraction process could be done in close proximity to the oil extraction from the shales that was already taking place. An outline agreement had already been drawn up with Svenska Skifferolje AB concerning prospecting for and extraction of uranium at the plant at Kvarntorp.

In addition, an experimental plant for the extraction of kolm had been set up in a factory at Vinterviken outside Stockholm. The plan was to build a larger extraction plant later, on the basis of the results obtained.[52]

Finally, on 28 December 1949 a more extensive collaboration agreement was signed for continued development work between FOA and AE. In general terms, the agreement meant that FOA would conduct research of importance for the defence of Sweden whilst AE would conduct research into the use of nuclear energy for industrial purposes. The parties agreed to conduct their work in close and confidential collaboration. FOA would give AE its research results as far as possible without conflict with military secrecy. AE undertook to keep FOA informed of the experience gained and the research results achieved in their own activity. In a serious military situation, AE would make its

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[51] Swedish National Defence Research Institute, Secretariat, Outgoing documents 1949 B IV, Volume 5, H 37:-1 (appendix).

[52] Swedish National Defence Research Institute, 13 June 1949, "Redogörelse över verksamheten inom Aktiebolaget Atomenergi under 1948 och program för bolagets fortsatta arbete" (Report on activity in Akitebolaget Atomenergi during 1948 and programme for the continued work of the company), H 4012-2091.

resources available to FOA. Both would carry out research assignments for each other for payment. Part of FOA's research into the civilian use of nuclear energy would be transferred to AE. Some of FOA's physicists were also taken on by AE, as was equipment that was thought to be more useful in the newly formed company. [53]

The government approved the agreement on 22 September 1950.[54]

2.3. What is needed to construct nuclear weapons?

Although Swedish nuclear weapons research had got off to a good start, no one involved had any precise knowledge at this initial stage of what was needed in order to manufacture nuclear explosive devices. The costing arrived at by the 1948 study was far from precise. It was based on current knowledge of how a nuclear weapon might be constructed and on estimates of operating costs for the production of uranium and plutonium. Two years later the picture was admittedly clearer, but there was a long way to go before a reasonably sustainable budget could be presented. For example, it was uncertain how much plutonium was needed to make an effective nuclear explosive device. In a memorandum of 1950, Torsten Magnusson makes some estimations on the basis of what was known about the American nuclear devices: "The amount of plutonium in an atomic bomb is undoubtedly between 10 and 50 kg and with a fairly high degree of probability between 15 and 30 kg". [55]

It was likewise difficult to carry out more exact calculations of the cost of nuclear weapons on the basis of the programmes being run in USA, Magnusson concludes in the memo, "... not only because of a lack of reliable information about costs but also because there exist various bases for calculation."

But considering that USA probably has about 400 atomic bombs and that the Soviet Union may have as many in 2-4 years, Sweden should give priority to the research that has already been started, writes Magnusson. The reason for this is quite simply that Sweden may also be exposed to attack by nuclear and radioactive weapons:

> "Effective action should therefore be taken without delay to create readiness for possible attacks with atomic weapon, both with a small number of atomic bombs and with radioactive weaponry."

For the fiscal year 1950/51, FOA's request for an increase of grants and for the creation of new posts was turned down.[56] But research continued and more reports were completed during 1950. Among these was a study that looked into the harmful effects of a hydrogen bomb attack and the energy developed in a nuclear weapon explosion.

FOA's was not granted all the funds it applied for in fiscal year 1952/53 either. No new posts were created, but the grant for certain research activities was increased by 500 000

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[53] Olof Forssberg's study (basis), p 18.

[54] Ibid.

[55] Swedish National Defence Research Institute, "Produktionskapacitet och lager av atombomber och radioaktiva stridsmedel" (Production capacity and stocks of atomic bombs and radioactive weaponry), 1950-10-09, H 4022-2092. The importance of Sweden acquiring readiness for a nuclear weapons attack was stressed in a memorandum about American and Russian production of atomic bombs by Sigvard Eklund, dated 27 March 1950. Swedish National Defence Research Institute H 2267-2092.

[56] Bill 1950:1, appendix 6, SU 4, rskr. 4.

SEK to certain research activities, although FOA had asked for 2,4 million SEK. The reason given by the government for not being able to meet FOA's requests was purely and simply the state of the nation's finances. The government also maintained that, with the funds already granted, FOA had expanded far more than was planned when the research institute was formed. [57]

A proposed work programme for department 2 during fiscal years 1951/52 and 1952/53, contains the following statement concerning the fact that FOA had received less funding than it had asked for: "It is expected that the purely basic research concerning the design of the atomic bomb could be conducted on a very small scale, since the limited capacity that FOA 2 now has in this area, in accordance with the decision of the council, must be used primarily in research and development work on radioactive measuring instruments". In nuclear physics, research would be directed primarily towards protection issues. [58]

Despite the dissatisfaction of the researchers, they keenly continued research into nuclear weapons and the possible use of nuclear energy at FOA. A report on the activity in departments 1 and 2 for fiscal year 1951/52 states that extensive studies were in progress. Among other things, the report states that advanced research into valuable nuclear materials that can be obtained in a uranium reactor had been done with support from the Atomic Committee. At the request of AE, investigations into the production of uranium from raw material had been completed. Work had been done on methods for the indication and decontamination of radioactive weaponry. Problems connected to the military use of nuclear energy had been successively followed up, mainly through studies of foreign specialised literature. Various calculations concerning the construction and operation of nuclear weapons had also been done[59] as well as theoretical calculations of the critical size of nuclear explosive devices, and pressure, temperature and radiation conditions in nuclear weapons explosions.[60]

2.4. Summary: 1945 – 1952

Swedish nuclear weapons got off to a flying start. As early as eleven days after the first nuclear device was dropped over Hiroshima, the Supreme Commander requested FOA rapidly to produce a report on the new weapon. Generous research funding was made available to FOA, which in turn placed assignments with other research institutions in order to obtain as much information as possible. Sweden was a small nation in research

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[57] Bill 1952:120, SU 172, rskr. 331.

[58] Swedish National Defence Research Institute , "Förslag till arbetsprogram FOA 2 F 1951/52 och 1952/53" (Proposed work programme for department 2 of the Swedish National Defence Research Institute), H 4007-209/51.

[59] Swedish National Defence Research Institute, August 1952, "Kortfattad redogörelse för forskningsverksamheten vid FOA 1 under budgetåret 1951/52" (Brief report on the research activity at the Swedish National Defence Research Institute department 1 during fiscal year 1951/52). See "Bifogat: förteckning över viktiga rapporter och skrifter m. m. från FOA 1 under 1951/52" (Attached list of reports and publications etc from the Swedish National Defence Research Institute department 1 during 1951-52), H 183-0013/1 28.

[60] Swedish National Defence Research Institute, "Redogörelse för verksamheten vid Försvarets forskningsanstalt under budgetåret 1950/51" (Report on activity at the Swedish National Defence Research Institute during fiscal year 1950/51), H 2253/51.

terms and the available researchers were linked in one way or another to the research that FOA was heading. Collaboration with the Royal Institute of Technology (KTH) in Stockholm and Chalmers University of Technology in Gothenburg began, and assignments were given to physicists and chemists at the universities of Uppsala and Lund. Within the framework of the work of producing uranium, the Geological Survey of Sweden (SGU) was given an order to carry out various mapping tasks. Collaboration in the area of uranium was also started with the companies Boliden Gruv AB, Svenska Skifferolje AB and Wargöns AB. ASEA and Svenska Philips AB were also contracted for certain work by FOA during this period (to produce certain measuring instruments, known as pen dosimeters).

1947 saw the setting up of AB Atomenergi, which would be responsible for the industrial development of civilian nuclear energy. At AE, the technicians and researchers immediately made plans to produce uranium. AB Atomenergi started working with Svenska Skifferaktiebolaget of Kvarntorp on the extraction of uranium from shales.

FOA started close collaboration with AE. In 1949 this collaboration led to a formalised agreement in which the responsibility and commitments of each party were defined. Up to then there had been no clear boundaries between civilian and military nuclear energy research. But this fact had nothing to do with any secret plan to link researchers and technicians to an equally secret nuclear weapons programme, as alleged by journalist Christer Larsson in Ny Teknik. The reason for this crossing of boundaries had more to do with the fact that nuclear weapons was a new research subject and there were relatively few researchers and technicians with special expertise available in Sweden. It can also be said that, from 1949-50 onwards, a more formalised and subdivided collaboration began to emerge. But it must be said: the projects that FOA and AE ran up to and including 1952 we to some extent intended to be used both for peaceful and military purposes.

No actual production of uranium and heavy water had started in the period 1945-1952. On the other hand, experimental work on and research into the extraction of uranium from shales had begun. There were also some undeveloped plans to produce heavy water. But there were no concrete or implemented plans.

Neither the government nor the defence forces expressed any wish that Sweden would acquire nuclear weapons during this period. The aim of the research that was conducted was broadly to gain as much knowledge and experience as possible in the field of nuclear energy. As far as nuclear weapons specifically were concerned, it can be said that the intention was to do research into protection against them. As early as December 1945, Torsten Magnusson drew a distinction between protection research and design research. But the Supreme Commander’s directive to FOA also included investigating the prerequisites for producing nuclear weapons. These prerequisites were set out in several reports between 1945 and 1952. The most important of these studies was completed in 1948 and spoke of a cost of 50 million SEK per year to produce Swedish nuclear weapons. Plutonium was considered to be the most suitable fissionable material in a planned device. Such an arrangement assumed Swedish uranium production and the construction of a large reactor to produce plutonium.

The calculations made were far from precise. In view of the great secrecy surrounding the American (and of course the Soviet) nuclear weapons programmes, there was not much information to be had.

Collaboration on nuclear energy between the government, the Supreme Commander and other official bodies was fairly undeveloped up to 1952. Swedish knowledge of nuclear energy had not yet reached the level at which more advanced projects concerning the use of nuclear energy could be launched. The Supreme Commander gave FOA the task of producing information on which to base future decisions, possibly to produce nuclear weapons. Government and parliament approved grants for research into the general exploitation of nuclear energy. As a direct consequence of this intention, Atomkommittén (the "Atomic Committee", AK) was set up at the end of 1945. This committee, which was made up of ten experts headed by county governor and social democrat Malte Jacobsson, would primarily investigate and plan overall nuclear energy research in Sweden.

FOA had certain amounts of uranium at its disposal during the years 1945-52, but since there were no accounting requirements it is not possible to obtain exact figures for any nuclear material used. They were probably very small quantities that were used in ongoing research work.

3. The period 1953-1959

In an internal memorandum written at the beginning of 1953, Jan Rydberg, head of the nuclear chemistry section of FOA, stated that a new study concerning Swedish nuclear weapons should be carried out. The reasons were that the military importance of nuclear weapons and the preconditions that applied to the 1948 study had changed. In Rydberg's view, it was possible to produce lighter nuclear weapons that could be used for tactical purposes. If the Swedish defence forces were equipped with a small number of nuclear weapons of this type, an attack on Sweden would be far more difficult. In addition there were good reasons why development in nuclear energy in recent years should mean lower production costs for nuclear weapons, in the analysis of the head of the nuclear chemistry section. [61]

Rydberg got his way. A second study, "Preliminär utredning av betingelserna för framställning av atombomber i Sverige" (Preliminary investigation of the conditions for the production of atomic bombs in Sweden) by Sigvard Eklund was completed.[62] The assignment from FOA had gone to associate professor Sigvard Eklund who had formerly been working in the physics department at FOA but who had, since 1950, been head of research at AB Atomenergi. Obviously the study had to be secret, but that a person who was head of research of the company which had been formed six years earlier for the industrial development of the civilian use of nuclear energy, should be chosen to write the rapport was more questionable.

In the government report, Olof Forssberg maintains that there is nothing remarkable about this. According to him, the assignment did not go to AE but to Sigvard Eklund personally: "So the study was an expression of Eklund's views on the matter and did not reflect the position of the company..."[63]

Before we comment on whether or not this was remarkable, which ultimately has to do with the question whether the military authorities had control over the civilian programme in order to use it primarily for the planned production of nuclear weapons, we should note the content of the report on the study.

The 1948 study had assumed that plutonium was preferable to U-235 in the actual nuclear explosive devices. This was still the case. But the results of recent years' research indicated that heavy water was preferable to graphite as a moderator. There were several advantages in choosing heavy water. Firstly, smaller amounts of nuclear materials were needed. Secondly this option gave greater freedom as to the choice of nuclear materials because of the more favourable neutron balance.

The production of 3-5 nuclear explosive devices per year required a reactor capacity of 150 000 kilowatts (Alternative 1 below), which was lower than the figure arrived at in the 1948 study. In this case two reactors would have to be built, since, as far as was

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[61] Swedish National Defence Research Institute, Department 4, Office, Incoming and outgoing secret documents 1953 F, Volume 4, H 4017-1.

[62] Swedish National Defence Research Institute, "Preliminär utredning av betingelserna för framställning av atombomber i Sverige" (Preliminary investigation of the conditions for the production of atomic bombs in Sweden), 1953-03-05 H 4011-2092.

[63] Forssberg 1987, p 26.

known, no reactor moderated with heavy water with a higher rating than 75 000 kilowatts had been built anywhere in the world. On the other hand, if 1-3 nuclear explosive devices were considered sufficient, a 75 000 kilowatt reactor should be enough, in the analysis of the head of research at AE.

Alternative	**Uranium** (tons)	**Heavy water** (tons)	**Graphite** (tons)	**Annual consumption uranium** (tons)
1 (one reactor)				
Min	5	10	200	5
Max	20	40	400	5
2 (two reactors)				
Min	10	20	400	10
Max	40	80	800	10

Table 1: The alternatives proposed in the studies and the required amounts of uranium, heavy water and graphite. Source: Swedish National Defence Research Institute (FOA), "Preliminär utredning av betingelserna för framställning av atombomber i Sverige" (Preliminary investigation of the conditions for the production of atomic bombs in Sweden), 1953-03-05, H 4011-2092.

The intention was to produce the uranium in Sweden, since importing uranium from abroad was regarded as out of the question. AE had experimental production running and expected soon to start factory production of five tons of uranium per year. It would certainly be possible to double production after a few years, according to the report. Converting the raw uranium concentrate into metallic uranium was a technically demanding process. But despite these difficulties Eklund felt that the time schedule could be met.

Heavy water could beneficially be imported from Norway, the head of research at AE continued. Norwegian production was 7 tons per year, but it was estimated that this could be increased to 15 tons.

This meant that the amount required for Alternative 1 could be met from Norway in three years and the maximum amount in Alternative 2 in six years.

All this assumed that Sweden would be able to import Norwegian heavy water. However, there was one problem with this arrangement, Eklund continued. There were not guarantees that Norway would meet these Swedish requirements. For this reason we ought to consider whether the best option might not be to bank on domestic production. On the other hand this would probably lead to a certain amount of delay and higher costs, Eklund concluded.[64]

For this project to succeed, an organisation of at least 500 people would be needed (one-fifth of which should have a university degree or equivalent qualification).

[64] It is interesting to note that Israel was considering the same approach. During the 1950's, Norway and Israel were negotiating for the sale of heavy water for the Israeli Dimona reactor. The agreement signed in 1959 meant that at big step had been taken towards producing Israeli nuclear weapons. See Cohen, Avner, *Israel and the Bomb* pp 33-34, 60-62, 83, 87.

If Alternative 1 were chosen, ie production of 1-3 nuclear explosive devices per year, a first reactor capable of producing weapons-grade plutonium could be ready by 1960. This would require the programme to start at the beginning of fiscal year 1954/55. To achieve this required a one-off cost of 240 million SEK and an annual cost of 26 million SEK.

If Alternative 2 were chosen, ie a production of 3-5 nuclear devices per year, it was estimated that a second reactor could be ready in 1963. The estimated one-off cost was 378 million SEK and the annual cost 41 million SEK.

A specially chosen group made up only of certain representatives of AK and AE was appointed to comment on Eklund's report. The reason for this selection was "the highly secret nature of the study" according to the introduction of the statement.[65]

Even if the appointees were of the opinion that Eklund's report was a correct summary of the situation of Swedish knowledge, they had some views that needed to be taken into consideration for the continued development work.

Firstly, they considered that Sweden should concentrate on domestic production of heavy water. In view of the fact that there were no guarantees that the necessary amount of heavy water could be imported, it was in Sweden's interest to attempt to manufacture it itself. It was decided that AE would look in to the matter.

Secondly, it was important that the extraction of uranium should be done in such a way that both the civilian and the military needs were met. Thirdly, the appointees were not entirely in agreement with Sigvard Eklund as regards the choice of nuclear material. The plutonium alternative was the best if it was a matter of producing a limited number of Swedish nuclear weapons, according to the representatives of AE and AK. On that basis, Eklund was right, according to the report. But if larger scale production were to take place and the time factor was not crucial, it was not at all obvious that plutonium would be the best alternative. The report concluded that a study should look into the matter. The need for personnel was also a matter that would have to be looked into more closely, according to the joint communication. In view of the large resources required in the form of qualified researchers, the consequences for other areas of society should be considered, according to the delegation group.

According to Olof Forssberg it is not possible to assert, on the basis of this document, that AK and AE "…were willing to allow the military part of the nuclear energy programme to play the principal role at the cost of the peaceful part", as Christer Larsson had maintained. On the contrary, the situation was reversed, according to Eklund, since the report came to the conclusion that the military programme should be postponed for a few years. During this period "work on nuclear energy would continue along the current lines".

This picture is correct. AK and AE also had other considerations to think of, with regard to universities and institutes of technology, and to industry's need for research. But even if it is correct that Sweden's combined resources in the field of nuclear energy were limited, one has to ask, in the light of Christer Larson's criticism: was it not strange that

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[65] Olof Forssberg's study (basis), p 26 et seq. The authors of the joint communication were the chairman of AK, county governor Malte Jacobsson, the managing director of AE, Harry Brynielsson and the secretary of AK, Gösta Funke. Other appointees were: professors Hannes Alfvén, Torsten Gustafson and The Svedberg, director Erik Bengtson and colonel Torsten Schmidt.

the task to investigate the preconditions for a Swedish nuclear weapons programme should go to the head of research at AE?

Olof Forssberg's view is that the assignment was given to Sigvard Eklund personally, rather than to AE. It was Eklund's expertise that was being used, not AB Atomenergi as a company. Earlier, as an employee of FOA, Eklund had been involved in the 1948 study and possessed extensive knowledge, especially about development on the reactor side. Admittedly the objection can be raised that the choice of Eklund to do the study went against the spirit of the agreement between AE and FOA as regards management. This may well be so, but at the same time one must ask oneself whether the choice of Eklund to carry out the study was more remarkable than instances where other leading researchers, for example from the Royal Institute of Technology (KTH) and the universities, were commissioned to undertake studies. It should also be borne in mind that the number of experts in Sweden, especially on the reactor side, was very small at that time. Larsson may have a point when he refers to the different areas that AE and FOA would be responsible for, but it is still difficult to agree with him when he states that the military aim took precedence over the civilian one.

Research into protection in departments 1 and 2 continued on a broad front during 1953. For example, associate professor Bo Aler did a study of the harmful effects of nuclear weapons.[66] But studies with the direct purpose of producing basic information for a Swedish nuclear weapon were done in the same year. Several X-ray crystallography studies to increase the level of knowledge about plutonium extraction were done. Various calculation tasks were carried out by researchers Lamek Hulthén, Torsten Magnusson and Sigvard Eklund to obtain information about, to quote a memorandum, "the effects of atomic bombs and super-bombs". Bo Aler and Lennart Lundberg looked closely into problems of initiation, which has to do with the actual triggering of nuclear explosive devices.[67] Experiments with the isolation of plutonium from reactor substances also continued.

3.1. The defence command is informed of the latest findings

> "Development in the fields of atomic energy are advancing rapidly, and fundamental details are becoming available to an ever greater extent. Sweden must keep up in this area to avoid the risk of falling behind technically in the future. The possibilities of producing atomic bombs will gradually increase. And this applies equally to Sweden. Because of the great advantages of atomic bombs from the point of view of defence, it is my opinion that sooner or later we will have to seriously consider manufacturing them."[68]

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[66] Aler, Bo, "Atombombers verkan mot olika mål" (The effects of atomic bombs on different targets), 28 May 1953, Swedish National Defence Research Institute H 4024-2092.

[67] See, for example, Aler, Bo, "Om initieringen av en atombomb" (On the triggering of an atomic bomb), 6 November 1953, Swedish National Defence Research Institute H 4049-2092.

[68] "Föredragning för försvarsledningen 26/4 1954 ang möjligheterna att tillverka en atombomb i vårt land" (Speech to the defence command on 26 April 1954 on the possibilities of producing an atomic bomb in our country), 26 April 1954, Swedish National Defence Research Institute, H 4019.

This was how the head of department 2, Torsten Magnusson, ended his speech to the defence command in April 1954. Naturally the Supreme Commander and other high-ranking Swedish officers were keenly following the research into a Swedish nuclear weapon. What Magnusson said here was echoed in the defence study, known as the ÖB-54 study, which was the first official plea for Swedish nuclear weapons from the defence command.

Magnusson also described the technical and scientific principles that underlie the Swedish plans for a nuclear weapon. The preconditions had changed in several ways since Sigvard Eklund completed his study in 1953, in other words one year earlier. Research at FOA progressed as new findings were presented, and the researchers were forced to revise their plans. But they still took the view that plutonium should be used in the nuclear devices (uranium called for major investment in the form of an enrichment plant, which would be a far costlier option than choosing plutonium) and that heavy water was the best option as a moderator for the reactor. The big difference from the previous year was the change in the amount of resources needed, especially the quantity of uranium. And this in turn meant higher costs. The table below illustrates the rapid developments during this period:

Plutonium-producing reactors, assumed resource need

	May 1953	April 1954
Nuclear explosive devices per year	3-5	3-5
Reactor output	150 MW	170 MW
Uranium, initial requirement	10-40 tons	100-160 tons
Heavy water, initial requirement	20-80 tons	30-40 tons
Plutonium per year	55 kg	55 kg
Uranium per year for operation	10 tons	35-40 tons

Table 2: Change in the assumed resource need between May 1953 and April 1954. Source: "Föredragning för försvarsledningen 26/4 1954 ang möjligheterna att tillverka en atombomb i vårt land" (Speech to the defence command on 26 April 1954 on the possibilities of producing an atomic bomb in our country), 26 April 1954, FOA, H 4019.

The reactor prototype that would be used for plutonium production research was the planned research reactor R 2 at Studsvik. The reactor was scheduled to go into service during 1959 with an output of 30 MW. An increase to 50 MW was possible provided that certain technical problems could be solved. But even if this succeeded, additional reactors would have to be built to carry out the needed plutonium production described in the speech. Magnusson was of the opinion that this fact in itself need not lead to particularly high cost increases.

The question of a chemical plant for the separation of plutonium had been looked into. A schematic diagram and sketches of the plant existed and preliminary plant and operating costs had been worked out (see below). Cost calculations for the separation of uranium 235 had also begun. Work on the study was done jointly by AE, the Royal Institute of Technology and AB Ångpanneföreningen.

Torsten Magnusson summed up his speech by recommending that every effort should be made to complete ongoing studies. AE's reactor 2 should be ready for use not later than the beginning of 1958, instead of 1959 as planned. AE needed more resources in the form of personnel and premises, the speaker continued. Detailed studies of the design of a Swedish nuclear explosive device must also be done if the plans were to be realised. In addition, most arguments were in favour of importing the necessary amount of heavy water from Norway during 1957. It would be possible to purchase the Norwegian heavy water far more cheaply than it would cost to produce it in Sweden, Magnusson maintained.[69]

During 1954 and 1955, department 1 put a great deal of effort into working out plans and cost calculations for the separation of plutonium.[70] In a proposal for a work programme, Rydberg described the level of knowledge in Sweden concerning the isolation of plutonium.[71] By studying foreign publications and through contacts between Swedish and foreign scientists, Rydberg was able to conclude that:

> "The information we in Sweden currently possess about the chemistry of plutonium, suitable separation methods and the appearance of the technical plant is exceptional."[72]

And one consequence of this was that Sweden was:

> "...in an entirely different knowledge situation than USA and Russia once were, and it is not unlikely that this also applies compared with Britain in 1946."[73]

This was followed by a time schedule showing how work should proceed in order to get plutonium production started. According to the time schedule, the experimental station at FOA department 1, completion of which was formerly planned for 1953, must be complete by the end of fiscal year 1955/56. In addition, the chemical separation plant that AE was planning at Hånö should go into service at the end of 1959. It was calculated that actual plutonium production would start in 1960/61, provided that everything worked as planned.

As an attached cost calculation shows, the research programme would cost 610 000 SEK over three years.[74]

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[69] The study showed that heavy water could be produced at Ljungaverken at a cost of 3 million SEK per 2 tons. This was a high price considering that the Norwegian price was 1 million SEK per ton.

[70] "Kostnadsberäkning av anläggning för isolering av plutonium" (Cost enstimation of a plant for the isolation of plutonium) by Jan Rydberg and Sten Mogensen, 28 January 1954, Swedish National Defence Research Institute, H 4091; "Tillägg till Kostnadsberäkning av anläggning för isolering av plutonium" (Supplement to cost estimation on a plant for the isolation of plutonium) by Jan Rydberg, 30 April 1954, Swedish National Defence Research Institute, H 4092; "PM angående arbeten med plutonium inom sektionen för kärnkemi" (Memorandum on work with plutonium in the section for nuclear chemistry), 13 February 1955, H 4017; "Kostnadsberäkning av anläggning för isolering av plutonium" (Cost estimation on a plant for the isolation of plutonium), by Jan Rydberg, 20 June 1955, Swedish National Defence Research Institute, H 2246.

[71] "Frågor av betydelse för isolering av plutonium för atombomber; förslag till arbetsprogram. (Issues of importance for the isolation of plutonium for atomic bombs; proposal for work programme)" by Jan Rydberg, Swedish National Defence Research Institute, 27 January 1955, H 4140.

[72] Ibid.

[73] Ibid.

[74] Ibid.

Together with Sten Mogensen, Jan Rydberg also looked into the question of where the plutonium would be isolated. The report states that the plan was for the core of the plant to consist of a separation department located in a huge rock cavern. The actual chemical process would be carried out in a trench or "canyon" 5-11 metres deep, 7 metres wide and about 150 metres long. An extensive protection and safety system would protect the personnel and the immediate surroundings. According to the calculations, the plant cost would amount to 22,8 million SEK and the annual running cost to 7,6 million SEK to produce between 65 and 130 kg of plutonium per year.[75]

The researchers at department 2 continued their theoretical investigations to gain more detailed knowledge of the design and effects of the nuclear weapon.

3.2. Completion of the 1955 study

At the end of November 1955, Torsten Magnussons study was complete.[76] Experts from universities and institutes of technology had been consulted as well as researchers and engineers from FOA and AE. The starting point was to establish as broad a basis as possible. The study is a good illustration of how rapidly development took place during this period. Swedish research constantly produced new knowledge and recently the Geneva Conference had taken place, where USA released previously secret information to collaborating countries under the "Atoms for Peace" programme.

The picture had become a great deal clearer since the 1953 study. Now a nuclear weapon weighing only about 100 kg was being discussed, far lighter than FOA had previously envisaged. The devices, which came to be known as tactical nuclear weapons, were regarded as easily transported and could easily be used in both missiles and torpedoes. They could even be fired from a gun according to the study. Each individual bomb would contain 6 kg of plutonium (if the alternative with plutonium was chosen) or 36 kg U-235 (if this alternative was preferred). The figures were not exact, and might have to be revised in the light of the changed research situation.[77]

The study saw many advantages with the plutonium alternative. First, reactors could be built which could be used for both nuclear weapons manufacture and energy production. Such a solution was considered to be financially more beneficial. Second, Sweden's scarce personnel resources in the nuclear energy field could be used more efficiently. Third, it was also possible to make progress with civilian energy development, even if Sweden decided *not* to manufacture nuclear weapons. In the study this is expressed as follows:

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[75] "Kostnadsberäkning av anläggning för isolering av plutonium" (Cost estimation on a plant for the isolation of plutonium), by Sten Mogensen and Jan Rydberg, 28 January 1954, the Swedish National Defence Research Institute, H 4091.

[76] "Utredning av betingelserna för framställning av atomvapen i Sverige" (Study of the conditions for the production of atomic weapons in Sweden) by Torsten Magnusson, 25 November 1955, Swedish National Defence Research Institute, 87-H 163:1-21A.

[77] Up to the summer of 1955 the expectation was that the bombs would have to contain at least 10 kg of plutonium or 18 kg of U-235. At the Geneva conference, certain calculations were released concerning the critical mass of a device that meant that the Swedish National Defence Research Institute's calculations could be heavily revised.

> "The major part of the expenditure, the experience gained and the plants constructed can be used in the civilian atomic energy programme. In addition, plutonium and uranium 235 produced for weapons purposes can at any time be used for reactor purposes, if there is no longer any requirement to reserve it for atomic weapons."[78]

The tables below show clearly that the alternative with plutonium was by far the most beneficial at a production rate of three nuclear explosive devices per year.

Three devices per year	**Plutonium**	**Uranium 235** Gas diffusion	**Uranium 235** Electromagnetic method
Uranium	45-65 tons	1 ton	1 ton
Heavy water	30 tons	30 tons	30 tons
Uranium per year	22 tons	25 tons	90 tons
Investment costs (SEK)	250 M	275 M	1 200 M
Annual costs (SEK)	30 M	60 M	200 M
Personnel required	600-700	600-700	2 000

Table 3: Comparison of different nuclear device alternatives. Source: "Utredning av betingelserna för framställning av atomvapen i Sverige" (Study of the conditions for the production of atomic weapons in Sweden) by Torsten Magnusson, 25 November 1955, Swedish National Defence Research Institute (FOA), 87-H 163:1-21A.

The plutonium alternative was also considered the most advantageous at a production rate of five nuclear explosive devices per year.

Five devices per year	**Plutonium**	**Uranium 235** Gas diffusion
Uranium	70-100 tons	1 ton
Heavy water	50 tons	1 ton
Uranium per year	35 tons	45 tons
Investment costs (SEK)	350 M	410 M
Annual costs (SEK)	45 M	90 M
Personnel required	800-900	900-1 000

Table 4: Comparison of different nuclear device alternatives. Source: "Utredning av betingelserna för framställning av atomvapen i Sverige" (Study of the conditions for the production of atomic weapons in Sweden) by Torsten Magnusson, 25 November 1955, Swedish National Defence Research Institute (FOA), 87-H 163:1-21A.

[78] Ibid.

As the tables show, the annual costs for the plutonium alternative are far lower than if U-235 enriched by gas diffusion is chosen.

The study expected it to take 8-10 years to produce the nuclear weapons, if the plans outlined above were realised. This time might possibly be shortened by two years if the pace were speeded up even more.

In order to realise the set goals, several steps should be taken at once, the study states. For example, more intensive research into the design and operation of nuclear weapons would have to be started, initially at FOA with the involvement of external experts. Increased production of uranium would also have to be started in Sweden. The possibility of importing uranium and heavy water from USA without reservations in the form of restriction on its use would also have to be investigated. If import was not possible, Sweden would quickly have to start its own production of these substances, Torsten Magnusson stated.

Much of the study dealt with activities that had not yet been started. But how far had Sweden actually come with what was perhaps the most important task as far a Swedish production of nuclear weapons was concerned – the manufacture of plutonium?

Department 1's annual report for fiscal year 1954/55 states that development work on extracting plutonium from irradiated uranium had begun. The researchers had isolated small amounts of plutonium. An experimentation facility for further investigations had also been built. [79]

The annual report for the next fiscal year states that an initial phase of the investigation into obtaining a good method for the isolation of plutonium and fission products from reactor-irradiated uranium had been concluded. An experimental plant for developing the extraction methods had also been put into service. In addition, research into initiation conditions and the dynamic sequence of events in a nuclear weapon explosion had continued. [80]

Knowledge was growing and an ever-clearer picture of how a Swedish nuclear weapon might be constructed was emerging. In purely technical terms, the technique for obtaining plutonium from spent nuclear fuel had been established. But a comprehensive nuclear weapons programme was still a long way off.

During 1956, explosion tests were carried out at a test site at Nausta in the north of Sweden to look into the effects. This test explosion work continued during the year that followed, with some tests being performed at the army administration's firing range at Marm in the county of Uppland. The largest charge contained 36 tons of nitrolite. The shock wave effect of this was equivalent to a 20 kiloton nuclear explosive device at a distance eight times greater.[81]

In 1956 a coordination group was formed to produce basic information for FOA's long-term planning. The information that the group handed over to the Supreme Commander

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[79] "Redogörelse för verksamheten vid Försvarets forskningsanstalt, avdelning 1, budgetåret 1954/55" (Report on activity at the Swedish National Defence Research Institute, department 1, fiscal year 1954.55), Swedish National Defence Research Institute, H 240/55.

[80] "Kortfattad redogörelse för verksamheten vid försvarets forskningsanstalt, avdelning 1, budgetåret 1955/56" (Report on activity at the Swedish National Defence Research Institute, department 1, fiscal year 1955/56), H 291/56.

[81] See Olof Forssberg's study (basis), p 76.

had Swedish nuclear weapons as the highest priority, meaning that they were regarded as being of crucial importance for the effectiveness of the defence force as a whole. It was considered that a study of the use of attack aircraft as a weapon carrier would be highly interesting. On the other hand, the group did not consider that a study to look into nuclear weapons in the form of long-range missiles (capable of reaching targets on the other side of the Baltic Sea) was equally important.[82]

3.3. The 1957 study

In May of 1957, the Supreme Commander gave FOA the task of carrying out a new study of the possibilities of producing nuclear weapons. Now it was only a matter of investigating the production and operation of the plutonium bomb. The Supreme Commander wanted the study to be completed during August of the same year. In other words it was urgent. A political decision would soon have to be made and it was essential that the information to base it on was as broad as possible.

The assignment was discussed in an internal memorandum at department 2 of FOA. One important precondition was that the content of plutonium 240 should not exceed 2%, and that the production capacity should be 40 or alternatively 80 kg of plutonium per year, writes Torsten Magnusson. Naturally the study would be secret. Apart from this there would be no preconditions on the study, for example concerning the choice of reactor type. The study should look into both "dual-purpose reactors" (producing both energy and weapons-grade plutonium) and an alternative with weapons-grade plutonium only, according to the brief memorandum.[83]

The work of the study should be done in two stages. The aim of the first stage was to produce a more general and approximate estimation of possible nuclear weapons manufacture. The plan was that this would be completed before the end of the year. The second stage would contain more detailed results and, as the assignment states, "the necessary schematic design proposals". This stage (or at least the essential parts of it) should be completed no later than 1 June 1958.[84]

The first, more general, partial study was completed in August. It was based on the prerequisites arrived at by the 1955 study. The fissionable material should be plutonium 239 (although U-235 was a possibility). This material would have to be available in gram quantities as early as 1957 so that experimental work could start. From mid-1961, 0,5 kg of plutonium would have to be produced weekly in order to fulfil the plans described in the study, the report of the study continues. This form of plutonium could have lower isotope purity than that needed to produce nuclear weapons. But by 1963 at the latest there would have to be 10 kg of weapons-grade plutonium (ie with higher isotope purity). The advantage of this alternative was that the actual plutonium was not consumed in the laboratory experiments but could be re-used.

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[82] Ibid., p 65.

[83] "P.M. angående utredningsuppdrag betr. reaktorer för produktion av plutonium av vapenkvalitet" (Memorandum on study assignment concerning reactors for the production of weapons-grade plutonium), 5 July 1957, Swedish National Defence Research Institute, H 4050-2092.

[84] Ibid.

The programme for the metallurgical work was intended to be carried out in three stages. The first stage involved setting up a metallurgical laboratory where methods for handling plutonium were worked out. In the next stage, an experimental factory would be set up, with the purpose of producing material for the experimental work. And in the third stage, the production factory, series manufacture of the nuclear weapons would take place.

It was calculated that at most 387 people would be needed (246 of which would be researchers), and these would be appointed in the last phase during 1962/63.

In order to realise this major project it was recommended that a slimmer and looser organisation should be created than is common in the state sectors, including FOA, the report stated.[85]

In November 1957 FOA asked for permission to acquire from abroad and subsequently to hold 10 grams of plutonium in the form of metal for research purposes. The government consented to this request.[86]

During fiscal year 1957/58 work started on building a special laboratory that would be used for the work involving plutonium. One of the most important tasks was to develop methods for the production of uranium and plutonium in their purest form. The annual report mentioned the complexity of nuclear weapons, which called for the expansion of several research fields such as nuclear physics, explosives technology, metallurgy and radiation biology. Pure protection aspects were investigated in a series of studies, which looked into such areas as the effect of shock waves on living organisms and different ways of cleaning up radioactive dust. Collaboration with a number of institutions and companies continued. Radiation-ecological studies were carried out with the aid of the Royal Agricultural College and the Royal Veterinary College. Orders for measuring instruments were placed with companies such as Bendix and AB Scienta.[87]

In December 1957 yet another partial study was completed, entirely in line with the time schedule outlined by FOA in July of the same year. It dealt with the technical preconditions for the construction of nuclear weapons. In many respects the analysis was based on the results obtained in the 1955 study.[88]

In January 1958, AE completed the partial report on the choice of reactors for a Swedish nuclear weapons programme. In the report, AE favoured a reactor solution for the production of plutonium for weapons use only. Such a solution would be technically and economically preferable compared with a reactor for both civilian and military use. There were many reasons for this, according to AE. One of the main ones was that a dual-purpose reactor would have to undergo frequent fuel changes, which was a complication. In addition, such a reactor would give rise to a number of technical and scientific problems in the form of lower pressures and other temperature levels.

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[85] "Utredning beträffande underlag för konstruktion av atomladdningar" (Study relating to basic information for the design of atomic explosive devices), 21 August 1957, Swedish National Defence Research Institute, H 4065-2092.

[86] Olof Forssberg's study (basis), p 77.

[87] "Redogörelse för forskningsverksamheten vid försvarets forskningsanstalt under budgetåret 1957/58 (Report on research activity at the Swedish National Defence Research Institute during fiscal year 1957/58), Swedish National Defence Research Institute H 1252/58.

[88] Olof Forssberg's study (basis), p 77.

A weapons-producing reactor with an annual production of 40 kg of plutonium required 60-70 ton of uranium per year, provided there were frequent fuel changes. On top of this, 40 tons of heavy water would be needed, AE stated in the report. It was estimated that actual plutonium production could start in 1965.[89]

In March 1958 a working party was formed with representatives of both FOA and AE whose job it was to deal with the plutonium issue. A plutonium laboratory would be built at Ursvik and be finished in January of the following year. AE would be able to use the laboratory until the metallurgical department at Studsvik was complete.[90]

The plutonium laboratory was completed during fiscal year 1958/59. A number of closed protection boxes had been built to be used when working with the toxic plutonium substances. In addition a special vacuum furnace had been tested to allow laboratory-scale casting of plutonium metal. [91]

In a written communication dated 16 May 1958, FOA asked to be permitted to carry out, together with AE, a study aimed at planning and conducting criticality experiments which were important in achieving a functioning and effective nuclear explosive device. AE would be in charge of the investigations, which would also include equipment and service arrangements. [92]

There was never any need to do these experiments, since the 1958 Geneva conference provided the required information.[93] In addition, when the IBM 7090 computer, which was considered to be the most powerful in northern Europe at the time, went into service, the work of calculation became much easier.[94]

3.4. Parliament decides on protection research

Swedish nuclear weapons research had now reached a stage at which a decision on the issue could be taken. For this reason, two studies were done, both of which were completed in July 1958. One, known as the device programme, was concerned with the production of nuclear weapons; the other, the protection programme, was intended to be used if parliament said no. Parliament would decide on the issue during the same month.

The device programme did not differ greatly from the 1957 study. However, there were two significant changes. First, the United States and Great Britain had began to publish data from experiments with fast reactors, which meant that less effort had to be channelled into that area of the activity. Secondly, the new level of knowledge was that plutonium could not be supplied in metallic form, but only as a chemical compound. The programme therefore maintained that the metallurgical research work would have to

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89 Olof Forssberg's study (basis), p 87 et seq.

90 Olof Forssberg's study (basis), p 88.

91 "Berättelse över verksamheten vid Försvarets forskningsanstalt under budgetåret 1958/59 (Report on activity at the Swedish National Defence Research Institute during fiscal year 1958/59), Swedish National Defence Research Institute, H 3457/51.

92 Letter to AE signed M. Fehrm, Swedish National Defence Research Institute, H 4034-2092.

93 Fröman 1993, p 58, 105; Forssberg's study (basis), p 91, 116.

94 Fröman 1993, p 76.

include the production of metal from a plutonium compound to meet the need of the criticality experiments for metallic plutonium. This would probably lead to delays.

In the device programme it was calculated that 10 kg of plutonium would be ready in 1965, provided that a decision to go ahead with the plans was taken in July 1959. This means a delay of two years compared with the 1957 study. A finished prototype of a Swedish nuclear weapon could see the light of day in 1966.

The number of personnel needed was estimated at 395 and the total costs would end up at about 120 million SEK during the period 1959-65.[95]

As the protection programme itself states, it was intended to cover the protection research needs "that are accommodated within the frame work of the general guidelines set out in the defence bill drafting committee's statement." For Sweden to be able to protect and defend itself against an enemy with nuclear weapons capability, extensive research would have to be done. The basic idea of this research was to obtain knowledge of an aggressor's nuclear weapons system so that the Swedish defence force could be configured in the best possible way. What was therefore needed, according to the authors of the protection programme, was basic information for:

> "making strategic assessments of the aggressor's way of working and efforts;
>
> drawing up operational plans;
>
> choosing Swedish tactics – army technology, navy technology and air tactics;
>
> the design of Swedish weapon systems to counter the atomic weapon efforts of the aggressor;
>
> the design of materials, such as tanks, and fortifications." [96]

This protection research would also include the production of plutonium, but it need not be weapons grade. The estimated number of personnel needed was 283 and the estimated costs were 100 million SEK.[97]

The 1958 defence bill was based on the Supreme Commander's study of 1957 (which advocated Swedish nuclear weapons) and the 1955 report of the defence bill drafting committee which advocated a line that could best be described as "wait and see".[98] The government took the line of the defence bill drafting committee and maintained that Sweden was not ready to take a decision on the nuclear weapons issue. In the bill, which was approved in July 1958, it was proposed that FOA should be given more funds to conduct protection research. In other words, the protection programmed was approved and the device programme was rejected.

In the debate that followed it was primarily international development in the field of nuclear weapons that was put forward as an argument for postponement. The underlying

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[95] "Forskningsprogram för framtagande av underlag för konstruktion av atomladdningar" (Research programme for the production of basic information for the design of atomic explosive devices), 4 July 1958, Swedish National Defence Research Institute, H 4041-2092.

[96] "Forskningsprogram avseende skydd och försvar mot atomvapen" (Research programme concerning protection and defence against atomic weapons), 4 July 1958, Swedish National Defence Research Institute, H 4040-2092.

[97] Ibid.

[98] Bill 1958:110; SU B 53; rskr. B 83.

idea was that Sweden should study the security policy situation in the years ahead and conduct protection research at the same time. This would mean that Sweden would not have lost much time if the international situation developed in a more threatening direction and the future security policy analysis favoured Swedish nuclear weapons.[99]

But how would protection research be defined? From the point of view of the research institutes, the interpretation of the decision taken by parliament was far too narrow. If FOA were really to be able to make the necessary preparations within the consideration period allowed, the concept would have to be broadened.[100]

So where were the limits on FOA's nuclear weapons research?

December 1959 saw the completion of an important report, which in many respects pointed the way to be taken by future protection research. It was then that the committee for the study of the nuclear weapons issue of the Social Democratic Party Council submitted its report.[101]

The study was very far-reaching and discussed various technical solutions relating to the choice of nuclear weapons. Like the decision of parliament in July 1958, the committee of the Social Democratic Party Council took the view that the future security policy situation should determine whether or not Sweden should acquire nuclear weapons. The analysis of the report was that Sweden had a breathing space at least until the mid-1960s, when international developments should provide an answer to the question. Until then, protection research should continue in order to enable as thorough a decision as possible. The report recommended that protection research should be broadened, since it was impossible to draw a clear line between protection aspects and design aspects:

> "such clarification should be provided in government-issued guidelines for the work of the research institutes. Doubtful borderline cases should be submitted to HM the King for a decision."[102]

Shortly after this, the report maintains that effective protection research can never provide sufficient information for the design of a Swedish nuclear weapon:

> "This requires more accurate investigations and calculations in certain areas, as well as laboratory experiments and tests with weapons-grade fissionable material. However, it will be several years before the time is ripe for this research, which, in terms of timing, is largely related to the expansion of the civilian atomic energy programme. If the government and parliament wish to take decisions about design research, there should be no need to take such a decision before 1963 at the earliest. This means that, within the framework of the 1958 decision of parliament on atomic

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[99] For a detailed discussion and analysis of the various lines of argument in the debate that followed, see Ahlmark, Per, *Den svenska atomvapendebatten* (The Swedish atomic weapons debate), Stockholm 1965.

[100] For example, parliament rejected the Swedish National Defence Research Institute's request for fiscal year 1960/61 to be allowed to produce basic information for a more secure technical and economic basis for nuclear weapons designs. However, the Minister of Defence stated in the finance bill that it was his intention to submit to the government a proposal for extended research into protection, Forssberg 1987, p 38 et seq.

[101] *Neutralitet Försvar Atomvapen* (Neutrality, Defence, Atomic Weapons), Stockholm 1960.

[102] Ibid., p 116.

> weapons research, the government can retain full freedom of action, in any case until 1963, as regards possible Swedish manufacture of atomic weapons."[103]

So was it only protection research that was being done by FOA? Christer Larsson answered this question with an emphatic "no". It is Larsson's view that, in fact, a small circle made up of a few members of the government, high-ranking military officers and researchers at FOA, deliberately misled the people of Sweden, parliament and even part of the government. All preparations for starting a nuclear weapons programme had been completed in secrecy by 1965. Secret funds had been made available to FOA to carry out all the necessary preparations in the form of design research and plutonium production.

Olof Forssberg maintain the opposite in his study of 1987:

> "My assessment of the grant conditions stipulated by parliament – imposed at the initiative of the government – must be that there was no absolute ban on any form of activity that gave results which could be used in a possible production of nuclear weapons." Such research as was required to shed light on the effects of nuclear weapons as a basis for protection measures was permitted according to the decision of parliament, regardless of whether it might also provide a certain amount of information for the design of such weapons. Only research directed *directly* towards design was banned."[104]

It is probably correct that it was hard to draw a crystal-clear line between what should be regarded as protection research and design research. Christer Larsson has gone far too far in his interpretation here. Although the bill and the decisions of parliament do not state specifically where the boundary of protection research runs, it is evident from the subsequent debate that no absolute ban was ever imposed on the production of information for the manufacture of Swedish nuclear weapons. It is perfectly clear from the report of the Social Democratic Party Council's Committee that it was difficult to draw a precise boundary between protection research and design research. But a boundary is specified in the report: there must not be design research aimed directly at the manufacture of nuclear weapons. In addition, another line had been drawn in the protection programme: weapons-grade plutonium must not be used in the context of future protection research.

Clearly certain preparations regarding the acquisition of nuclear weapons were permitted within the framework of the protection research decided on by parliament. But the key question is rather: did the research that FOA carried out remain within the limits set by parliament and the government?

As a result of the new direction, a fourth department was set up at FOA in 1959. It would deal only with research into protection against nuclear weapons.[105] But what was allowed in practice within the framework of the protection research that had been decided on?

FOA also struggled with that question during next few years.

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[103] Ibid.

[104] *Svensk kärnvapenforskning 1945-1972* (Swedish nuclear weapons research 1945-1972), p 58.

[105] Olof Forssberg's study (basis), p 104.

In September 1959 FOA wrote to AE asking it to investigate the technical and economic preconditions for the production weapons-grade plutonium.

Under this assignment the plutonium produced would be based on Swedish uranium and inspection-free heavy water (ie without inspections by the supplying country).[106]

Did this assignment stay within the permitted limits? As far as the grant for producing basic information for design of nuclear explosive devices is concerned, it is entirely reasonable to argue that this remained within the bounds of protection research. To be able to protect oneself against nuclear weapons, you need to know what their properties are. The same can be said of FOA's request for AE to produce basic information for weapons-grade plutonium. Although the protection programme clearly states that the plutonium to be used must not be weapons-grade, here it was a matter of producing basic information for a future decision. It was not a matter of using weapons-grade plutonium at that actual time in the ongoing research.

On the other hand, as far as the economic aspects of such a production are concerned, it is doubtful. Was it not a matter of producing information *directly* aimed at envisaged nuclear weapons production? Clearly, in effective protection research, it would be necessary to deal with fundamental matters of nuclear weapon design. But is it equally self-evident that economic calculations relating to important stages in the production of Swedish nuclear weapons should be performed? Has not the limit of protection research been passed at this point?

FOA was faced with walking a difficult tightrope. On the one side it was bound by parliament's decision about protection research, which was perceived as far too restrictive; on the other hand it would have to provide the government, Supreme Commander and parliament with information on which to base a future posture within the framework of the time allowed for consideration.

The dual assignments amounted to an inherent contradiction, which could not continue unless the concept of protection research was broadened.

3.5. Summary: 1953-1959

Plans for Swedish nuclear weapons began to mature in the security policy debate during this period. Previously the question had only been discussed in a narrow circle of politicians, army officers and researchers. But when the Supreme Commander's study was presented in 1954 the debate began in earnest.[107] The Supreme Commander advocated that Sweden should acquire nuclear weapons in order to defend the country's non-alignment.

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[106] In November, AE replied to the Swedish National Defence Research Institute and described how and in what order the investigation work should be done. 20 November 1959, H 4067-2092. Swedish National Defence Research Institute accepted AE's proposed approach. 26 November 1959, H 4071-2092.

[107] For a detailed discussion of the view of the Swedish military on Swedish nuclear weapons, see Agrell, Willhelm, *Alliansfrihet och atombomber. Kontinuitet och förändring i den svenska försvarsdoktrinen 1945-1982* (Non-alignment and atomic bombs. Continuity and change in the Swedish defence doctrine 1945-1982), Stockholm 1985; Björnerstedt, Rolf, "Sverige i kärnvapenfrågan" (Sweden on the nuclear weapons issue).

Nuclear weapons-related research took major steps forward during this period. Three major nuclear weapons studies were carried out, in 1953, 1955 and 1957. The basic form of a Swedish device had already been largely decided in 1953. The nature of the project was that the military nuclear weapons programme was part of civilian nuclear energy development. In other words, the heavy water technology that was being developed would be used for both military and civilian purposes. The actual nuclear weapon would be light or, as it came to be known in the technical language, a tactical nuclear weapon. The fissionable substance would be plutonium and the best option as a moderator was considered to be heavy water (earlier studies had talked of graphite). The plutonium-producing reactors would be loaded with Swedish natural uranium. Later studies would broadly only refine and develop this basic form, depending on technical developments and the availability of the necessary nuclear materials and other advanced equipment from abroad. The 1957 study sketched a nuclear weapon that weighed about 100 kg. This view would persist well into the 1960s, although there were plans for other weight classes in parallel.

The heavy water would be imported from Norway. Considering that the Swedish requirements would be very high – both for the civilian and the military programmes – it might be worth investigating whether it would be preferable to produce it in Sweden. Studies carried out between 1953 and 1959 argued that there were no guarantees that Norway could manage to supply Sweden with the required amounts of heavy water in the future.

Plutonium was the most important component for Swedish nuclear weapons production. Advanced plutonium research was conducted at both FOA and AE. During fiscal year 1954/55, FOA succeeded in isolating small amounts of plutonium; this was a major step forward. During the same fiscal year an experimentation facility for the development of extraction methods had been built. On a purely technical level, the plutonium question had been solved, according to an annual report for fiscal year 1955/56. This may have been true in principle, but the production of plutonium in a form suitable for nuclear weapons was still a long way off. In 1959 a plutonium laboratory was also opened at FOA in Ursvik. In the laboratory, which was equipped with advanced facilities, various experiments with metallic plutonium could be conducted to advance Swedish nuclear weapons research.

Several studies looked into a separation plant for plutonium, within the framework of Swedish nuclear weapons production. These were concrete studies in which the plant was sited in certain suitable areas and cost calculations for operation were done.

According to existing notes, 10 grams of plutonium, which had been borrowed abroad (as Forssberg also states) in 1957, were used. It was not until 1956 that detailed records of nuclear materials began to be kept, in the light of the safety regulations that were worked out and stipulated in the legislation. It is an almost impossible task to determine what amounts of uranium and heavy water had been used before then.

The 1955 study establishes that it was technically possible from then on to produce a Swedish nuclear weapon, given access to plutonium. Technically the plutonium question had been solved – although it would be modified with time. It was equally clear to FOA what steps would have to be taken in a production process and approximately what the project as a whole would cost in the form of capital and scientific and technical expertise. Sweden now had a reactor, the R 1 close to the Royal Institute of Technology, which went into service in 1954, and considerable expertise had

been developed at FOA and AE. In addition, there were large uranium resources in Sweden, although the content was low.

In view of this, there are strong indications that Sweden achieved latent capability to produce nuclear weapons as early as 1955. This is two years earlier than Stephen Meyer states in *The Dynamics of Nuclear Proliferation*. The 1955 study estimates that Sweden would be able to produce its first nuclear weapon under series production within six years if the pace were speeded up. In Meyer's categorisation, with the time calculation put forward in the 1955 study, Sweden falls into the group that had no nuclear infrastructure at all. Countries in that group are estimated to need up to six years to produce their first device. But on the other hand, Sweden, which, in terms of knowledge, was well ahead in the nuclear energy field from the international viewpoint (although the number of engineers and professionals trained to deal with nuclear energy issues was not yet great), would be able to produce its first nuclear explosive device sooner than within six year if all forces were channelled towards this goal (see Appendix 3, list of criteria for latent capability). In the light of this interpretation, the objection can be raised that continued research modified parts of the results arrived at by the 1955 study. For this reason, we should not take the 1955 study too literally on the issue of capability to produce nuclear weapons. Although there is much in favour of this objection, there are nevertheless reasons to assume that FOA would have succeeded in solving the technical problems that arose – provided that parliament decided to acquire nuclear weapons in 1955.

The weapon carrier systems that were discussed in the years in question were primarily the attack aircraft A 32 Lansen and A 35 Draken. The nuclear weapons would be in the form of missiles. In the mid-1950s, there was a new type of aircraft on SAAB's drawing boards, a bomber designated A 36. The idea was that the bomb bay of the A 36 would be capable of accepting heavy nuclear weapons which could be dropped over Soviet territory. But the project was cancelled in 1957.[108]

By 1957, Swedish research had reached a point at which a political decision on the issue was possible. FOA therefore put forward two programmes on which the government and parliament could decide. One, the device programme, would be carried out if Sweden chose to acquire nuclear weapons. The other, the protection research programme, was intended to be directed towards protection research, and would be carried out if parliament said no to Swedish nuclear weapons. In the political debate, yes and no camps had emerged since the ÖB-54 defence study had been presented, meaning that a course of action for Swedish nuclear weapons had been drawn up. In July 1958, parliament decided in favour of the protection programme. The bill approved by parliament states that the technical preconditions were such that a period of time for consideration had been granted. The directives that the government issued for FOA referred to the July 1958 bill.

Olof Forssberg has rightly refuted Christer Larsson's criticism which stated that the protection research on which parliament decided in 1958 precluded any preparations for the future acquisition of nuclear weapons within the framework of the protection research undertaken. On the other hand, Christer Larsson has a point when he draws attention to the fact that it was the head of research at AE, Sigvard Eklund, and not a

[108] Berns, Lennart, "A 36 – SAAB:s atombombare avslöjad" (The A36 – SAAB's nuclear bomber unveiled), *Flygrevyn* no. 4, 1991.

researcher at FOA who did the 1953 FOA study of Swedish nuclear weapons. It is remarkable that Eklund headed this study, considering the stipulated division of areas of responsibility into civilian and industrially oriented research (AE) and military research in nuclear energy (FOA). But Larsson goes too far when he maintains, against that background, that the military goals of producing a nuclear weapon took precedence over civilian nuclear energy development. Rather, this was due to the fact that Sweden was a small country with limited resources in the new field of research and that Eklund was a highly competent scientist. One may also ask oneself whether the choice of the head of research at AE was more remarkable than the placing of assignments with researchers at colleges of technology and universities.

Pure protection research also developed during this period. Broad-based collaboration with various research institutions and companies continued. For example, The Royal Veterinary College carried out radiation-ecological investigations and Bendix and AB Scienta designed various measuring instruments that could be used in the work.

4. The period 1960-1967

For fiscal year 1960/61, FOA requested a further 5,6 million SEK specifically for the purpose of producing basic information for the design of a nuclear explosive device in accordance with the instructions of the Supreme Commander. The intention was to arrive at a more secure basis for a future decision.

Through Minister of Defence Sven Andersson the government rejected the proposal on the grounds that it would conflict with the decision on protection research:

> "In line with the government's position in 1958 in relation to the grants to the research institutions, I still do not consider myself able to support the application, submitted by the research institutions at the request of the Supreme Commander, to begin research with the aim of producing basic technical and economic information for a future position on the issue of the construction of atomic weapons."[109]

But although the government was not willing to accommodate FOA's requirements, Sven Andersson states in the bill that the present orientation of the research was far too narrowly formulated. The bill also states that a proposal for expanded research would shortly be put forward.

Indeed, a directive arrived for fiscal year 1960/61, laying down the guidelines that would apply to future protection research under FOA:

> "His Majesty charges the National Defence Research Institute to conduct, within the limits of available resources, research relating to protection against nuclear weapons in accordance with a research programme approved by the head of the Department of Defence. The Institute will study the factors and carry out the investigations that are significant for knowledge of the effects of different types of nuclear weapons and about the preconditions for their use in armed combat, and develop the methods and equipment required for civilian and military protection against nuclear weapons. Research directed towards producing basic technical and economic information for the manufacture and testing of nuclear weapons must not be undertaken."[110]

4.1. Protection research or not?

During the spring and summer of 1960, several reports were completed at AE relating to the production of weapons-grade plutonium. The reports had been written at the request of FOA with reference to the communication of September 1959, which was discussed in the previous chapter. These are detailed technical reviews with cost proposals and

[109] Bill 1960:1, Appx 6, p 27 et seq and 292 et seq.

[110] Directive I of 5 May 1960, letter of 17 June 1960.

personnel requirements.[111] For example, AE carried out a thorough study of the preconditions of a Swedish plutonium factory with very precise figures.[112]

Several "system studies" were in progress to assess the consequences of Sweden possessing nuclear weapons. A memorandum states that the army administration had given SAAB the task of investigating the preconditions for a ground-based missile system, which could be used for nuclear weapons. For this reason, FOA would help SAAB to produce data and other information to make the task possible. FOA had previously handed over information about the external dimensions of a 50 kiloton nuclear explosive device. SAAB now intended to modify this data to suit a new missile system.[113]

Another example is when the Commander-in-Chief of the Swedish Army wanted to know the smallest possible diameter for a grenade with a nuclear charge. FOA replied that a projectile weight of 40 kg could be fired with a calibre of 15 cm. But that it should not be done at too great a range since the spread of hits must be in reasonable proportion to the radius of action.[114]

The annual report for fiscal year 1959/60 states that the agreed research programme could largely be followed. Earlier delays due to linking to the civilian programme cannot be recovered, the annual report continues. In addition, further delays are to be expected in view of the relatively slow development of the civilian nuclear energy programme.[115] Another retarding factor was the lack of the necessary premises.[116]

For fiscal year 1961/62, similar guidelines were given for continued protection research as for previous fiscal years.[117]

In July 1961, parliament decided that FOA 4, which had been run on a trial basis since 1959, would be made permanent.[118]

During the same year, several reports on plutonium production at the reactors in Ågesta and Marviken were completed. The picture of the way Swedish plutonium production would be organised was beginning to grow ever clearer.

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[111] "Rapport över etapp 3 av utredningsuppdrag beträffande reaktorer för produktion av plutonium av vapenkvalitet" (Report on stage 3 of study assignment concerning reactors for the production of weapons grade plutonium), 28 April 1960, Olof Forssberg's study (basis), p 116; "En rapport över etapp IV beträffande val av reaktor för plutoniumtillverkning" (A report on stage IV concerning choice of reactor for plutonium production), H 4120-434; "Svensk plutoniumfabrik under 1960-talet" (Swedish plutonium factory during the 1960's), 20 June 1960, H 4162-434.

[112] "Svensk plutoniumfabrik under 1960-talet", (Swedish plutonium factory during the 1960's), 23 August 1960, H 4162-434.

[113] Olof Forssberg's study (basis), p 118.

[114] Svar till CA på fråga (Answer to the Commander-in-Chief of the Swedish Army to the question), H 4027-403.

[115] Swedish National Defence Research Institute's annular report 1959/60, 29 September 1960, 013-H 345:1.

[116] "Redogörelse för forskningsverksamheten vid försvarets forskningsanstalt under budgetåret 1957/58" (Report on research activity at the Swedish National Defence Research Institute during fiscal year 1957/58), H 1252/58; "Berättelse över verksamheten vid försvarets forskningsanstalt under budgetåret 1958/59" (Report on activity at the Swedish National Defence Research Institute during fiscal year 1958/59), H 315/59.

[117] Bill 1961:1, Appx 6, p 245 f.

[118] Olof Forssberg's study (basis), p 104.

Are these studies not in conflict with the directive? This clearly states that:

> "Research directed towards producing basic technical and economic information for the manufacture and testing of nuclear weapons must not be undertaken."[119]

Were the reports on plutonium production not examples of basic technical and economic information for the manufacture and testing of possible Swedish nuclear weapons? Before we answer this crucial question, we must familiarise ourselves with two further studies that involved FOA: "Svenska kärnstridsmedel" (Swedish nuclear armaments) and "Kärnladdningsgruppens betänkande" (Report of the nuclear explosive device group).

4.2. The plans begin to take concrete shape

In May 1961, the Supreme Commander's working party completed their draft entitled "Svenska kärnstridsmedel" (Swedish nuclear armaments). The document would also serve as a basis for a possible presentation to the decision-making political bodies and for a possible open paper on the nuclear weapons issue.[120] The starting point was to maintain freedom of action in the framework of protection research and to make preparations aimed at production. But if circumstances changed, it would be possible to phase out the programme smoothly since weapons production was envisaged as taking place within the framework of civilian nuclear energy development.

Much of the document was an analysis of how Sweden's security policy would change if the defence forces were to be equipped with nuclear weapons. Several arguments for equipping the defence force with nuclear weapons were presented. (In this report I shall not analyse the security policy assessment, but such a study is planned.)

The Supreme Commander's working party assumed that the level of knowledge in relation to the design of a nuclear explosive device was sufficient to make an initial, rough nuclear explosive device even today, given access to fissionable material. Since Swedish nuclear weapons production went hand in hand with the development of civilian nuclear energy, series production could not be expected to start before the end of the 1960s.

After this, various possible reactor options were discussed. The options theoretically available were the Ågesta reactor; Marviken and a reactor made especially for this purpose.

If the fuel elements in the Ågesta reactor were to be changed twice as often as is usual in civilian service, it would be possible to obtain 18-20 kg of plutonium per year from 1963, the draft document maintained. This amount was calculated to be enough for two devices per year. The precondition was that the 26 tons of American heavy water would be replaced with Norwegian or other inspection-free heavy water (in 1957, AE had bought this amount of heavy water to be used in research work). Admittedly it had been acquired without specific restrictions on its use, but to use the heavy water in the production of nuclear weapons would go against the collaboration agreement entered

[119] Directive I of 5 May 1960, letter of 17 June 1960.

[120] "Svenska kärnstridsmedel" (Swedish nuclear armaments) by Bror von Vegesack, H 4149.

into with USA in 1956.[121] In any event, a separate separation plant would have to be built.

Marviken was planned to go into service in 1967. The problem with that option was that the reactor would probably be supplied with heavy water that was not allowed to be used in plutonium production because of restrictions imposed by the supplier country. The assessment was that it would take far too long to obtain restriction-free heavy water. If Marviken was to be used at all, a separate separation plant would have to be built. This was possible, but so costly that it would be just as expensive as creating a programme solely for nuclear weapons production.

The option with a reactor built for the purpose was also judged to be far too costly, according to the document.

Regardless of whether the Ågesta option or a special reactor were chosen, a reprocessing plant would have to be built in order to obtain weapons-grade plutonium, the report states. It was estimated that this would take four years.

These plans contained a dilemma. It would be very costly and technically complicated to invest in a reprocessing plant in Sweden. Also, there were plans to build a reprocessing plant in Belgium in 1963. Like most European countries, Sweden would be permitted to use this plant. In the light of this, it would be difficult to persuade those responsible for Swedish civilian nuclear energy development to invest in an all-Swedish reprocessing plant. Or, as it was expressed in "Svenska kärnstridsmedel" (Swedish nuclear armaments):

> "It is doubtful whether, from the civilian point of view, there is any alternative to awaiting the experiences that will emerge no sooner than 1963 from a reprocessing plant which is being built in Belgium in the framework of European atomic collaboration. If we have to wait for these experiences, the reprocessing plant just referred to cannot be ready until 1968 to 1969 at the earliest. The decision on this rests with the government."[122]

In the justifications for the grant application for fiscal year 1962/63 it is admitted that delays have occurred but that they will be made up.[123]
In February 1962 an important report was completed. The "nuclear device group" presented its results.[124] The group had been appointed on 27 June 1961 with the task of producing better basic information for elaborating the Supreme Commander's future approach in connection with the Supreme Commander study to be presented in 1962. It was not FOA that carried out the study, but the institute was very closely involved.

The study was the most thorough that had been done so far. As well as dealing with the preconditions for the design of nuclear weapons, including tactical and strategic considerations, it covered harmful effects in nuclear war and the weapon carrier issue.

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[121] Jonter, T., *Sverige, USA och kärnenergin. Framväxten av en svensk kärnämneskontroll 1945-1995,* (Sweden, USA and nuclear energy. The emergence of Swedish nuclear materials control 1945-1995), SKI Report 1999:21, p 24 et seq.

[122] Ibid.

[123] Bill 1962:1, Appx 6, p 227 f.

[124] "Kärnladdningsgruppens betänkande" (Report of the nuclear device group), HH 006.

According to the report, the studies had shown that the military value of Swedish nuclear explosive devices was significant. Sweden's potential to withstand threats would increase and the country's position in negotiation situations would be considerably enhanced.

Admittedly there were drawbacks with acquiring nuclear weapons, the group stated when summarising its results, but these are outweighed by the benefits:

> "The possession of nuclear devices would therefore bring decisive benefits for us but also some unwanted risk. However, in the long term, a nation which is unwilling to run certain risks in its security policy has no option but subjugation."[125]

It was still unclear when the programme would be able to start. If a pure weapons program were to be elaborated, the production time would be shortened considerably. But since the intention was that a possible nuclear weapons programme would be accommodated in the framework of civilian development work, it would take far longer. For this reason, the authors of the study propose a gradual process of acquisition of nuclear weapons capability:

> "Such an approach would mean postponing a definitive decision until devices could be added to the organisation relatively quickly, but it assumes that all necessary measures are taken to prepare for rapid acquisition – including research into the construction of the necessary plant. These measures must not pre-empt the definitive decision, only facilitate the elaboration of a flexible security policy. However, this may mean exploiting the civilian atomic energy programme to a greater extent than would be economical from the point of view of pure acquisition".[126]

The 1959 study had calculated that the first nuclear explosive device could be ready in 1966. But the delay in the civilian nuclear energy programme had put this date back to 1972. Admittedly the lost time could be limited to two or three years, if inspection-free heavy water were to be ordered more or less immediately.

As in the social-democratic study of 1959, the nuclear device group took the view that international developments must determine a decision for or against in Sweden. If international agreements to ban nuclear weapons are realised, Sweden should abort all preparations and destroy all plants, the authors maintain. On the other hand, if it proves impossible to conclude such an international agreement, the Swedish armed forces should be equipped with nuclear devices for tactical use.

Some design problems still remained unsolved. For example, the physical processes in a discharge could not be described in detail. But the problem was considered to be sufficiently understood for a projection of a discharge in the 5 to 50 kiloton range to be foreseen to some extent.

Studies of the design of weapon carriers also remained to be done. Choice of weapon carrier was by no means an unimportant component at this stage, since the design of the bomb/device itself had to do with the consumption of plutonium. If there was a requirement to make the device smaller, this could be done by increasing the plutonium content at the expense of the amount of natural uranium and explosives, the report

[125] Ibid.

[126] Ibid.

states. The nuclear device group primarily had the A 32 Lansen attack aircraft in mind when considering the choice of weapon carrier. The Lansen could easily be modified to be equipped with nuclear bombs and missiles. The A 37 Viggen, production of which was planned to begin at the end of the 1960s, could also be fitted with similar weapons. Submarines could also be equipped with explosive devices containing nuclear weapons, in the form of torpedoes, the report affirms.

The idea of importing nuclear weapons was dismissed as unrealistic in view of the fact that such an arrangement would seriously curtail Sweden's non-alignment. The authors of the study laconically pointed out:

> "If the Swedish defence force is to be equipped with nuclear explosive devices, these must be produced in Sweden."

The choice of reactor was now the opposite of that recommended in "Svenska kärnstridsmedel" (Swedish nuclear armaments). Marviken was now considered to be the best option. On the other hand, the Ågesta reactor would have to be written off in view of the high operating costs and the fact that the production output of plutonium would not be sufficient.
Using Marviken depended on the availability of inspection-free heavy water:

> "We must therefore as soon as possible reach an agreement with Norway to import the necessary amount without conditions or decide to start the manufacture of Swedish heavy water."

Another precondition was that it should be possible to set up a reprocessing plant. The civilian nuclear energy programme was not expected to need one before 1975. For this reason, continued planning should take into account the need to build a reprocessing plant to avoid further delays.

The total costs of the planned nuclear weapons programme for 100 devices were calculated for three options:

1. If a pure plutonium-producing reactor were chosen and if attack squadrons were used as weapon carriers, the cost would be 1 115 million SEK.
2. If the Marviken reactor were used to produce plutonium with aluminium-encased fuel elements and if the weapon carriers were missiles, the cost would be 1 812 million SEK.
3. If the Marviken reactor with zircaloy-encased fuel elements were chosen, and attack squadrons, missiles and submarines were used as weapon carriers, the total cost would be 1 988 million SEK.

What do these costs mean in relation to the defence budget?

If the programme with 100 tactical nuclear weapons were carried out during the period 1965-75, the total cost is calculated to be 5% of the entire budget of the Swedish defence force. If a programme were begun in 1964/65 with planned completion in 1979/80, this would correspond to 2,7 % of the entire military budget during this period.

In the light of these figures, the report concluded that a nuclear device programme could be managed within the framework of the budgets proposed in the Supreme Commander's defence study (ÖB 62) with no risk of significant reductions in other weapon systems.

In order to be able to proceed in the manner recommended by the nuclear device group, the approach of the current protection research would have to be extended. Freedom of action also required freedom of movement in terms of military technology:

> "In a programme of gradual acquisition, the restrictions on the research work would also have to be successively removed. However, research cannot tackle design problems only from the theoretical viewpoint. Many problems must be studied in connection to well-defined projects. Extended research therefore requires a number of questions relating to military use to be answered. At present it is considered urgent to be allowed to undertake studies of pure design details that can only be partially studied under the protection research programme." [127]

Does not this study – and the other studies referred to – conflict with the directive for fiscal year 1960/61?

According to Olof Forssberg, this boundary was never overstepped.

But was not this precisely what was done? Forssberg does not discuss in detail how the wording of the directive should be interpreted; he simply states that FOA always stayed within the limits set by the government and parliament.

Admittedly is can be asserted that it was the Supreme Commander who carried out the studies "Svenska kärnstridsmedel" (Swedish nuclear armaments) and "Kärnladdningsgruppens betänkande" (Report of the nuclear device group) and the Supreme Commander was not bound by the directive. (Forssberg does not discuss this in the study, but this may well be his reasoning.) But on the other hand, this cannot reasonably apply to the assignments that FOA gave to AE for plutonium extraction, unless FOA's request is interpreted as an assignment to be done was ultimately by the Supreme Commander. In view of this FOA's action should only be interpreted as mediating between the Supreme Commander and AE, and the information would simply form the basis of the Supreme Commander's – and the defence command's – own studies. In order to be able to provide as broad a basis for decision-making as possible for future decisions on the issue, he placed assignments with FOA, among others.

But this begs the question: What is the point of the announced protection research which would be controlled by directives? In practical terms, technical and economic basic information research could continue as before without FOA or any other involved party – FOA, AE or the Supreme Commander – transgressing against the protection research approach stipulated by parliament.

But did FOA not feel bound by the government's directive in relation to the Supreme Commander? In principle FOA could refuse to supply the Supreme Commander with technical and economic basic information. We do not know how the government and the minister of defence acted on this issue, but it goes without saying that the government, at least Minister of Defence Sven Andersson, knew of this arrangement. After all, he was personally deeply involved in defence planning and must have been aware of what was being done.

Another possible interpretation is that the directives make an implied distinction between *research* and *basic information*. The directives for fiscal years 1960/61 and

[127] "Kärnladdningsgruppens betänkande" (Report of the nuclear device group), HH 006.

1961/62 state that *research* directed towards the production of technical and economic basic information for the manufacture and testing of nuclear weapons must *not* be done. Charitably interpreted, this might mean that it was permissible for protection research to include design-related elements including technical and economic calculations, so long as it was not the aim to create basic information for manufacture. When the Supreme Commander gave FOA the assignment to investigate the preconditions for Swedish nuclear weapons production, the researchers at FOA stopped this protection research and took up a new role in which their task was to produce basic information for manufacture. The fact that the researchers used the results of the protection research in their new role of investigating nuclear weapons production was another matter. Seen in this light, FOA did not go against the directive.

If that logic were to apply, it only enhances further the interpretation that a political game was being played.

To summarise, it is reasonable to conclude that Christer Larsson's interpretation is exaggerated. Parliament did not decide to ban all conceivable preparations for the future acquisition of nuclear weapons. And in view of this, it is hard to agree with him when he says that parliament and parts of the government were misled. It is correct, as Olof Forssberg pointed out in his study, that parliament was able to look into these matters via the standing committee on defence issues, which was entitled to access the secret information about the nuclear weapons issue. The fact that most members of parliament did not do so and lived in blissful ignorance of the decisions that had been taken, is quite another matter.

Another conclusion is that the limits on the protection research permitted in accordance with the directives issued by the government were overstepped during the period 1958 to 1962.

4.3. Protection research disappears

From fiscal year 1962/63, the ban on research aimed at producing technical basic information of the manufacture and testing of nuclear weapons no longer appears in the directives sent to FOA.[128] The reason for this is not known, but it is Olof Forssberg's view that:

> "the wording of the ban was not particularly reconcilable with the freedom of action approach that parliament had accepted and which the defence minister had undertaken to observe. Admittedly the nuclear weapons research that would take place in the years ahead at FOA was aimed at studying the effects of and protection against nuclear weapons, but the design aspects that it included also contributed to some extent to keeping open freedom of action to eventually choose between a no and a yes on the acquisition of nuclear weapons. My assessment is therefore that the government's interpretation– as I have understood it – of the freedom of action approach gave an acceptable balance between the views of the nuclear weapons issue since the regulations of 1960 and

[128] However, the Swedish National Defence Research Institute annually submitted proposals for continued protection research even though there was no obligation to do so.

> 1961 ceased to apply. As I have already pointed out, for the next few years, this did not lead to any significant changes in the content and direction of the research programmes that the government approved."[129]

Reasoning along similar lines, Forssberg is of the opinion that the directive which the government gave FOA for fiscal years 1960/61 and 1961/62 was more restrictive than the decision of parliament in 1958:

> "This may have been the reason why the directives were not renewed after the first two fiscal years."[130]

It is probably the case that the Minister of Defence and the other parties involved took the view that a proper freedom of action approach on the nuclear weapons issued meant that research on technical and economic basic information could be done. But it is difficult to see the logic in the reasoning that the 1958 decision of parliament would have been less restrictive compared to the directives that applied between 1961 and 1962. If you study the bill approved by parliament it is difficult to find support for Forssberg's hypothesis. The decision refers in general terms to the fact that only protection research was permitted. The only clarification as to the outer limits on this activity is as follows:

> "Obviously there is no question of research aimed directly at the design of atomic weapons. Such work will not take place without a decision by parliament on the matter."[131]

If matters were as Forssberg assumes, it is hard to understand why the committee of the Social Democratic party council so strongly advocated an extension of the protection research to allow a functioning freedom of action approach. And why did the Minister of Defence call for extended protection research in the 1960 budget proposals, if it was not needed.

A more reasonable interpretation is that Swedish nuclear weapons research and the general political situation required a firm basis for a yes or no on the issue (so far I agree with Forssberg). The protection research defined in the directive for fiscal year 1960/61 had an inhibiting effect in that respect. That is why the government no longer issued directives about government grants. It would carry too great a political risk to go to parliament and ask for permission for further expansion, in view of resistance to Swedish nuclear weapons that had grown in recent years. At the same time, the freedom of action approach required – especially since both a yes camp and a no camp had emerged – that it should be possible to reach a decision on the issue.

But once again, it is not clear how the government was thinking on this issue. To achieve clarity, a political analysis would have to be done, in which the players are, in addition to the government, parliament and media, the Supreme Commander, FOA and other sectors in the defence force.

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[129] "Svensk kärnvapenforskning 1945-1972" (Swedish nuclear weapons research 1945-1972), p 61.

[130] Ibid., p 81.

[131] Bill 1958:110, p 93.

4.4. The problems accumulate

It turned out that the plans outlined in the studies of the nuclear device group were difficult to carry out in practice. There would be both technical and financial difficulties in accommodating the weapons programme in the framework of civilian nuclear energy development.

At a meeting at the Chief of the defence staff, it emerged that, despite the recommendations of the nuclear device group, most of the indications were that Marviken should be loaded with enriched uranium instead of natural uranium as planned. This was mainly for financial reasons, according to the memorandum of the meeting. And if this were to be done, the consequence would be that the enriched uranium would have to be imported from USA, which in turn gave USA the right of inspection. Consequently Marviken could not be used for nuclear weapons production. Admittedly the reactor could be loaded with natural uranium at a later date, but this would lead both to delays and to far higher costs. In addition, such a procedure might attract attention, since it could hardly be concealed.[132]

The authors of the memorandum seem to have been hinting that USA would probably not accept such an arrangement in Sweden. The US government would then be able to maintain that the Swedish players had misled the concerned American authorities and the companies that sold the enriched uranium. This would have an adverse effect on the otherwise rewarding Swedish-American collaboration on nuclear energy. Another reason which FOA and other Swedish players doubtless had in mind was that the domestic critics of a Swedish nuclear weapons programme would be sure to find a reason to say that it was not just a matter of protection research.

In this connection it is important to realise that USA was highly sceptical about Sweden's plans to acquire nuclear weapons. In 1960 the *National Security Council* (NSC) took a decision which meant that USA would try to prevent Sweden reaching nuclear weapons capability. Presumably as a part of this policy – not just with regard to Sweden but to all technologically advanced countries that were considering such plans – USA had lowered the prices of enriched uranium. By imposing conditions on sales to other countries, USA could prevent at least the sold uranium being used to produce nuclear weapons.[133]

In this way, the process of gradual acquisition would be made more difficult. The critics, both in Sweden and abroad, would then be able to put obstacles in the path indicated by the nuclear device group. In the worst case, the freedom of action for this research would shrink so drastically that it would not be possible to produce Swedish nuclear weapons at all.

The choice of uranium was not the only problem. Obtaining heavy water would also come up against complications. Was it at all realistic to expect to get all the required heavy water from Norway, the authors of the memorandum asked themselves. Admittedly there are 50 tons of inspection-free heavy water in the country, the memorandum stated, but a further 50 tons would be needed to carry out a programme.

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[132] Olof Forssberg's study (basis), p 145 et seq.

[133] Jonter 1999, p 37 et seq.

But despite this objection, is was felt that it would be possible to obtain the required heavy water without undue delays.

Soon afterwards it was quite clear that it would be far cheaper to import enriched uranium from USA. This was known before, but not that the costs would be so much lower.

When talking to advocates of the American nuclear energy policy the Swedish players were now wondering if it was for tactical reasons that USA was dumping the price of U-235. For example, Jan Rydberg raised the question with the head of the United States Energy Commission, Nobel prizewinner Glenn Seaborg.

Seaborg stated that there were no grounds at all for the Swedish suspicions. There were no political reasons for the low prices. At the same time Seaborg said he found it hard to understand the Swedish approach with the use of natural uranium and heavy water, considering the low price of U-235 in USA.

Glenn Seaborg suspected that, in spite of everything, Sweden had plans to produce nuclear weapons. And he actually asked if this was the case. Rydberg stated that there was no such programme, but that the protection research that was being conducted generated knowledge that would be of practical value if Sweden decided to acquire nuclear weapons. Seaborg replied that he understood this, but at the same time USA took an extremely negative view of such a development.[134]

The question is whether or not it was a deliberate strategy on the part of USA. Regardless of whether or not it was a planned American action, the low prices of uranium in USA created problems for the realisation of a Swedish nuclear weapons programme.

FOA's annual report for fiscal year 1962/63 states that the production of metallic plutonium on the one-gram scale had begun, as well as the investigation of methods for the recovery of plutonium from laboratory waste.[135]

AE was asked by FOA to carry out a study of reactor options in the light of the rapid pace of technical development, which was thought to have made earlier studies obsolete.

4.5. Nuclear weapons plans are abandoned in research

AE's study of reactor options was completed in March 1964. As well a doing cost calculations for reactor operation, AE had also included the construction of the necessary fuel factory and reprocessing plant. The plan was to locate all these plants at Sannäs in Bohuslän, in the southwest of Sweden.[136]

In FOA's grant application for fiscal year 1965/66, research area 2, Nuclear explosive devices, still had priority. For example, a miniaturised version of a neutron source had been designed, and production of metallic plutonium on a one-gram scale had been achieved.

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[134] "Samtal med doktor Seaborg" (Conversation with Dr Seaborg), 29 January 1963, H 4020-412.

[135] "Berättelse över verksamheten vid Försvarets forskningsanstalt under budgetåret 1962/63 (Report on activity at the Swedish National Defence Research Institute during fiscal year 1962/63), 0013-H 370.

[136] Olof Forssberg's study (basis), p 171.

The pure protection research was meant to produce descriptions and analyses of different types of nuclear weapons designs in order to allow the potential enemies' operational possibilities to be studied. This work included testing and production of conventional explosive charges and the development of manufacturing methods in order to be able to analyse different types of charge.

The defence department did not advocate any new services in the 1965 budget and the extent of future protection research was expected to be the same as in previous fiscal years.[137]

When the time came for the presentation of the Supreme Commander's defence study 1965 (ÖB-65), the army administration decided not to raise any requests for nuclear devices in it. The freedom of action approach would remain in force, states the proposal, which was approved by the Supreme Commander, with the title "PM rörande kärnladdningsfrågan i ÖB-65" (Memorandum concerning the nuclear device issue in ÖB-65). The memorandum contained a cost calculation for a nuclear weapons programme comprising 100 nuclear explosive devices (including weapon carriers, testing and development costs). The total cost was estimated at 1 950 million SEK. This figure was lower than the 1963 calculation, which arrived at a total cost of 2 200 million SEK. The difference was thought to be due to the fact that the estimated final sum in the 1963 calculations included interest charges and repayments. Now, two years later, the calculation was done with possible depreciations in mind. Another essential difference from before was that this study did not consider a double-action option in the choice of reactor. Now it was simply a matter of producing an optimised reactor for plutonium production.

It was also felt that the time between decision and production could be shortened compared with two years earlier, from 7 till 5,5 years. The main reason for this was said to be the accelerating rate of increased knowledge in the nuclear energy field.[138]

The basic information for a chiefs of staff meeting on 15-16 March 1965 also stated that the freedom of action approach should also apply for the time being. At the same time, the freedom of action conducted up to then was considered far too vague, making rational planning more difficult. The concept of freedom of action would have to be defined more precisely if it were to be possible to produce the necessary technical documents in order to shorten the production time after a positive decision on the issue. Such a procedure required preparations in the form of project planning and design work. In concrete terms, this would mean, for example, that heavy water would be stored to speed up production – if a decision to purchase nuclear weapons were taken.[139]

These thoughts resurfaced at a meeting of the regional chiefs in the defence force in May of the same year. But heavy water and uranium oxide were not mentioned specifically. On the other hand it was stated that the freedom of action must be extended to include storage possibilities for the necessary raw materials. The combined costs of carrying out the necessary construction work and storage were calculated at 50 million SEK.

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[137] Bill 1965:1, Appx 6, p 253 f.

[138] Olof Forssberg's study (basis), p 190.

[139] Ibid., p 193 et seq.

In addition, it was now abundantly clear that the civilian nuclear energy development was designed without taking possible future requirements for nuclear devices into consideration. And in view of this it would be extremely important for these preparations to be done, argued those attending the chiefs of staff meeting. [140]

During the late autumn of 1965 the chief of defence staff handed over a memorandum which took up most of these suggestions for a revision of the concept of protection research in the framework of an extension of the concept of freedom of action. In the memo, FOA was asked to investigate alternative research plans in order to be able to comply with the government's and parliament's decision on ÖB-65. If the government and parliament said no to the proposed project planning programme, the question might be raised as to whether the research resources ought not to be reduced or at least kept at the current level.[141]

FOA worked out a plan which would enable it to live up to the Supreme Commander's requirements. But the government maintained in the budget proposals for 1966 that it was not possible to meet FOA's request. According to the Minister of Defence, it was admittedly essential for advanced research to be conducted in the nuclear weapons field, but not with the orientation suggested by FOA. Of the requested applications for 6 million SEK, 3 million were approved, but to be used for research concerning long-term defence force planning, evaluation of different defence options, etc.

Parliament approved the government's proposals. [142]

In practice, this decision means that the Swedish plans to acquire nuclear weapons had been abandoned. With the reduced scope for action that the decision of parliament entailed for continued research, it was more or less impossible to make the necessary preparations that were required in order to be able to realise a programme at a reasonable cost and in a reasonable time.

One consequence of the decision of parliament was that some planned research projects had to be changed radically and in some cases cancelled. For example, AE's uranium works at Ranstad, where test operation started in 1965, did not become the significant producer of uranium that it was planned to be. In addition, AE did not continue with the plans for setting up a reprocessing plant for the production of plutonium, land for which had been purchased in Bohuslän.[143]

But the pure protection research continued with more or less the same orientation as in previous fiscal years. It is evident from FOA's annual report for fiscal year 1965/66 that the basic design and operation of nuclear explosive devices has been summarised, and the need for further studies has been investigated. FOA personnel had also been used as advisers on the Swedish disarmament delegation at Geneva.[144]

FOA was now planning for a reduction of research work on nuclear weapons.[145] At a planning conference in March 1967, FOA prepared itself to meet the new demands of

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[140] Olof Forssberg's study (basis), p 195 et seq.

[141] Swedish National Defence Research Institute, Department 4, Office, Incoming and outgoing secret documents 1965 F, Volume 62, H 4222-5.

[142] Bill 1966:1, Appx 6, p 188 et seq.

[143] On these plans, see Olof Forssberg's study (basis), p 195.

[144] Swedish National Defence Research Institute, Planning office, 0013-H 385:1.

[145] See Olof Forssberg's study (basis), p 209 et seq.

the future. To start with, a less favourable economic position was to be expected. Secondly, a new view of the risk of a war involving nuclear weapons was emerging. And thirdly and finally, the earlier orientation approach towards freedom of action was obsolete.

According to the planning meeting, activities in future should be directed towards pure protection research.

Severe budget cutbacks came into force. According to the defence staff, nuclear weapons share of FOA's entire research had fallen from 26,5 % in fiscal year 1965/66 to 20% in the current fiscal year 1967/68.[146]

Although no political decision had been taken on the nuclear weapons issue, FOA had known for a long time that the plans would never be realised.

4.6. Summary: 1960 -1967

The extensive studies needed to enable FOA to produce basic information for a future decision on the nuclear weapons issue required an expansion of the protection research. After the directive for fiscal year 1960/61, such an expansion took place. The limits imposed on this protection research meant that no research could be done that was aimed at producing basic technical and economic information for the production and testing of nuclear weapons.

According to Olof Forssberg, FOA never crossed the limit of what was permitted. But after a closer review of the studies by FOA (or where FOA was involved) after the directive came into force, it is difficult to agree with Forssberg. Admittedly the government did not accept all the proposals that came from FOA or the Supreme Commander between 1960 and 1962. There was of course a limit on what would be allowed during the time given for consideration. But the conclusion must be that, on a few occasions, FOA went further than the directive allowed. For example, when FOA asked AE to provide precise basic information for the manufacture of plutonium with exact localisation and cost calculations, which was realised during the spring of 1960. As far as the studies for which the Supreme Commander was responsible, it can be maintained that the Supreme Commander was not bound by the directive. On the other hand one may ask oneself whether the entire protection research was not just playing to the gallery. In practice, investigations that were in conflict with the directive were carried out.

At the same time, it should be stressed that FOA *had to* provide this basic technical and financial information if a decision within the framework of freedom of action were to be possible. The varied fortunes of protection research had more to do with the political game. There is every indication that the government did not want to run the risk of going to parliament and asking for a new orientation of FOA's research, whether or not it was to be called protection research. Resistance to nuclear weapons had also grown in the early 1960s, and it was very likely that parliament would say no, so that freedom of action had been seriously damaged in practice. Instead, there is every indication that, fiscal year 1962/63, the government choose no longer to issue directives in which the

[146] Ibid., p 222.

conditions of protection research were defined. But we can safely assume that the government was aware of what was happening and what the various secret studies were about in concrete terms.

Perhaps the most important study done during this period was the report of the nuclear device group which was presented in 1962. The report says that if international developments do not lead to a ban on nuclear weapons, Sweden should equip its armed forces with them.

The acquisition of one hundred tactical weapons was still being discussed. The first of these could be ready in 1972 (even earlier if measures and steps were taken to speed up the process). The main weapon carrier systems would be the A 32 Lansen and the planned A 37 Viggen attack aircraft. Submarines could also be equipped with nuclear weapons, in the form of torpedoes, the study noted. Another possibility mentioned in the report is a ground-based missile system. SAAB was working on such a system.

In order to succeed in carrying out a programme of this magnitude, a gradual acquisition process was recommended, which meant that heavy water and uranium oxide would have to be stored.

Marviken was seen as the best choice of reactor, according to the study.

The choice of Marviken as the reactor would eventually lead to problems in relation to USA. The indications were that the first fuel batch would be enriched uranium, bearing in mind the requirements of civilian nuclear energy development. The price of enriched uranium was very low in USA and in all probability industry would never agree to use the costly Swedish natural uranium. A costly reprocessing plant would have to be built. Such a plant had been planned within the framework of European nuclear energy collaboration. This would mean mandatory inspection by USA. Admittedly a second fuel batch could contain Swedish natural uranium. But the Swedish defence force administration wondered how USA would react to such an arrangement. Researchers at FOA and generally all players involved in the nuclear weapons plans were asking themselves whether the drastic fall in the price of enriched uranium was a deliberate strategy on the part of USA to prevent countries such as Sweden developing their own nuclear weapons.

This was one of many obstacles that would hamper a Swedish nuclear weapons programme.

During fiscal year 1964/65, FOA had succeeded in producing metallic plutonium within the framework of the protection research it was conducting. The plutonium that was used in this research had been borrowed from another European country. During 1960-1967, FOA had the following amounts of nuclear materials at its disposal in the research it was undertaking: plutonium, about 600 grams (the statement in the Forssberg study that FOA never used more than 0,5 kg of plutonium at the same time is correct. In all, FOA used about 0,7 kg plutonium during its entire operation, according to the registers of the possession of nuclear materials). According to the same register, which is kept in SKI's archive, FOA had access to 20 kg of natural uranium during the period. There is no documentation on possession of heavy water.[147]

[147] "SKI:s materialbokföring 1970-1975" (SKI's materials bookkeeping 1970-1975), "Sammanställning av uppgifter om transporter av kärnämnen till och från Sverige åren 1955-1979" (Compilation of

From 1965 on, civilian development continued without taking account of the military needs. In practice, the plans to purchase the American enriched uranium meant that, from now on, a purely military reactor programme would have to be carried out if Sweden were to acquire its own nuclear weapons. For this reason, the defence command felt that is was compelled to carry out the gradual acquisition procedure if a freedom of action approach worthy of the name were to apply. However, in the 1966 budget proposals the government said no, and with this the Swedish nuclear weapons plans were in practice abandoned.

Severe slimming-down of FOA's nuclear weapons research began. A radical redistribution of research resources was started. For example, the project for AE's uranium factory at Ranstad, which started trial operation in 1965, was abandoned. AE's plans for a reprocessing plant, for which land had been purchased in Bohuslän, were not fulfilled either. But pure protection research continued as before. To what extent, we shall find out in the next chapter.

information about transports of nuclear materials to and from Sweden between 1955 and 1979), Division of Materials Control, SKI archive.

5. The period 1968-2000

The 1968 defence bill maintained that it was not in Sweden's interest to acquire nuclear weapons.[148] Parliament passed the bill and with this the freedom of action option disappeared from the security policy agenda. The decision did not mean that Sweden had said no to nuclear weapons capability for good. Theoretically, it was still possible, but when the government signed a treaty on non-proliferation of nuclear weapons in August of the same year, that possibility had been radically restricted. And it had completely disappeared on 9 January 1970 when Sweden ratified the non-proliferation treaty.[149]

But even if the defence decision of 1968 did not preclude – purely theoretically – Sweden from being able to re-evaluate its posture, it means in practice that the plans had finally been scrapped.

Both the defence staff and FOA accepted that resources would have to be re-directed from nuclear weapons research to activity directed towards conventional warfare.

But not all nuclear research would have to be stopped. Certain parts of the pure protection research would even increase, for example the area dealing with the mechanical and thermal effect of war involving nuclear weapons. It was mainly the design aspects that would disappear from current research (see Bill 1968:110). Now there was no reason to continue with the research that was previously being done to produce information for the production of nuclear weapons by Sweden. Personnel and materials could also be transferred to other areas in FOA. From 1968 onwards, there was a deliberate strategy of transferring personnel and equipment resources from nuclear weapons work to the area of materials research.

In 1970, the department for nuclear chemistry was transformed into a department for materials research. The work on plutonium was also phased out. The annual report for fiscal year 1971/72 states that experimental plutonium activity at Ursvik had been completely shut down. All areas in the active laboratories had been decontaminated and had been inspected by the Swedish Radiation Protection Institute.[150]

However, FOA had retained very small amounts of plutonium in preparations during the 1970s. According to the registers kept by the Swedish Atomic Energy Board and Swedish Nuclear Power Inspectorate of 1974, two grams were stored there until 6 April 1986. On that date, one gram of uranium 236, which had been stored since 1969, was removed. In 1971, FOA acquired 81 grams of U-235 (93%) which was kept until the following year. There was 20 kg of natural uranium at FOA from 1972 to 1986, when it was removed. There was more depleted uranium, however. 110 kg was acquired in 1971 and used in ongoing research until 29 October 1985. During the 1970s FOA also had 7

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[148] Bill 1968:110; rskr. 281.

[149] Prawitz, Jan, *From Nuclear Option to Non-Nuclear Promotion: The Sweden Case*. Research Report from the Swedish Institute of International Affairs, Stockholm 1995, p 19 et seq; see also Dassen van, Lars, *Sweden and the Making of Nuclear Non-Proliferation: From Indecision to Assertiveness.* SKI Report 98:16.

[150] "Berättelse över verksamheten vid Försvarets forskningsanstalt under budgetåret 1971/72" (Report on activity at the Swedish National Defence Research Institute during fiscal year 1971/72), 0013-H 340.

kg of heavy water, according to the entries in the registers. On conclusion of the research work, two grams of plutonium and one gram of uranium 236 were sent to the Department of Physics at Uppsala University. The rest of the uranium was sent to Studsvik and the heavy water was poured down the drain.[151]

In 1971, department 4 was re-trained and re-named "A-skyddsteknik" (atomic protection engineering). The department would still be working on protection research, although on a smaller scale. At a programme conference in the new department in January 1972, it was noted that the department's share of FOA's budget had fallen from 22 to 15 % since 1968/69.[152] In terms of person-years, the reduction was even more drastic; see Figure 1.

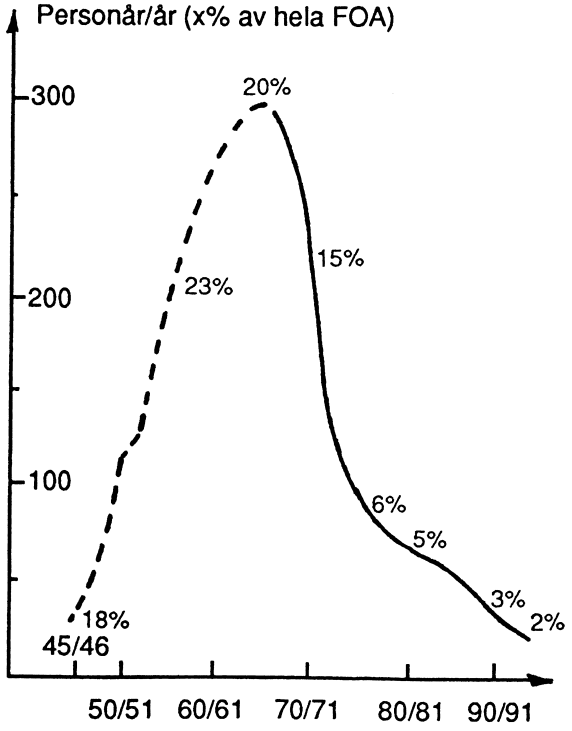

Figure 1: Number of people at FOA engaged in nuclear weapons research. The percentages show the proportion of FOA's entire workforce. Source: FOA VET om försvarsforskning (FOA knows about defence research), 8. FOAs kärnvapensforskning (FOA's nuclear weapons research), ISBN 91-7056-093-5, 1995, p 67.

[Personår/år (x% av hela FOA) = Person-years per year (% of all of FOA)]

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[151] "SKI:s materialbokföring 1970-1975" (SKI's materials bookkeeping 1970-1975), "Sammanställning av uppgifter om transporter av kärnämnen till och från Sverige åren 1955-1979" (Compilation of information about transports of nuclear materials to and from Sweden between 1955 and 1979), Division of Materials Control, SKI archive. On the way waste management was handled, see Larsson, Alf and Karlsson, Lars Gunnar, *Hantering av radioaktivt avfall i Sverige före 1980 samt radium och radiumavfall fram till år 1996 (*Handling of radioactive waste in Sweden before 1980 and of radium and radium waste up to 1996*)*, SKI report 96-18. See also the article by Wingefors, Stig, "Gammalt radioaktivt avfall kartlagt" (Old radioactive waste recorded), Nucleus 1997:14.

[152] Swedish National Defence Research Institute, 14 January 1972, 0012-H 12:2.

An important part of the history of FOA was now definitely at an end. Only 27 years had passed from the first reports to be written, when one of the main motives was to look into the possibilities for Swedish nuclear weapons. The aims were now reversed. Now, Sweden would not be trying to produce its own nuclear weapons at all. Or, as the research programme for 1972/73 says, the new goals of FOA's nuclear weapons research would include environmental aspects in addition to protection, and be able to support Swedish foreign policy with technical information which would enable Sweden to operate effectively in disarmament negotiations. Many of the researchers working at FOA began working on nuclear weapons disarmament.

A reading of the annual reports from the beginning of the 1970s to the end of the 1990s shows that it was the work on international disarmament that increasingly came to characterise FOA's nuclear weapons research. Some examples. The annual report for fiscal year 1981/82 states that FOA must help the Swedish Foreign Office in the international work of arms limitation in the form of expert help to the Swedish disarmament delegation in Geneva and work towards international control of ongoing nuclear weapons development.[153] One result of this was that experts from FOA played an active part in drafting the Swedish proposal for an agreement on a complete ban on nuclear weapons presented in Geneva in June 1983.[154] During the 1990s, FOA collaborated with the Swedish Radiation Protection Institute with the aim of locating and diagnosing radioactive objects. As a consequence of this development work, a station for monitoring airborne radioactivity was completed and installed in collaboration with USA. The station was located in eastern Russia.[155]

Although the international aspect became increasingly clear in traditional protection research, FOA's task of providing the defence force with information about nuclear weapons developments for an analysis of potential threats did not cease. The focus on the properties of nuclear explosive devices continued. For example, investigations of the storage properties of plutonium devices were undertaken. Since the 1960s, there had been interest in protection against electromagnetic pulse (EMP), which, alongside ionised radiation, heat waves and pressure waves, is a consequence of the detonation of a nuclear device. FOA conducted vigorous research into EMP and provided the authorities with information on how the harmful effects could be reduced or prevented. During the 1980s and 1990s part of the work had to do with obtaining technical information on issues relating to the spread of nuclear weapons.

The year 2000. Fifty-five years had passed since FOA initiated its nuclear weapons research. Sweden long ago gave up plans to acquire its own nuclear weapons and has become one of the most active countries working against the acquisition and spread of nuclear weapons. The extensive research that has taken place at FOA since 1945 has resulted in the development of a large fund of expertise which, when plans for nuclear weapons were abandoned, was channelled into international peace work. These efforts have resulted in a high level of international "good will" for the Swedish commitment to disarmament and nuclear weapons limitation.

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[153] Swedish National Defence Research Institute's annual report 1981/82 – Missive, FOA reg. no. 6-82-2354-00B.

[154] Swedish National Defence Research Institute's annual report 1982/83 – Missive, FOA reg. no. 6-83-1992-00B.

[155] Swedish National Defence Research Institute's annual report 1995/96, Stockholm 1997.

6. Conclusions

The time has now come to sum up. The first main question to be answered is: can the work that was being done at FOA be characterised as protection research?

Generally it can be said that FOA conducted its activities within the permitted limits. But there are some cases that ought to be discussed. Before that, we should first ask ourselves during which periods this protection research was in fact being done. Between 1945 and the decision of parliament on July 1958 there were no restrictions. The first reason for this is that it was not until 1957 onwards that Sweden had sufficient capability to take a decision on whether or not to manufacture nuclear weapons. In other words it was considered that there was no need to make a distinction between protection research and design research before that year. (However, such a distinction was made in practical terms. As early as 1945 the then head of the physics department, Torsten Magnusson, distinguished between protection research and design research). From fiscal year 1962/63 the government ceased to issue directives.

In the light of these points, it is only the period from 1 July 1958 up to and including June 1962 that is directly affected by parliament's decisions on protection research.

Did FOA go against the directives that defined the direction of protection research? The only reasonable conclusion must be that, on a few occasions, FOA went further that the directive allowed. For example, the studies that AE did for FOA into Swedish plutonium production in 1960 contained information that went beyond the permitted limits. This was basic information with technical details of every step of production, as well as cost calculations. On the other hand, it could be objected that FOA did this for the Supreme Commander, who needed technical and economic information for a future decision on the issue. The Supreme Commander was not bound by the definition of protection research in the directive and could therefore carry out the investigations needed so that the freedom of action line could be followed. A further charitable interpretation is that the terms *research* and *information* must be separated in the directives for fiscal years 1960/61 and 1961/62, which FOA had to comply with in relation to the permitted protection research. Since the directives did not *per se* forbid FOA to produce information for the manufacture of nuclear weapons, the limit was never crossed (however, *research aimed at producing information* was *not* allowed).

Whether one regards the interpretation with the Supreme Commander in the leading role or the interpretation where a distinction is made between research and information as the most reasonable one, the next question following on from this must be: What was then the point of specifying the scope of protection research if it could be exceeded with another principal or by means of a clever formulation? In practical terms, research was done, the purpose of which was to produce technical and economic information for a Swedish nuclear weapon.

At the same time, it has to be said that, in view of the freedom of action decided on by parliament, it was "understood" that such information would be produced. It should also be taken as self-evident that the government was aware of what FOA, AE, the Supreme Commander and other players were doing during the years in question. The problem was – from that perspective – that the government had more or less reduced its scope for

action by the definitions of the concept of protection research that had been formulated from 1958 and the years immediately following.

The government choosing not to issue directives, starting from fiscal year 1962/63, should be seen as a way of avoiding this conflict.

The other major question relates to when Sweden should be regarded as having reached latent capability to produce nuclear weapons. In this study I have found plenty of indications that Meyer's date of 1957 is at least two years too late. Meyer did not investigate Swedish expertise himself; instead he bases his work on a 1972 paper by Jerome Garris, which in turn was not based on what FOA was doing but on open sources.

There are reasons to assume that it was in 1955 that Sweden could at least deliver the expertise that Meyer himself had set up as a criterion. The 1955 study maintained that Sweden would be able to produce its first nuclear explosive device within six years if the pace were speeded up (probably even sooner if this had been required, considering that a reactor already existed and that considerable expertise had been developed at FOA and AE, equivalent to what was needed according to the criteria Meyer set up for a latent capability to produce nuclear weapons, see Appendix 3). The objection can of course be raised that this estimation was not based on well-founded research, since work in later years would revise this perhaps over-optimistic view. This research pointed to technical problems with arranging the production of nuclear weapons according to the guidelines suggested in the 1955 study. There may well be much to be said for that objection, but on the other hand more intensive research aimed directly at producing nuclear weapons (if Sweden had decided in 1955 to manufacture them) would have been more likely to solve technical and other problems as the work progressed. In addition, Sweden had ample expertise in the form of engineers and researchers at the time in question. As well as having a working research reactor and a uranium project, Sweden had ample uranium resources, although they were of low content.[156]

How advanced was the Swedish latent capability when plans for Swedish nuclear weapons were abandoned in the practical sense in 1966? Christer Larsson states in one of the articles in Ny Teknik that it would only have taken six months if a decision to go ahead with production had been taken in 1965. Production of nuclear weapons could hardly have been started quite so soon. For example, the planned reprocessing plants would have to be built, and the necessary amounts of uranium and heavy water not subject to international inspection would have to be acquired. But technically it would have been possible to produce an initial nuclear explosive device, given sufficient weapons-grade plutonium. However, this is not the same thing as Sweden starting its own nuclear weapons programme. After all, the planned Swedish programme was going to have to achieve a production of 100 nuclear explosive devices. But in view of the expertise that existed in 1965, the plants that could be used or were being planned, it is no exaggeration to state that Sweden had an advanced latent capability. According to Meyer, a state has an advanced capability if the country in question would be able to produce its first device within the framework of series production within two years.

[156] On the importance of uranium, see Skogmar, Gunnar, *De nya malmfälten. Det svenska uranet och inledningen till efterkrigstidens neutralitetspolitik* (The new ore fields. Swedish uranium and the neutrality policy of the post-war period), Research programme Sweden during the cold war, Working report no. 3, 1997.

Technically, financially and organisationally, Sweden would probably have managed this, if the government and parliament had decided on this objective.

In the light of the above, Sweden cannot be said to have had a nuclear weapons programme. The criterion for being able to assert this is, first, that a state has reached latent capability according to Meyer, and second, a political decision to start a nuclear weapons programme must have been taken. Admittedly, all conceivable preparations were made in Sweden, several necessary plants existed, so that, in purely technical terms, it was possible to produce nuclear explosive devices. In addition, if Swedish nuclear weapons production ever went ahead it would do so in the framework of civilian nuclear energy development. As civilian nuclear energy was developed, plants were built and the necessary equipment was purchased, it can be said that the degree of preparation for nuclear weapons production increased, and not only from the theoretical viewpoint. But no decision to produce was ever taken and consequently the most important steps towards obtaining the most vital components of such a programme – plutonium and the requisite amount of heavy water — were never taken.

The third main question concerns how the design-oriented research at FOA was phased out after Sweden signed the non-proliferation treaty in August 1968. The picture presented by Forssberg in the 1987 study is correct. Phasing-out of the preparatory activities was started and by 1972 FOA's premises where experiments with plutonium had been done were decontaminated. Even so, FOA still had some nuclear materials (very small amounts of plutonium, natural and depleted uranium, and heavy water) which were removed later in the 1970s and in the mid-1980s. There was nothing remarkable in the fact that these substances were still held at FOA. They were small amount which were needed in the ongoing protection research.

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Appendix 1. Chronology of Swedish nuclear weapons research

1945	FOA established
1947	AB Atomenergi established
1948	FOA's first report to the Supreme Commander about the technical preconditions for Swedish nuclear weapons
1949	Agreement between FOA and AB Atomenergi on collaboration in nuclear technology research
1953	FOA's second report to the Supreme Commander about the technical preconditions for Swedish nuclear weapons
1954	Reactor R 1 goes into operation at the Institute of Technology. Operation ceased in 1970.
1955	The first "Atoms for Peace" conference in Geneva FOA's third report to the Supreme Commander about the technical preconditions for Swedish nuclear weapons
1956	Experiments with the detonation of conventional explosives at Nausta began The delegation for atomic energy issues was set up The heat irradiation plant became operational
1957	International Atomic Energy Agency (IAEA) established FOA's fourth report to the Supreme Commander about the technical preconditions for Swedish nuclear weapons
1958	The second "Atoms for Peace" conference in Geneva FOA formulated two research programmes: 1) The protection programme ("S-programmet") for research into protection and defence against nuclear weapons 2) The device programme ("L-programmet") to produce information for the design of nuclear weapons Parliament decided that only protection research was permitted
1959	The plutonium laboratory at Ursvik became operational
1960	AB Atomenergi research reactor R 2 at Studsvik became operational Department 4 for protection research was established after a trial period
1962	The report of the nuclear device group was complete
1963	The reactor at Ågesta was started. Operation ceased in 1974
1965	The fifth and last report to the Supreme Commander about technical preconditions for Swedish nuclear weapons
1968	The non-proliferation treaty (NPT) was signed by the Swedish government The issued of Swedish nuclear weapons was resolved
1972	FOA's plutonium experiments ended
1974	Swedish Nuclear Power Inspectorate established
1976	Responsibility for nuclear weapons research was taken over by FOA 1
1994	All nuclear weapons research brought together under FOA 4 (ABC-protection)

Appendix 2. FOA's holdings of plutonium, uranium and heavy water[157]

The period 1945-1959

10 grams of plutonium

The period 1960-1968
Plutonium, about 600 grams

Natural uranium 20 kg

The period 1968-1986
Plutonium: small amounts of plutonium in preparations during the 1970s (two grams were still held at Swedish National Defence Research Institute up to 6 April 1986. On that date, one gram of uranium 236, which had been stored since 1969, was removed.)

U-235 (92.3 %): 81 grams, acquired in 1971. This amount was removed from the operation in 1972.

Natural uranium: 20 kg (from 1972 to 1986)

Depleted uranium: 110 kg (from 1971 to 1985)

Heavy water: 7 kg heavy water

Source: "SKI:s materialbokföring 1970-1975" (SKI's materials bookkeeping 1970-1975), "Sammanställning av uppgifter om transporter av kärnämnen till och från Sverige åren 1955-1979" (Compilation of information about transports of nuclear materials to and from Sweden between 1955 and 1979), Division of Materials Control, SKI archive.

[157] It is important to note that AB Atomenergi had plutonium and other nuclear materials in the context of its research.

Appendix 3. Criteria for latent capability of producing nuclear weapons

The list is taken from Meyer, Stephen, *The Dynamics of Nuclear Proliferation*, Chicago, 1986.

TABLE 24
RESOURCE DEMAND COMPONENTS BY STAGE

Stage	Resource Demand Components
1. Mining	Indigenous uranium deposits Previous national mining activity Initial operating costs
2. Milling	Metallurgists Chemical engineers Concrete, steel Construction force capital Research, development, and testing (RD&T) costs Initial operating costs
3. U-metal conversion	Metallurgists Chemical engineers Concrete, steel, electricity Construction force Capital RD&T costs Initial operating costs
4. Fuel fabrication plant	Metallurgist Electricity Capital RD&T costs Initial operating costs
5. Production reactor	Industrial engineers Nuclear engineers/physicists Metallurgists Chemical engineers Concrete, steel, electricity Graphite production capacity Construction force Capital RD&T costs Initial operating costs
6. Plutonium reprocessing plant	Chemical engineers Nuclear engineers Industrial engineers Metallurgists Concrete, steel, electricity Nitric acid Construction force Capital RD&T costs Initial operating costs
7. Weapons Fabrication Laboratory	Nuclear physicists Metallurgists Explosives/electronics experts Electricity Construction force Capital RD&T costs of weapon Initial operating costs

TABLE 25

PRELIMINARY LIST OF RESOURCE DEMAND COMPONENTS FOR THE BASE CASE ATOMIC WEAPONS PROGRAM

Previous national mining activity
Indigenous uranium deposits
Metallurgists
Steel
Construction work force
Cement/concrete
Chemical engineers
Nitric acid (production capacity)
Electricity (production capacity)
Nuclear engineers/physicists/chemists
Nuclear graphite (production capacity)
Electronics/explosives specialists
Capital costs of various plant facilities
Research, development, testing, and engineering costs
Initial operating costs of the process plants
Industrial engineers: civil structural, electrical, mechanical specialties