Institutional
Aspects of the Nuclear Fuel Cycle

by
R. Dolzer, M. Hilf, E. Münch, B. Richter, G. Stein
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Institutional
Aspects of the Nuclear Fuel Cycle

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The contents of this work are the sole responsibility of the authors. The physical and technical argumentation is due to E. Münch, B. Richter and G. Stein, legal considerations were contributed by R. Dolzer and M. Hilf.
This study does not quote the views of the Bundesministerium für Forschung und Technologie.

March 1980
### INSTITUTIONAL ASPECTS OF THE NUCLEAR FUEL CYCLE

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Abbreviations

ABL.  Amtsblatt der Europäischen Gemeinschaften
     (Official Journal of the European Communities)

AdG  Keesing's Archiv der Gegenwart

AGR  Advanced Gas-cooled Reactor

ATW  Atomwirtschaft/Atomtechnik

AWF  Amt für Wissenschaft und Forschung (CH)

B    Belgium

BAnz. Bundesanzeiger
     (Common informer of the Federal Republic of Germany)

BGBl. Bundesgesetzblatt
     (Law gazette of the Federal Republic of Germany)

BMFT Bundesministerium für Forschung und Technologie
     (Ministry for Research and Technology of the Federal Republic of Germany)

BNFL British Nuclear Fuels Ltd.

BReg Bundesregierung
     (Government of the Federal Republic of Germany)

Bull Bulletin

BWR Boiling Water Reactor

CEA Commissariat à l'Energie Nucléaire (F)

CEN Centre d'Etude de l'Energie Nucléaire (B)

CENTEC Gas Centrifuge Enrichment Company, Federal Republic of Germany,
           The Netherlands, United Kingdom

CH  Switzerland

COGEMA Compagnie Générale de Matières Nucléaires S.A.

c/s containment/surveillance

D  Federal Republic of Germany

DK  Denmark

DWK Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen m.b.H.

EC  European Communities

ECN Stichting Energieonderzoek Centrum, Nederland

EdF Electricité de France
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
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<tbody>
<tr>
<td>ENEL</td>
<td>Ente Nazionale per l'Energia Elettrica</td>
</tr>
<tr>
<td>ERDA</td>
<td>Energy Research and Development Administration (USA)</td>
</tr>
<tr>
<td>ESK</td>
<td>Europäische Schnellbrüter-Kernkraftwerksgesellschaft m.b.H.</td>
</tr>
<tr>
<td>Euratom</td>
<td>European Atomic Energy Community</td>
</tr>
<tr>
<td>EUROCHEMIC</td>
<td>European Company for the Chemical Processing of Irradiated Fuels</td>
</tr>
<tr>
<td>EUROIDIF</td>
<td>Usine d'enrichissement d'uranium per diffusion gazeuse S.A.</td>
</tr>
<tr>
<td>F</td>
<td>France</td>
</tr>
<tr>
<td>FBR</td>
<td>Fast Breeder Reactor</td>
</tr>
<tr>
<td>GfK</td>
<td>Gesellschaft für Kernforschung m.b.H., Karlsruhe</td>
</tr>
<tr>
<td>GHH</td>
<td>Gutehoffnungshütte AG</td>
</tr>
<tr>
<td>GW_{e,a}</td>
<td>Gigawatt-year (electrical); Giga = 10^9</td>
</tr>
<tr>
<td>HTR</td>
<td>High-temperature gas-cooled reactor</td>
</tr>
<tr>
<td>HWR</td>
<td>Heavy Water Reactor</td>
</tr>
<tr>
<td>I</td>
<td>Italy</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency, Vienna</td>
</tr>
<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>ILM</td>
<td>International Legal Materials</td>
</tr>
<tr>
<td>INB</td>
<td>Internationale Natrium-Brutreaktor-Baugesellschaft m.b.H.</td>
</tr>
<tr>
<td>INFCE</td>
<td>International Nuclear Fuel Cycle Evaluation Conference</td>
</tr>
<tr>
<td>INFCIRC</td>
<td>Information Circular (IAEA)</td>
</tr>
<tr>
<td>INTERATOM</td>
<td>Internationale Atomrektorbau-GmbH</td>
</tr>
<tr>
<td>IRL</td>
<td>Ireland</td>
</tr>
<tr>
<td>JET</td>
<td>Joint European Torus (joint undertaking)</td>
</tr>
<tr>
<td>J.O.</td>
<td>Journal Officiel de la République Française</td>
</tr>
<tr>
<td>JRC</td>
<td>Joint Research Centre</td>
</tr>
<tr>
<td>KEWA</td>
<td>Kernbrennstoff-Wiederaufarbeitungs-Gesellschaft</td>
</tr>
<tr>
<td>KfK</td>
<td>Kernforschungszentrum Karlsruhe GmbH</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogramm</td>
</tr>
<tr>
<td>KWU</td>
<td>Kraftwerk-Union AG</td>
</tr>
</tbody>
</table>
KKW  Kernkraftwerk  
(Nuclear power plant)
L    Luxembourg
LMFBR Liquid metal cooled fast breeder reactor
LWR  Light water reactor
MUF  Material unaccounted for
MWh/t Megawatt-days per tonne heavy metal; Mega = $10^6$
N    Norway
NEA  Nuclear Energy Agency (OECD)
NERSA Société Centrale Nucléaire Européenne à Neutrons Rapides S.A.
NL   The Netherlands
MOX  Mixed oxide (uranium-plutonium-mixed oxide)
NPT  Nuclear Non-Proliferation Treaty
NRC  Nuclear Regulatory Commission (USA)
NSG  Nuclear Suppliers Group
O    Oxygen
OECD Organization for Economic Cooperation and Development /NEA
O.J. Official Journal of the European Communities  
(Before the accession of the United Kingdom, Denmark, and Ireland referred to as AB1.)
Pu   Plutonium
RBU  Reaktor-Brennelement-Union GmbH, Hanau  
(Federal Republic of Germany)
RWE  Rheinisch-Westfälisches Elektrizitätswerk AG
S    Sweden
SALT Strategic Arms Limitation Talks, USA/USSR
SAS  Scandinavian Airlines System
SNR  Schneller natriumgekühlter Brutreaktor  
(Sodium-cooled fast breeder reactor)
Th   Thorium
TNT  Trinitrotoluol
TOV  Technischer Überwachungsverein  
(Technical regulatory commission of the Federal Republic of Germany)
U Uranium
UCN Ultracentrifuge Nederland
UK United Kingdom
UKAEA United Kingdom Atomic Energy Authority
UN United Nations
URANIT Uranisotopen Trennungsgesellschaft m.b.H.
URENCO Uranium Enrichment Company, Federal Republic of Germany, The Netherlands, United Kingdom
URG United Reprocessors Ltd.
VO Verordnung (regulation)
VÖEST Vereinigte Österreichische Eisen- und Stahlwerke AG
WAK Wiederaufarbeitungsanlage Karlsruhe
Introduction

Since the mid 1970s, the international discussion of nuclear proliferation has come into a state of flux. Intensive efforts were made in the 1960s, especially on the part of the super-powers, to prevent further horizontal proliferation of nuclear weapons via a maintenance of the status quo in the area of strategic nuclear capability. The appropriate means to this end were seen at that time in the renunciation of nuclear weapons construction by non-nuclear weapons states, accompanied by a general freedom in the field of peaceful use of nuclear energy, even with active support and assistance by the nuclear powers. This carefully weighed compromise was crystallized in 1968 in the form of the Nuclear Non-proliferation Treaty (NPT). The USA have commented on this treaty:

"In the history of international diplomacy it is hard to recall a treaty more painstakingly negotiated, in due recognition of the interests of so many governments and of its worldwide impact and importance."/1/

In the following years the Treaty was ratified by more than one hundred countries. A satisfactory consolidation became thus apparent in a situation generally recognized within the international community as being very threatening. Five years after the coming into force of the NPT, however, this development was to obtain a new direction which would basically call into question the consensus that had been achieved with such great difficulty. The initiation for this turn of events was, above all, the nuclear explosive test by India in 1974. Although India had not ratified the NPT, Canada, Australia and above all, the United States took this explosion as grounds for a reappraisal of the consensus expressed in the NPT. As a result of this re-thinking in the interest of strengthened proliferation resistance, the dividing line for non-nuclear weapons states was no longer to be drawn between peaceful and military use of nuclear energy but rather within the field of peaceful application itself, at that point where a potential military misuse becomes possible. This is to apply
especially to the so-called sensitive activities such as enrichment and reprocessing, but also to the existence of highly enriched uranium.

President Ford introduced new activities into the development of American non-proliferation policy which led, under the Carter administration, to a restrictive phase and to a new effort towards an enhancement of resistance to proliferation in the peaceful nuclear fuel cycle. This manifested itself in a multitude of considerations and measures, and led ultimately to the initiation of the International Nuclear Fuel Cycle Evaluation (INFCE) Conference. This conference, in which more than 60 countries were taking part, had the following goal:

"The participants in the Organizing Conference of the International Nuclear Fuel Cycle Evaluation are conscious of the urgent need to meet the world's energy requirements and that nuclear energy for peaceful purposes should be made widely available to that end. They are also convinced that effective measures can and should be taken at the national level and through international agreements to minimize the danger of the proliferation of nuclear weapons without jeopardizing energy supplies or the development of nuclear energy for peaceful purposes."/2/

Before conclusion of this conference, the Nuclear Nonproliferation Act of 1978 (NNPA) was passed in the United States which demanded new restrictive measures within the area of peaceful use of nuclear energy.

Proliferation has technical, political and institutional aspects. The speculation that technical means, along with safeguards measures, could not in themselves offer an effective deterrent to proliferation, led to a demand on the part of the USA to reduce risk of proliferation with the aid of institutional models for the sensitive stations within the fuel cycle. Institutional models comprise both the use of public and private corporations for the effective and safe operation of nuclear facilities with the inclusion of, for example, economic contracts, multilateral agreements, technical support and research programs, international studies, treaties of
nonproliferation, contracts for the assurance of supply, and international and multinational institutions. In the process of assessing within the context of INFCE and in consideration of the American Nuclear Nonproliferation Act and its consequences, it became of necessity to analyze, fill out and make more concrete the, in itself, empty institutional model formula /3/. This meant an investigation of the preconditions and consequences of institutional models for fuel cycle installations, and this not only with regard to additional deterrence of proliferation, but also with consideration of economic, environmental and political aspects, as well as on assurance of supply. The present study intentionally does not deal with all aspects of institutional models, but rather concentrates on the presentation, development and assessment of international models of cooperation in the nuclear fuel cycle.

At the present time there exists a large number of examples of international cooperation involving the Federal Republic of Germany. Additional models have already been discussed by various organizations, and examples from other areas of economic life have been proposed as models for cooperation in the field of nuclear energy. Until now, however, a systematic investigation and valuation of these forms of cooperation has been lacking. It appeared therefore reasonable, in a more comprehensive analysis of technical and legal aspects, to investigate institutional models for nuclear fuel cycle facilities and to make an assessment based on various criteria.

The present study describes causes and ways which can lead to proliferation and presents the present status and development of control measures. Beginning with a compilation of existing forms of international cooperation with participation of the Federal Republic of Germany, a systematic presentation of possible institutional models with regard to proliferation resistance is achieved. With the aid of a catalogue of criteria giving recognition to a variety of aspects, the institutional models are assessed, whereby due account is taken of already existing institutional forms of cooperation in the field of nuclear energy. From the analysis, discussions and valuations the authors have worked out a recommendation, which, because of its abbreviated form, can only be indicative but not representative of the entire content of the study. Results of the discussions and assessments of the institutional models are summarized in Sections 7.1.9 and 7.2.3.
References and Comments


/3/ W. Doub and L. Weiss, International Nuclear Development in the Age of Interdependence, 32 Vanderbilt Law Review 843 (1979), for instance, place strong emphasis upon future international cooperation without indicating the details which need to be discussed in the implementation of their proposals. It is remarkable that a much more cautious approach toward international cooperation is advocated in: Nuclear Proliferation and Safeguards (Congress of the United States, Office of Technology Assessment) (1977), p. 219 f.
1 Causes of and Ways to Proliferation

1.1 Definition

Proliferation /1.1/ can be understood in a technical sense as being the spreading and the furthering of the spreading of nuclear weapons, as well as of materials and of technology which are of importance to the development and production of a nuclear weapon. A political assessment or an assessment under international law is irrelevant in this technical context. Proliferation can take place at various levels:

- Proliferation brought about by national governments of non-nuclear weapons states (horizontal proliferation)
- Proliferation within nuclear weapons states (vertical proliferation)
- Proliferation brought about by sub-national groups.

Proliferation brought about by national governments of non-nuclear weapons states is the subject of active discussion on the political level due to such recent events as the nuclear explosion in India, as well as the tense situations in the Near East, South Africa, Taiwan, Korea, Pakistan and South America.

Proliferation within nuclear weapons states by continuous enhancement of nuclear potential presents an equally serious problem and is therefore the object of international disarmament measures such as the Test Ban, SALT, etc.

Proliferation brought about by sub-national groups, as for example for purposes of terrorism, is dealt with by "physical protection" measures which are exclusively the responsibility of national authorities. To be sure, an international convention opposed to the misuse of nuclear material by sub-national groups is at present being worked out. Due to the different potential of misuse involved, emphasis in physical protection measures is placed on defence against sabotage, and less on the prevention of use of nuclear material for the construction of a nuclear weapon.
1.2 The causes of proliferation

Before investigating the ways and means that a country may come into possession of nuclear weapons, it is necessary to consider the reasons which might move a national government to such an undertaking, especially in view of the fact that an analysis of this kind can serve as a basis for the determination of possible counter measures. These predominantly political causes obtain additional relevance, if one accepts the premise that, in principle, every state has the potential to produce nuclear weapons.

In the international literature the following causes conceivably leading to proliferation are mentioned:

- defence against a nuclear threat
- involvement in an international crisis
- loss of credibility of treaty partners
- weakening and violation of international agreements
- threat from abroad
- revolution, civil strife
- enhancement of political, industrial and technological potential

The consideration of these causes may lead to a preference being given to political and institutional aspects, when evaluating criteria for proliferation resistance, as opposed to the consideration of purely technical aspects of the respective fuel cycle and the associated control procedures /1.2/.

1.3 Cost of a nuclear weapons program

It has been shown in American investigations /1.3/ that a state already in possession of an advanced technology and operating a complete "peaceful" fuel cycle requires about one year from the time of decision to build a bomb to its realization. If the state is less highly developed and possesses
only a partial nuclear fuel cycle, for example reactors, then a correspondingly longer time is required, about 6 years. For the purposes of this study, however, only nuclear weapons states (states possessing nuclear weapons or explosives) and non-nuclear weapons states are differentiated.

An extensive literature exists describing the technical interplay of activities conducive to proliferation /1.2/- /1.5/. Therefore only an abbreviated representation of the situation will follow here.

The estimates presented in Table I of financial costs and time required for realization of a nuclear weapons program assume a yearly production of 5 nuclear warheads. About 8 kg of Pu-239 or about 25 kg of U-235 are needed for a single weapon. These quantities of strategic nuclear material may correspond to nuclear weapons with yields in the vicinity of 100 kilotons of TNT. Nuclear explosives of this order of magnitude have normally only military application /1.4/.

1.4 Nuclear materials which may be misused

Nuclear materials which lend themselves to weapons construction are the uranium isotopes U-235 and U-233, as well as the plutonium isotopes Pu-239 and Pu-241. U-235 is produced by isotopic enrichment of naturally occurring uranium. U-233 is obtained in the irradiation of Th-232, Pu-239 and Pu-241 in the irradiation of U-238. The fissionable isotopes produced by irradiation are isolated by chemical reprocessing of irradiated material.

A criterion for the strategic value of the isotope is its fast critical mass. Tables II and III summarize these critical masses for various isotopes and isotope mixtures.

The specific neutron activity is a further criterion for the usefulness of the different fissionable isotopes. A high specific neutron activity can lead to premature ignition making more difficult, for example, the use of LWR plutonium for weapon construction and raising the demands on the conventional components of the device.
### Table I: Estimated minimum cost and effort for the construction of nuclear weapons

<table>
<thead>
<tr>
<th>Category of State</th>
<th>Minimum time (years)</th>
<th>Minimum cost ($ 1,000,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Highly developed countries possessing a complete fuel cycle and correspondingly detailed know-how and experience</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 Countries with power and research reactors as well as with the technological basis for a nuclear weapons program</td>
<td>5</td>
<td>110 enriched uranium available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51 facilities available for hot reprocessing in the LWR-cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 facilities available for cold reprocessing in the HTR-cycle</td>
</tr>
<tr>
<td>3 Countries without detailed know-how in the area of nuclear technology</td>
<td>6</td>
<td>210 no nuclear infrastructure</td>
</tr>
</tbody>
</table>

### Table II: Critical masses for U-235 as a function of enrichment

<table>
<thead>
<tr>
<th>Enrichment (% $^{235}$U)</th>
<th>Critical mass $^{235}$U</th>
<th>Critical mass kg U total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>80</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>60</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
<td>75</td>
</tr>
<tr>
<td>20</td>
<td>~ 50</td>
<td>~ 250</td>
</tr>
<tr>
<td>10</td>
<td>~ 130</td>
<td>~ 1300</td>
</tr>
</tbody>
</table>
Table III: Critical masses of plutonium for various isotopic compositions

<table>
<thead>
<tr>
<th>Fraction of $^{240}$Pu + $^{242}$Pu (%)</th>
<th>Critical mass $^{239}$Pu with $\alpha$-Phase $^{239}$Pu with thick U-reflector (kg)</th>
<th>$Pu_{\text{total}}$ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>20</td>
<td>4.5</td>
<td>5.6</td>
</tr>
<tr>
<td>30</td>
<td>4.6</td>
<td>6.7</td>
</tr>
<tr>
<td>40</td>
<td>4.7</td>
<td>7.8</td>
</tr>
<tr>
<td>50</td>
<td>4.8</td>
<td>9.6</td>
</tr>
</tbody>
</table>
1.5 Nuclear fuel cycles

Only a short sketch of the reactor types and fuel cycles finding international application will be presented here /1.6/. Apart from specific research applications, fissionable materials appear not in the metallic form most desirable for nuclear weapons construction, but as nitrates and oxides and in mixtures with the already mentioned breeding materials (U-238, Th-232). Specifically, the following stages of nuclear material may be identified:

- pure, separated fissionable material in various chemical configurations (oxides, nitrates)
- fissionable material - breed material mixtures, which are chemically separable and not radioactive
- fissionable material - breed material mixtures as isotopic mixtures and not radioactive
- fissionable material - breed material mixtures as isotopic mixtures and radioactive.

The ease of production of pure strategic material from the different stages varies strongly and is partly dependent upon the fuel cycle involved.

1.5.1 Uranium-plutonium-cycle

Light water reactors (LWR)

The yearly charging of an LWR amounts to around 33 MWe/t of UO₂ with a U-235 enrichment of about 3 %. After a burnup of 33,000 MWe/t the enrichment is reduced to about 0.8 %. The plutonium bred from the U-238 undergoes for the most part fission in situ and is responsible for some 35 % of the energy produced. Approximately 215 kg of Pu are removed yearly in the spent fuel elements and are available for recycling after chemical reprocessing.

Heavy water reactors (HWR)

The heavy water reactor, which is fuelled with natural or slightly enriched uranium, requires a yearly charge of about 150 t of natural uranium. The discharged plutonium, after an average burnup of 7,500 MWe/t, amounts to around 360 kg/GWe·a.
High temperature reactors (HTR) and advanced gas-cooled reactors (AGR)

Advanced gas-cooled reactors require a 2.5 % enrichment. At present, an 8 - 10 % enrichment is under discussion for the HTR.

Fast breeder reactors

Recycling is a necessary precondition for a breeding reactor. The fast breeder operates with U-Pu fuel elements. The yearly charging of the core amounts to 12.5 t U-238 with 14 %, i.e. 1.7 t, plutonium. For a breeding factor of 1.2 and an average burnup of 28,000 MWD/t - corresponding to a core burnup of 70,000 MWD/t - an excess of some 160 kg of plutonium is generated.

1.5.2 Thorium-uranium cycle

All of the above mentioned reactor types can in principle and without fundamental modification be operated in the Th-U cycle instead of the U-Pu cycle.

Light and heavy water reactors

Both LWRs and HWRs may be operated in the pure Th-U cycle with 93 % enriched U-235 or U-233 as fuel. The fissile material may be mixed with the thorium breed material within the fuel element itself or, alternatively, in separate fuel rods or plates.

High temperature reactors

In the case of the HTR the fissile material may be employed separately or directly as U-Th mixed oxide (feed/breed concept). Assuming a closed fuel cycle, the highest conversion factors, i.e. the optimum uranium utilization, are achieved with an average burnup of only about 25,000 MWD/t.

Fast breeder reactors

Fast breeders, whether liquid metal or gas-cooled, in principle can also be operated in the Th-U-cycle, whereby the breeding factor is approximately
10 to 20% smaller than in the U-Pu cycle. With highly enriched U-235 instead of U-233 as fuel, the gas-cooled fast breeder would be operable in this fuel cycle, the liquid metal fast breeder only with difficulty.

1.5.3 Denatured cycle

A further possibility presently being discussed is a mixed U-Pu/Th-U fuel cycle (denatured cycle).

A mixed cycle is achieved through the use of medium enriched instead of highly enriched uranium with thorium as additional breed material. Light and heavy water reactors as well as high temperature reactors are operable in such a mixed fuel cycle, and also a combination of different reactor types.

If the uranium and thorium are introduced as mixed oxides, a so-called denatured cycle results, since the U-233 bred from the thorium is isotopically mixed and diluted with U-238.

1.5.4 Sensitive stages in the various fuel cycles

From the point of view of proliferation, the sensitive points in the different fuel cycles may be recognized as enrichment and reprocessing facilities as well as installations where large quantities of nuclear material are stored or processed.

In a comparison, no single fuel cycle stands out as offering the greatest deterrence to proliferation

- In a once-through cycle, enrichment services are required: With increasing operating times for the facilities, considerable amounts of nuclear material will accumulate in spent fuel elements. The access to this strategic material becomes easier with increasing storage time. The feasibility of safeguarding a final storage site for spent fuel elements is questionable.

- For the recycling in thermal reactors both enrichment and reprocessing facilities are needed. Strategic material is stored and processed in separated form or as mixed oxide.

- Reprocessing facilities are needed for breeder cycles. Strategic
material is stored and processed in separated form.
- A denatured fuel cycle requires enrichment and, if the cycle is closed, reprocessing facilities.

1.6 Forms of proliferation

1.6.1 Proliferation brought about by sovereign states

The following assumptions appear to be realistic in an analysis of the various proliferation scenarios:

- A country violates its treaty obligations and covertly develops nuclear weapons by removing declared nuclear material from internationally safeguarded fuel cycles (diversion).
- A country breaks all nonproliferation agreements and begins overtly to construct nuclear weapons (seizure).
- A country begins with the overt development of a strategic nuclear capacity without violating its treaty obligations (for example by giving due notice of withdrawal from the NPT).
- A country covertly develops nuclear weapons by misuse of undeclared nuclear material in safeguarded fuel cycle facilities.
- A country builds up a clandestine atomic weapons capacity, without violation of international non-proliferation agreements.

All of these actions may be carried out by a single country, or as a cooperation among two or more countries. The two-mentioned proliferation forms - covert development of atomic weapons with and without treaty violation - can occur simultaneously when internationally controlled facilities are operated with undeclared material.

The time required by a country to come into possession of a nuclear weapon is generally recognized as an essential criterion for all forms of proliferation. For this reason no patent recipe for production of a nuclear weapon exists, rather each state will follow a path determined by its own resources and technological capacity /1.7/.

Should a country withdraw from or break all agreements which committed it to a renunciation of nuclear weapons, its already existing commercial nuclear
facilities and materials take on fundamental importance. Of essence here is the existence of sensitive facilities, or knowledge of the technology necessary for enrichment of uranium and reprocessing of irradiated fuel /1.2/.

Also of importance are stockpiles of nuclear material, be it in separated form or even in the form of spent fuel elements. Examples are stores of enriched uranium (fresh fuel elements), excess plutonium as well as spent fuel element storage areas, since after sufficiently long storage time the separation of plutonium from spent fuel is technically simple.

Of the five possible paths to proliferation mentioned above, the covert development of an atomic weapons capacity is seen at the present time as being the most probable. The following possibilities present themselves:

- Covert diversion of declared nuclear material from safeguarded fuel cycles.
- Clandestine use of undeclared material in safeguarded facilities.
- The production of strategic material by completely secret means.

The first two possibilities are always associated with a violation of treaty obligation (for example of the NPT), while the third one can occur without such a violation, provided a country has avoided from the beginning all relevant international commitments.

In this regard two realistic alternatives may be recognized for countries not already possessing sensitive technologies:
Valuable weapons-grade plutonium may be produced in the U/Pu-cycle via short-term irradiation in small production reactors. The ion-exchange process then provides a simple technical means for isolating the plutonium.

The second alternative involves isotope enrichment, whereby technically simple systems whose reliability need not meet commercial standards would suffice.

1.6.2 Proliferation brought about by subnational groups

The theft of fissionable material by subnational groups may have as its object extortion, the construction of an explosive or, by selling the material
to a third party, making money. The extent to which small groups are
technically capable of producing effective nuclear weapons has been the sub-
ject of recent discussion /1.8/. Here it should be remarked that, in an
attempt to use reactor plutonium for such a purpose, technical problems in-
volving premature ignition must be overcome which have often been under-
estimated /1.9/. Proliferation involving subnational groups is not a subject
of this investigation.

1.6.3 Counter measures

Taking into account the proliferation paths listed in Section 1.6.1, three
means of minimizing the danger of proliferation exist:

- Control measures, which will be described in Section 2.1 and whose
effectiveness will be assessed in Section 2.2.
- Technical security measures, which are beyond the scope of this study
and which will be discussed only briefly in Section 2.3.
- Institutional measures which are the subject of this investigation
and which will be discussed and assessed in Section 7.

Within the existing network of non-proliferation agreements (NPT, Euratom)
especially only the diversion of nuclear material from safeguarded fuel
cycles has been considered; all other paths to proliferation remain more
or less unaccounted for.

International arrangements and forms of cooperation may in principle be seen
as barriers to proliferation in the first four scenarios mentioned above.
Therefore in future more significance should be given to the application
of proliferation restricting international and institutional arrangements
as complementary measures.

The clandestine production of nuclear weapons can only be detected with the
aid of an effective intelligence service. This aspect will not be touched
upon in the present study.
References and Comments (I Causes of and Ways to Proliferation)

/1.1/ The problem of proliferation, in connection with international safeguards in the framework of the NPT, is also the subject of a work performed by D. Fischer, International Safeguards 1979, International Consultative Group on Nuclear Energy, September 1979, published by The Rockefeller Foundation/The Royal Institute of International Affairs, N.Y. and London.


/1.3/ A. Wohlstetter et al., Moving Toward Life in a Nuclear Armed Crowd? ACDA/PAB-263.


2

**STATUS AND DEVELOPMENT OF CONTROL MEASURES AND TECHNICAL METHODS OF SUPPRESSING PROLIFERATION**

2.1 **IAEA and Euratom safeguards**

2.1.1 **IAEA safeguards**

The supervision of nuclear material is the worldwide responsibility of the International Atomic Energy Agency (IAEA) founded on July 29, 1957. Any country may request of the IAEA the application of safeguards measures to any of its activities in the field of nuclear energy. According to article III.A.5 of its statute, the IAEA is authorized upon request to apply such measures within any member state. Those countries which have signed and ratified the Nuclear Non-Proliferation Treaty (NPT) /2.1/ are obliged to accept international safeguards as established in an agreement to be negotiated with the IAEA, and, singly or in common with other countries, are required to conclude such an agreement.

The IAEA statute permits application of safeguards measures to special fissionable and other materials, services, equipment, facilities and information which have been made available by the IAEA, or at its request or which are under its control or supervision, in order to establish that no military purpose is being served. Two documents form the basis of IAEA nuclear material safeguards:

- The document INFCIRC/66/Rev.2./2.2/ concerns itself with all arrangements made outside the framework of the NPT.
- The document INFCIRC/153./2.3/ serves as basis of obligation for all agreements with non-nuclear weapons states party to the NPT.

INFCIRC/153 defines safeguards goals and obliges the IAEA to formulate technical conclusions regarding the material unaccounted for within each material balance area, based on its verification activities. These conclusions may have as their consequence the taking of further steps against a country under safeguards, whereas such steps are not required under INFCIRC/66/Rev.2.
2.1.2 Euratom Safeguards

The European Atomic Energy Community (Euratom) was founded in the year 1957, which at the same time marked the beginning of nuclear materials safeguards in Europe. The Safeguards Board of Directors, which took up residence in Luxemburg, was appointed to carry out nuclear materials control in order to ensure that fissionable nuclear materials be devoted to their proper purpose only.

The non-nuclear weapons states Germany, Belgium, the Netherlands, Luxemburg, and Italy, being NPT-signatories as well as member states of Euratom (hereinafter referred to as "the Community"), charged the Community to negotiate an agreement with the IAEA on nuclear materials safeguards. The agreement was signed on the 5th of April 1973 by the Community, IAEA, the states referred to, as well as by Denmark and Ireland. It consists of two parts, the agreement /2.4/ which is based upon the IAEA document INFCIRC/153, and the protocol having the same effectiveness and rank as the agreement. This protocol, in particular, specifies the peculiarities for the application of safeguards which result from the existence of the multinational control authority Euratom /2.5, 2.6/. Details for the nuclear materials control have been defined by the Community and IAEA and are annexed to the agreement as subsidiary arrangements. The agreement as well as the NPT were ratified by the German Bundestag on the 4th of June, 1974. When the agreement together with the subsidiary arrangements came into force on the 21st of February, 1977, it required a modification of the Euratom safeguards system, in particular with respect to nuclear material book inventory taking as well as the nuclear facility operator's reports and the supplying of technical design information. In the Federal Republic of Germany the operators of nuclear facilities are obliged by law /2.7/ to accept IAEA safeguards.

In article 1 of the agreement the basic undertaking is defined: the states undertake ---, "to accept safeguards ... on all source or special fissionable material in all peaceful nuclear activities within their territories, under their jurisdiction or carried out under their control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices."

For the two remaining states of the European Communities, the United Kingdom and France, both of which are nuclear weapons states, the situation is the
following: The United Kingdom is signatory to the NPT and thus is not com-
mitted to accept IAEA safeguards. Nevertheless this country has offered to
submit to nuclear materials control on a voluntary basis similar to that
being applied to non-nuclear weapons states with the exception of areas
relevant to national security. In consequence an agreement has been made be-
 tween the United Kingdom, the Community, and IAEA, similar to that cited
above.

France is not a signatory to the NPT. In addition to Euratom safeguards
France committed herself to an IAEA-Euratom-agreement (procedures accord-
ing to INFCIRC/153) on the 27th of July, 1978, with military facilities be-
ing excluded and the scope of facilities put under control being determined
by France herself (see section C of the annex).

2.1.3 The Safeguards concept under the Verification Agreement

The objective of the safeguards procedures set forth in this agreement
is the timely detection of diversion of significant quantities of nu-
clear material from peaceful nuclear activities to the manufacture of nu-
clear weapons or of other nuclear explosive devices or for purposes unknown,
and deterrence of such diversion by the risk of early detection (article 28).
The actual prevention of diversion is not an objective of safeguards but of
physical protection.

First of all the safeguards concept requires the definition and quantifica-
tion of the notions "timeliness" and "significant quantity". Here we refer
to the safeguards objectives quantified by the IAEA in its contribution to
INFCE (International Nuclear Fuel Cycle Evaluation) /2.8/ . There has been
no quantification under the verification agreement. A significant quantity
of nuclear material is understood to be the approximate quantity of nuclear
material for which - taking into account any conversion process involved -
the possibility of manufacturing a nuclear explosive device cannot be ex-
cluded. In order to answer the question of timely detection of diversion one
has to know the conversion time, which is defined as the minimum time re-
quired to convert different forms of nuclear material to the metallic com-
ponents of a nuclear explosive device. This influences also the tenable de-
tection time which is defined as the maximum time which may elapse between a
diversion and its detection by IAEA safeguards. Consequently the timely de-
tection of diversion of a significant quantity depends upon the frequency and timing of controls, upon the quantity of material to which the conclusion refers as well as the probability of detection and the probability of a false alarm.

From the safeguards activities it has to be possible to draw conclusions with respect to the material unaccounted for as well as to judge the reasons for discrepancies between the operator's statements and the information of the safeguards authorities. Material accountancy is the safeguards measure of fundamental importance, with containment and surveillance as important complementary measures (article 29).

The determination of physical inventory and auditing are always done for a particular material balance area. A material balance area is an area in which inventory changes of nuclear materials are measured and can be verified and in which the real material inventory can be determined. The establishment of material balance areas is done in consultation between the state and the safeguards authorities. The strategic points at which essential information on flow and inventory can be gathered and verified are called key measurement points. Material balance areas as well as key measurement points are defined in the facility attachments set forth under the verification agreement.

A nuclear facility can be divided into one or more material balance areas. The plant operator has to keep records for each material balance area and has to notify the Community on all changes of nuclear material inventory. Often this information has to be based upon measurements. The starting point is an initial determination of physical inventory. The Community passes this information on to IAEA. Safeguards inspectors of both authorities would verify the data given by the plant operators by independent measurements or by comparison with verified shippers' or receivers' data. Within certain time intervals, which depend on the type of the facility and the material, the plant operator has to determine, record and report the physical inventory of nuclear material. The verification of the physical inventory by Euratom and IAEA safeguards inspectors in general is performed by random sampling. After each inventory taking the physical inventory is compared with the book inventory of nuclear material, thus performing a material balance. The book inventory consists of the preceding physical inventory and the inventory changes which have taken place in the meantime. For facilities in which nuclear material is converted in certain process steps, there is usually some difference bet-
ween the book inventory and the physical inventory. The reasons for such differences may be measuring uncertainties, failure to measure parts of the inventory, an unmeasured loss of material, or a diversion. The difference between book inventory and physical inventory is the "material unaccounted for" (MUF). Having verified the physical inventory, material flow, as well as the operator's quoted measurement uncertainties, the amount of MUF provides an essential basis for the authorities' conclusions. Thus MUF is a tool for judging the possibility of diversion.

If it is possible to determine the continuity of identity and integrity of nuclear material charges by means of containment and surveillance measures, measurements of nuclear material contents of such charges can be omitted, thus simplifying the verification procedures. A containment measure is one that takes advantage of existing structural characteristics, such as containers, tanks, and pipes, to establish the physical integrity of an area or item by preventing the undetected movement of nuclear material or equipment (socalled containment/surveillance-systems). Surveillance refers to both human and instrumental observation aimed at detecting the movement of nuclear material. For these purposes cameras or other devices are mounted at strategic points. Periodic or continuous personnel presence may be required at key measurement points. Containment and surveillance measures are designed in a way to avoid any additional restriction in plant operation. However, it is absolutely necessary that the authorities are able to interpret any movement which occurred during the absence of the inspectors.

It is laid down in the verification agreement that the Community and IAEA shall avoid unnecessary duplication of safeguards activities /2.6/. It is only in certain exceptional cases that the implementation of safeguards is not done simultaneously. The Community undertakes to cooperate with the Agency. IAEA applies its safeguards in such a manner as to enable it to verify findings of the Community's inspectors, inter alia by independent measurements and observations, in so far as it can thus fulfill its objective of safeguards. The frequency of inspections is determined by the amount of nuclear material or material flow in a facility as well as by the type of facility. In the verification agreement (article 80, facility attachments) limiting values for the approved maximum IAEA routine inspection effort at each facility are also set down.

The Agency informs the Community for the use of the states involved on the
results of its inspections and the conclusions it has drawn from its verification activities. The conclusions state whether the nuclear material under safeguards has been satisfactorily accounted for during the interval between two physical inventory takings. If this is not the case, further investigation is called for and the state is requested to examine the causes of any inadequacy and undertake the steps necessary to remedy the situation. Statements made by the IAEA with regard to safeguards applied pursuant to INFCIRC/66/Rev. 2 agreements merely report whether the Agency has or has not detected deviations from the terms of the agreement.

2.2 Assessment of nuclear materials safeguards taking account of the possible forms of proliferation

The building up of a clandestine nuclear capacity is considered at present to be the most probable path to proliferation. With respect to this proliferation path and under the given international constellation, the assessment of nuclear materials safeguards has to be restricted to those non-nuclear weapons states that have signed agreements with the IAEA. In one respect it is a question of states party to the NPT being at the same time members of the IAEA, and on the other hand of states being members of the IAEA without having signed the NPT. Non-nuclear weapons states parties to the NPT are necessarily subject to IAEA safeguards set forth in the model agreement INFCIRC/153, whereas the latter group of states may voluntarily sign agreements with the Agency either on the basis of the document INFCIRC/66/Rev. 2 or the document INFCIRC/153 (see preceding chapter 2.1).

The efficiency of nuclear materials safeguards has to be judged from the ability of the safeguards authorities to detect in a timely manner a concealed diversion of significant quantities of nuclear material from nuclear fuel cycle facilities, the purpose being the deterrence of such a diversion. The safeguards system set forth in the IAEA model agreement (INFCIRC/153) as well as in the verification agreement takes into account neither the abuse of safeguarded facilities with non-declared nuclear materials, nor the clandestine production of strategic material in non-declared facilities.

The key quantity of nuclear materials safeguards is the material unaccounted for (MUF). Two diversion strategies are most probable: 1) Removal of nuclear material without falsification of measurement data with the intent
of concealing the diversion in the declared measurement uncertainties; 2) Falsification of material flow or inventory data, for example by overstating discards. In general a combination of both strategies could be used.

Many diversion strategies which safeguards attempt to counter can be applied in several, if not all, types of nuclear facilities. The largest difficulties for nuclear materials safeguards arise in facilities in which the process inventory of fissionable material is large. This applies in particular to commercial reprocessing plants and gas diffusion enrichment plants. In defining the safeguards measures it turns out that material accountancy on the one hand and containment and surveillance on the other hand may assume different importance depending upon the type of facility under safeguards.

The efficiency of nuclear materials safeguards depends upon the inspection effort as well as upon the achievable measurement accuracy of MUF. According to R. Imai /2.10/ there exists a number of problems within the present international nuclear materials safeguards system:

(I) The application of sampling theories to the material flow in material balance areas proceeds from the assumption that plants are always operated normally as planned.

If this is not the case, inspectors have to be experts in statistical theory capable of rearranging sample takings according to the actual operational modes that they find the plant to be in.

(II) The MUF value depends upon the material throughput of a facility as well as on the measurement accuracy of the nuclear material controls.

In order to keep the uncertainty of the MUF value in any case smaller than a threshold amount - this is approximately the quantity of special fissionable material necessary for one nuclear explosive device - with increasing material throughput either the time intervals for material balance closing have to be reduced or the measurement accuracy has to be improved. However, there are certain limitations for this.

(III) Material balancing requires a certain time for data acquisition and analysis. For specific materials the conversion time is short.

Also under this aspect and with regard to an abrupt diversion there has to be high frequency of inspections in order to reduce the detection time sufficiently. In this connection abrupt diversion is defined as diver-
sion of one significant quantity of nuclear material from one and the same facility between two succeeding applications of safeguards measures and conversion into the metallic components of a nuclear explosive device.

An approach to solving the safeguards difficulty outlined above may be an increased use of containment and surveillance measures. However, at present the required effort cannot be fully estimated. An additional difficulty could be that certain areas in a facility must be excluded from access by Agency inspectors, for instance for reasons of confidentiality of information.

In conclusion one can state that with regard to the outlined proliferation scenarios only the variant "diversion" is met by the technical safeguards system described above and set forth both in INFCIRC/153 and the verification agreement, whereas the scenarios of "vert building up of nuclear weapons with or without violating international agreements" and "the concealed use of safeguarded facilities with non-declared material" as well as the "absolutely clandestine building-up of a nuclear weapons capacity" are hardly influenced by this international safeguards system. But also in the case of diversion, considerable difficulties with respect to performance and efficiency of safeguards activities became evident /2.11/. Although the application of technical control measures in connection with the prevention of proliferation is not called into question, supplementary measures to achieve the non-proliferation objective appear to be desirable. Therefore, in the frame of this study, the applicability and efficiency of institutional models as complementary measures to the technical safeguards system are investigated. In addition it has to be examined to what extent institutional arrangements can render superfluous certain technical control measures.

2.3 Technical measures to reduce proliferation

The co-location of facilities offers itself as a pre-eminent technical measure for the reduction of proliferation possibilities. In the area of the back-end of the fuel cycle, for instance, the reprocessing plant itself and the corresponding fuel element refabrication plant could have one location in common. In the field of enrichment it would seem to be reasonable to pool facilities for conversion, enrichment and fuel fabrication.
The number of transports and of course the number of separated facilities can be reduced by a suitable choice of location. Furthermore a simplified implementation of safeguards measures would be the consequence of an appropriate structural design of such an integrated facility park.

Co-processing, co-conversion as well as the corresponding storage and transport of plutonium as mixed oxide are methods intended to achieve the goal of handling plutonium as far as possible in mixed and thus non-strategic configurations.

Co-processing means that plutonium which is recovered from spent fuel elements in reprocessing facilities is never completely separated. There exists a uranyl nitrate stream as well as a uranium-plutonium-nitrate mixture.

In the co-conversion process the plutonium nitrate, after reprocessing, will be mixed with uranyl nitrate and subsequently be converted to mixed oxide. Thus the product, which is necessary for the fuel element fabrication, can be stored and transported as mixed oxide.

All of these techniques require further development before they can be made use of on a commercial scale. Their proliferation resistance is particularly effective with respect to subnational groups.

Moreover, there exist techniques involving the admixing of radioactivity, thus providing an additional barrier against unauthorized access:
- Spiking
- Preirradiation
- Partial processing

It is also true for these techniques that they require additional development before they can be established on a commercial scale. However, their nonproliferation relevance with regard to international proliferation is dubious. A state has at its disposal considerable resources so that radioactive admixtures add only insignificant difficulties to a separation of strategic material.

On the other hand, if potential divertors are subnational groups, because of their limited possibilities, access to strategic material is made significantly more difficult. Another aspect of importance with regard to these technical
measures is that they render more difficult measurements on irradiated nuclear material. For international nuclear materials control the consequence is a deterioration in the quality of material balancing /2.12/.

Finally, the possibility exists of making access to nuclear material more difficult by constructional measures such as appropriate concrete structures. These safeguards measures, which at the same time are necessary to protect against radiation, are able to restrict considerably or even prevent access to nuclear material. Furthermore both national and international nuclear materials safeguards can be substantially simplified by abandoning in process control of nuclear material and putting the safeguards emphasis on the application of C/S-system (for explanation see chapter 2.1.3). However, these methods, too, require further development before they can be implemented.
References and Comments (2 Status and Development of Control Measures and Technical Methods of Suppressing Proliferation)


/2.3/ IAEA-INFCIRC/153, The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons.


/2.5/ Compare also J. Pander, Die Sicherheitskontrolle nach dem Nichtverbreitungsvertrag in den EG-Staaten.


/2.7/ BGBl. 1980 II, p. 17.


/2.10/ R. Imai, Basic Structure of Nuclear Non-proliferation Logic and the Role of Safeguards, 1978.

/2.11/ As to divergent American views of the value to be attributed to IAEA safeguards see: G. Gleason, Nuclear Power at Home and Abroad: The Quest for a New Non-proliferation Policy, 11 Connecticut Law Review (1979), pp. 512, 533.
3 Existing Forms of International Cooperation with the Participation of the Federal Republic of Germany

Due to her particular political and economic situation, the Federal Republic of Germany is incorporated in a wide network of international cooperation. As a non-nuclear weapons state as well as signatory of the NPT she is subject to the international safeguards systems of IAEA and Euratom which were outlined above. As an industrial state dependent on the delivery of nuclear material from third party states, possessing a high standard of technology, and supporting the export of industrial and nuclear energy facilities, the Federal Republic of Germany is faced with the necessity of assuring her own supply through the practice of mutual and open international cooperation including, if possible, technology transfer and the delivery of nuclear facilities. For treaties of this kind the provision of measures to prevent the spread of knowledge pertinent to the production of nuclear weapons is just as essential as for agreements involving a lesser degree of mutual cooperation.

In the annex to this study, the most important international treaties as well as agreements on cooperation between industrial enterprises in the field of nuclear technology are summarized in a survey of accessible publications. For all parts of the nuclear fuel cycle there exists a number of bilateral and multilateral arrangements for the Federal Republic of Germany which are due to her membership in Euratom, IAEA and OECD and which result in a far reaching network of international commitments (Part A).

For the supply with nuclear fuel the Federal Republic of Germany entered into agreements with the European Nuclear Supply Agency; therefore the general rules published by the Community have also been cited (Part B I).

In the areas of enrichment and reprocessing, which are of particular relevance for Germany, there exist two competitive systems of contracts. On the one hand the Federal Republic of Germany, within the framework of the Treaty of Almelo (1970), participates in the Urenco/Centec cooperation (gas ultra centrifuge plant), on the other hand the gas diffusion plant Eurodif is also supplying several German utilities (Part B II).
In the field of nuclear reactors five out of the fourteen presently operating facilities have the legal form of a joint undertaking as defined by the European Atomic Energy Community. Furthermore the Federal Republic of Germany is participating in the development and operation of reactors in the framework of the OECD activities, and is cooperating with several European states, above all with France, as well as with a number of other third party states (Part B III).

The Federal Republic of Germany has at her disposal only a small reprocessing plant. Her international cooperation presently consists of the participation in the terminated Eurochemic project as well as in the participation, together with the United Kingdom and France, in United Reprocessors (Part B IV).

Finally, for reasons of costs, the field of research and development requires a concentration of technical and economic capabilities of the individual states. In the survey, the most important programs of Euratom are given, with emphasis on the first genuine joint undertaking JET as well as OECD (Part B V).

Those control and safeguards agreements which have been entered into predominantly during the recent years, the bilateral contracts of the Federal Republic of Germany on cooperation, and the most important international agreements on the security of transport of nuclear material conclude the survey (Parts C and D).
4 DELIBERATIONS UPON PROGRESSIVE FORMS OF INTERNATIONAL COOPERATION

There is hardly any other country comparable to the Federal Republic of Germany which to a similar extent has opened nuclear industry to international cooperation and which has at its disposal a similar amount of experience in this field. On the basis of such experience it makes good sense to examine if the already existing or alternative institutional forms of cooperation fulfill the requirements of non-proliferation.

It lies within the responsibility of every state in the world not to endanger international political stability and world peace as a consequence of making increasing peaceful use of nuclear energy. The effort of the Federal Republic of Germany in this direction has been manifested in the past by effectively renouncing the building up of a nuclear weapons capacity on her territory (1955) /4.1/, by joining the NPT (1977) as well as by the declaration of the German Government, in the same year, not to export reprocessing technology to other states. Nevertheless, the discussion about further developments and improvements of institutional non-proliferation measures has been carried also into Germany.

Just because of the present situation concerning the supply with uranium it is necessary for Germany to follow carefully the international discussion. The European Community - and thus also Germany - for the time being is purchasing nuclear fuel mainly from Canada, Namibia, Gaboun, Niger, South Africa, and (to a very limited extent) also from the USA /4.2/. Until now the Community was able to cover only about a quarter of its requirements in nuclear fuel from its own resources /4.3/. The supply agency is foreseeing a shortage of the European uranium supply within the next ten years unless programs are initiated for a speedy mining of uranium ore on its territory. Independently of the question of where to economically exploit deposits of uranium ore - whether on territory of the Community or on other continents -, all of the European uranium companies are forced to get engaged significantly in new explorations either in cooperation or on their own responsibility, otherwise the member states of the Communities will in the long run fall into a situation similar to their dependence upon the international oil market /4.4/.
During the past years third world supplier countries have more and more adopted a restrictive export policy, either in order to make as high a profit as possible or to obtain in return (nuclear) technology or above all economic support for national industrialization. In the future industrial cooperation in the form of "joint ventures" will have to be more and more the focus of interest with regard to its legal and economic aspects as well as technical safety and proliferation /4.5/.

The Community, as shown above in the survey, has binding delivery contracts with the USA, Canada, Brazil, Argentina, and Australia. In contrast to the agreements with the USA and Canada the supply clauses in the agreements with Brazil and Argentina are only of minor importance.

All of the supply agreements, after the coming into force of the NPT, no longer included a peaceful-use-clause only, but also (mainly on insistance of the supplier countries) were secured by trilateral verification agreements with the IAEA.

During the past years interruptions of deliveries from the USA and Canada have occurred. The supply of the Community was affected to 50% in natural uranium and to 100% in highly enriched uranium. In renegotiating the agreement with Canada, the application of IAEA safeguards in all member states of the Community became the fundamental demand. Under the new agreement - sealed by an exchange of letters /4.6/ - Canada explicitly reserved the right to "revise her contractual ties" /4.7/ should any difficulties occur with regard to reconciliation between Euratom and IAEA safeguards as well as in case of a French refusal - which in the meantime has been abandoned - to come to an agreement with the Agency.

In the USA this development occasionally led to delivery stops and to the tightening up of conditions for the export of fissionable material /4.8/. Recent political deliberations in the USA in particular with regard to the legal aspects of the non-proliferation issue culminated in the Nuclear Non-Proliferation Act of 1978. However, it is doubtful whether the promulgation of this law is in accordance with the obligations which the USA have accepted by signing the NPT; the legal considerations on the subject cannot be followed up here.
Independently of these legal difficulties and from a political point of view the question arises, to what extent the suggestions contained in this law should be followed with regard to international cooperation in the peaceful use of nuclear energy. In Section 104 of the law the President is authorized and urged to initiate international negotiations with the purpose of creating an "International Nuclear Fuel Authority (INFA)" (subsection (a)(1)); likewise it is to be an item of these negotiations to establish binding international undertakings within the nuclear fuel cycle in general, including the storage of fresh and spent nuclear reactor fuel (subsections (a)(3) and (4)). No specifications are made in the law as to how such international cooperative forms should be organized.

Independently of INFA, when creating new international organizations, it would be reasonable to refer to the experience with hitherto existing international organizations. Indeed, one can occasionally find similar stimulations in the literature. One suggestion is to take INTELSAT or Scandinavian Airlines System (SAS) as a model /4.9/. The major idea is to adopt specific legal forms with regard to the structure of the organization.

In our opinion suggestions of this kind have only limited value /4.10/. The fact that the above mentioned organizations fulfill certain international duties which several states have in common may give a first indication for possible structures of an international nuclear organization. In this respect, however, it must be clearly seen from the very beginning that a nuclear organization, as regards its intended purpose, would differ fundamentally from organizations such as INTELSAT or SAS /4.11/. The political importance of the proliferation issue, the significance of a nuclear organization for its member states, the extent and the specifications of the organization's activities, the operation within the territory of a host state, and the financial framework of such an organization would be unique and not even approximately to be found in this specific configuration in existing organizations /4.12/. The legal structure of a nuclear organization would have to be adjusted to these particular circumstances. For this reason the reference to legal forms of existing organizations might conceal rather than clear up the specific problems and difficulties in connection with the creation of a new nuclear orga-
nization. An international organization having a parallel field of duties has not been created within the international order up to now. Certainly the dimensions of the problems to come could give rise to innovations. In the following the problems occurring in this connection will be set forth and investigated. A review of the total possible range of cooperation requires that, apart from international organizations, also cooperational forms other than organizations are taken into account.
References and Comments (4 Deliberations upon Progressive Forms of International Cooperation)


/4.3/ Kom (79) 80, p. 3; ATW (1977), p. 56.


/4.6/ Exchange of letters dated 16th January, 1978; see also Part B1c of the annex.


/4.8/ Kom (79) 23, p. 13 f.


/4.10/ This statement is justified when one considers the list of criteria (see chapter 6), because essential criteria such as inhibition of proliferation are of no relevance for SAS and INELSAT.


/4.12/ A more optimistic view of the potential for a multinational reprocessing plant is found in C. Smith and A. Chayes, Institutional Arrangements for a Multinational Reprocessing Plant, in: International Arrangements for Nuclear Fuel Reprocessing (A. Chayes, W.B. Lewis, ed.) (1977), pp. 145-176. It will be observed, though, that the authors have in mind a "corporate" form; thus, their conclusions may not be so different from the present ones as it appears at first sight. In general, Smith and Chayes appear to perceive less political problems of an international organization than the present authors.
5  Systematic Presentation of Institutional Models

In the following a relevant selection out of a spectrum of conceivable institutional models for international cooperation in the field of sensitive production and storage facilities for nuclear material is briefly described: the cooperational form having the least degree of internationalization is taken to be a national facility being operated by a state poor in uranium and exclusively subject to safeguards provided for by the NPT. At the other end of the spectrum is a facility being operated by an international organization on extraterritorial ground. In between these two extremes may be found many different models that can be constructed and classified according to their increasing intensity of internationalization. Out of this large number only those models are selected which most clearly illuminate the fundamentally conceivable solutions and their respective characteristics. Therefore the list of possible models is not claimed to be complete.

The list of models is based upon the legal organizational nature of the holder of rights (i.e. the national facility or the institutional organization). On the other hand, the specific considerations of individual parts of the nuclear fuel cycle, such as the storage of excess plutonium, will be dealt with separately. The models were worked out by taking into account that a nuclear facility, as regards proprietary rights, can be divided into four sections:

(1) The industrial right to make use of the technological know-how contained in the facility (e.g. patent rights),
(2) the proprietorship of the existing facilities and materials,
(3) the right of operating and utilizing the facility, and
(4) the right of utilizing the products of the plant.

No differentiation between the above mentioned areas (1) and (2) will be made with regard to the models presented because the legal organization of these fields has no significance with respect to the forms of proliferation discussed at the outset. In any case, with respect to proliferation, no dangers would arise from the holder of the industrial right in the sense of area (1), as far as for a given facility the operator in the above mentioned sense of area (3) is not identical with him.
However, if technological know-how were to be transmitted on a resale basis to third party states, the situation could be different as soon as the proprietor of know-how entered into agreements with purchasing states to which a perceivable proliferation risk could be ascribed /5.1/. On the other hand, a difference in the legal delimitation between areas (3) and (4) can be found. As to the national facilities, in the sense of the following classification, both areas are liable to national law, even if separate holders of rights of different nationalities are involved. This justifies, for reasons given below, the fact that the list of models will contain no particular differentiation with respect to the first area. With respect to proliferation a separate consideration of the proprietary areas (3) and (4) will deserve a special assessment only in a case where the operation and the utilization of the facility is effected by a multinational or international organization. Different valuations in the case of a multinationally organized holder of rights could arise as soon as this holder of rights has the right not only to operate and utilize the facility but, in addition, to make use of the products of the facility. In contrast, it is assumed for what follows that an international organization will be active within area (3) only.

Under these viewpoints the following possibilities for institutional models result:

(1) A facility of the nuclear fuel cycle is operated under national law and with a completely national management. Due to the fact that the states under consideration are signatories to the NPT the facility in point is subject to IAEA safeguards such as described in the document INFCIRC/153. With respect to physical protection measures the facility is subject to the regulations of the respective state (see Chapter 7.1.1).

(2) As model (1), however, the operating state shall be subject to additional regulations on the basis of its membership to Euratom (see Chapter 7.1.2).

(3) A facility under national law is operated with national personnel and management; however, on the basis of international arrangements certain contingents for processing are kept available for other states. The operating state has the right to make financial claims against the participating state (see Chapter 7.1.3).
(4) Like model (3), however with the **obligation** under international law of the operating state to make use of the facility exclusively for peaceful purposes (see Chapter 7.1.4).

(5) Pursuant to an **obligation** under international law a facility subject to national law is operated permanently with international staff (or under international control). A differentiation has to be made as to whether the international staff has or has not access to sensitive technology (see Chapter 7.1.5).

(6) Pursuant to an **obligation** under international law a facility being subject to a national law is permanently operated with an international management. The differentiation must be made as to whether the international management has or has not access to sensitive technology (see Chapter 7.1.6).

(7) A national /5.2/ facility is operated by a multinational undertaking (consisting of private or public holders of rights). The differentiation must be made as to whether staff and management have or have not access to sensitive technology (see Chapter 7.1.7).

(8) The operating state, by its own legislation and with reference to the facility which is operated by a multinational undertaking, renounces (pursuant to an **obligation** under international law) the use of its sovereign rights. The laws applicable to the facility are completely determined in an agreement under international law (see Chapter 7.1.8).

(9) The facility is operated by an international organization without the host country renouncing its sovereign rights (see Chapter 7.2.2.1).

(10) The facility is operated by an international organization, and the host country enters into an agreement renouncing the application of certain sovereign rights (see Chapter 7.2.2.2).

(11) A facility is operated by an international organization on extraterritorial ground (see Chapter 7.2.2.3).

The different conceivable structures of an international organization (9, 10, 11) result from variable arrangements which refer to budget, rights and duties of the organization, rights and duties of the member states, term of validity as well as to the modalities of the agreement between the organization and the host country.
Apart from the analysis of institutional models for sensitive production facilities of the nuclear fuel cycle, institutional models for storage facilities containing significant amounts of nuclear material have also to be investigated. Storage places for special fissionable materials and excess plutonium, such as mentioned in particle XII.A.5 of the IAEA statute, as well as storage places for spent fuel elements belong to this category.

Because of the existing prescriptions of the IAEA statute for storage facilities only the model of an international organization is discussed and analysed for such facilities (see Chapter 7.3). In this study it is not considered to what extent a worldwide plutonium management system going beyond this model might be appropriate with regard to proliferation, assurance of supply, and environmental aspects.
Comments (5 Systematic Presentation of Institutional Models)

/5.1/ Concerning the question of possible pressure put on the operator by the proprietor compare also Chapter 7.1.5.

/5.2/ In this connection the notion "national" is not used with regard to proprietorship but shall be defined as the respective assignment to a national legal order.
6 VIEWPOINTS FOR THE ASSESSMENT OF INSTITUTIONAL MODELS

For the overall assessment of conceivable institutional models a large number of criteria has to be paid attention to, and these shall be defined and considered in the following. From a political point of view the assessment of an institutional model will depend upon the importance of the individual assessment criteria. It has also to be kept in mind, that the assessment criteria mentioned below are not always independent of each other. The sequence in which the criteria are here presented is not intended to imply relative importance.

6.1 Catalogue of criteria

6.1.1 Proliferation hindrance

The assessment is made under the standpoint of the extent to which a non-nuclear weapons state, by application of institutional models to the commercial nuclear fuel cycle, is hindered in the acquisition of a nuclear weapon.

6.1.2 Political independence of participating states

Each institutional model has to be examined, as to whether and in how far open or concealed political dependence of the participating states is implied with respect to the host country, the organization (in the sense of the co-operative model), the remaining member states or - as seen from the non-nuclear weapons states - with respect to nuclear weapons states.

For this reason the aspects of sovereignty and political independence are related to other assessment criteria in a variety of ways. For instance, take the security of supply: political dependences may arise well in advance of those situations which would immediately result in difficulties of supply. However, from the very beginning, it cannot be excluded that, in the case of an international model, the preservation of political good will on the part of the host state would latently play a role for the participating states in the general relations. In the medium term a dependence upon nuclear
weapons states could result, if through the existence of the organization (in the above mentioned sense), these states were to be less handicapped than non-nuclear weapons states in their technological development as well as in their right to carry out research and development activities.

6.1.3 Assurance of supply

By this is understood the assurance of the participating states to be supplied under any circumstances with all necessary services and materials.

6.1.4 Assurance of planning

By assurance of planning is meant the ability of participating states, in following an overall concept, to rely upon the continuity of a program once it has been specified.

Here there is an overlap between this criterion and the preceding one. For instance, if the provisional duration of an international organization amounts to 20 years, the supply could certainly be guaranteed throughout this period. Regardless of these guarantees, a participating state would have to take precautions in planning for the time following the possible dissolution of the organization. By this means, additional expenditure would become necessary, even if after the lapse of 20 years difficulties in supply were not to arise (e.g. the decision of a receiver state to invest could be considerably prejudiced should a supplier state unexpectedly exercise reservations of a right with regard to reprocessing).

6.1.5 Profitability

The aspect of profitability raises above all the question of the size of a facility which was taken as a basis for the respective institutional model and also the question of the sharing of the burdens of the cost and risk.

For example, within the scope of an international cooperation, states having smaller nuclear programs could derive advantage from the more economic scale of the facilities. On the other hand, there would be higher transportation costs as well as, under certain circumstances, higher expenses for administration.
6.1.6 Promotion of undesired technology transfer

In this connection the essential aspects are protection and utilization of know-how in the economic sense as well as of secrecy and retention of technology with regard to non-proliferation of nuclear weapons. Technology transfer in general encourages proliferation.

Technology transfer refers to technical equipment, methods, data, and ideas, and it takes place as a flow of information in form of technical reports, plans, education and training of staff, as well as passing-on of particular components and techniques.

6.1.7 Furtherance of technology transfer

This criterion is of importance in two respects: firstly in the sense of a support possibly given by technology-holding states to developing countries, secondly in the sense of technological innovation derived from scientific research in the field of nuclear energy.

From this research additional knowledge could be obtained which could be of considerable significance not only in the narrow range of nuclear energy supply, but also in other fields of technological application. If a co- operational model should have as its consequence the hampering of future nuclear research, then from the viewpoint of furtherance of technology this would be considered a negative factor.

6.1.8 Health, safety, and environment

This criterion refers both to protection against radiological endangering of staff and environment by a facility of the nuclear fuel cycle and also to the physical protection against action from outside /6.1/.

For example, institutional models have to be examined under the following aspects:
- Motivation of the operator to run the facility in an optimum way,
- the operator's use of all means meeting world standards with respect to education and experience of the staff as well as with regard to state of the art of equipment and components /6.2/,
- the operator's willingness, even at the expense of profitability, to spend more effort in shielding and decontamination systems with the aim of reducing radiation exposure,
- extent and quality of medical precautions, securing of facility and its operation as well as fire prevention,
- extent and quality of emergency precautions: this aspect refers both to emergency equipment and planning at the facility and to coordination between operator and external authorities,
- extent and type of physical protection measures as well as coordination with the appropriate external authorities.

6.1.9 Political acceptance by the host country

The establishment of an international organization is closely linked to far-reaching restrictions of the host state in the exercise of its sovereign rights. In the planning it has to be considered that in the long run possibly only few states would be ready to accept such restrictions. With respect to the element of time, a differentiation must be made between the date of founding the organization and periods in the future, when political circumstances in the host country may have changed.

6.1.10 Social acceptance in the host country

An already existing resistance of the population against the establishment of a facility can grow as a consequence of the fact that the facility is designed to store or process foreign products as well /6.3/.

6.1.11 Capability to impose sanctions

This criterion is aimed at the possibility of states participating in an institutional model to offer effective resistance to a violation of contractual commitments.

6.2 Special problem: sanctions under international law

The question of the contracting parties' right to impose sanctions in case of
one party violating its obligations in acts and forbearances does not arise for one single model, but rather for several institutional alternatives which are discussed here. With regard to the object of sanctions the following legal areas can be discriminated: sanctions with and without contractual relations as well as sanctions with and without the exercise of force.

6.2.1 Sanctions within the contractual framework

In this connection one might consider primarily the exercise of non-observance of one's own contractual obligations as well as the cancellation of the contract. In principle, either form of sanctions is permissible. However, it is the question if such sanctions have any effectiveness at all in the area under investigation here. By and large this will not be the case. On the contrary, a state violating its contractual obligations for cooperation would hardly do so, if it were dependent on additional contractual services of its contractual partners in the fulfillment of plans opposed to the terms of the agreement. Likewise a cancellation of the contract by the parties observant of the agreement giving notice of the agreement will not be in the international interest, which is characterized by the desire to maintain the continuous validity of the agreement.

6.2.2 Sanctions outside the contractual framework

Beyond the scope of the contract, the efficiency of possible sanctions mainly depends on whether efficient sanctions are legally permissible and indeed possible in fields not covered by the agreement. First the use of force against the non-observant party will not be dealt with.

In principle, international law also permits sanctions (as reprisals) in fields outside the scope of the agreement. The state whose interest is violated by the infringement of the contract can react by exercising acts and forbearances in a field of its own decision, which would be illegal without the preceding infringement. Thus, for example, it is possible to cease to observe agreements or to break off economic relations. Hence, it follows that there are no differences between the operational models under investigation here and the NPT, once more leaving out of account the fact that the NPT has a short period of giving notice.
However, it has to be taken into consideration that in the case of the NPT, according to general principles of international law, each observant state may decide freely whether to impose sanctions and, if so, in which field this should occur. In making the contractual arrangements for an international cooperatorational model, however, a replacement of this freedom of choice by appropriate prescriptions within the agreement could be considered. This could be achieved in such a way that, in case of a violation, each observant state is committed to impose certain sanctions, such as the complete discontinuance of all economic relations. By this means the preventive effect of possible sanctions could be considerably increased in comparison with the situation that was set up in the NPT. According to international law such a restriction of freedom of action imposed on the observant states is permissible. The efficiency of such an arrangement would certainly depend on the problem of working out a contractually determined procedure by which an infringement of the contract could be defined in a manner absolutely binding for all contracting parties. For instance, a group could be established with each contracting party (except for the non-observant party) delegating a representative; this group would have the task to decide unanimously or by a certain majority upon the questions of contract infringement.

It is a question of political assessment, in how far such a legally self-contained, efficient mechanism of sanctions can be considered practical and functionable. No particularly optimistic lessons can be learnt from previous international experience with regard to the carrying through of the obligation to preserve peace by means of comparable arrangements.

6.2.3 Sanctions with or without using force

A further question is whether using force as a reprisal can be justified under international law. With regard to the field under investigation here, the main issue is, whether the action itself which is in violation of the terms of the agreement could be impeded by foreign states using force on the territory of the non-observant state, and whether, for example, diverted plutonium could be confiscated or facilities operated in a way contrary to the terms of the agreement could be destroyed.

At the present stage of development of international law it is hardly possible to answer in a clear manner the legal issues thus addressed. The UN charter
proceeds from the basis that states are permitted to use force against other states as a means of self-defence only. In this connection a precondi-
tion is, however, that the UN themselves secure the observance of peace in a collective manner. As this is not totally the case, the limitations with respect to the prohibition of force used by individual states become poorly defined. This was shown, for example, by the Israeli Action at Entebbe. Neither a consensus nor a coherent practice of states involved have so far emerged in this field.

It is a matter of conjecture whether the permissibility of using force could be legally secured in a way that each state party to the agreement would already express in the agreement its approval of the use of force by the other parties in the event of its own violation of the agreement; the answer de-

dpends on whether or not the prohibition of force, so far as it is valid in the sense of the UN charter, has a peremptory character. Also to that extent there is no absolutely clear opinion with regard to international law. However, considering the fundamental importance of the prohibition of force as a product of the collective organization of the community of states in the United Nations, it seems to be justifiable to regard as invalid stipulations recognizing the use of force in a contractual context. On the other hand, just because of the doubts with respect to the validity of the prohibition of force, the contractual provision to use force against actions which are in violation of the agreement and a threat to peace could be considered permissible under international law. Taking into account that the use of force in this case functions unmistakably in a peace-preserving manner - the UN nowadays practically do not function as a peacemaker - there would be good reason to believe that a contractual arrangement with respect to using force as a reprisal could be valid in international law.

However, even with respect to this result, it is still important for each cooperational form to assess the prospects for a timely detection of actions contrary to the agreement or the preparation to such actions. If the infringe-

ment of the agreement can be detected only after the acquisition of a nu-

clear weapon, the use of force is also politically questionable.
References and Comments (6 Viewpoints for the Assessment of Institutional Models)


/6.3/ See, e.g., the resolution of the South Pacific Forum with regard to the project of international storage of spent fuel elements in the South Pacific.
In the following it is discussed which institutional models of international cooperation will be relevant in future in the area of civil use of nuclear energy. Therefore the models involved are investigated with regard to essential international and internal conditions and legal consequences.

In assessing the models, their influence upon proliferation will not be discussed from the German viewpoint. Considering the contractual obligations of the Federal Republic of Germany, it may be taken for granted from such an internal viewpoint that a real proliferation threat is not perceivable in Germany. Rather, an international standpoint is assumed with respect to proliferation which, although giving due regard to existing obligations, does not attribute to them an exclusively deciding importance.

The assessment of the models undertaken is thus not universally applicable for all regions of the world. This is especially valid when one considers that the Federal Republic of Germany is subject to the Euratom Treaty and, moreover, that her strong economic and political involvement internationally allows and indeed requires a special, not universally valid assessment with respect to the criterion of "vulnerability to sanctions".

For all other criteria aside from proliferation hindrance the consequences of the various models will be looked at from the peculiar perspective of the Federal Republic of Germany.

The Nuclear Non-Proliferation Treaty (NPT) provides an essential yardstick for the assessment of non-proliferation effectiveness /7.1/. It will be assumed that all countries involved have ratified this treaty /7.2/.
This is realistic for Western Europe because, apart from France and Spain, all countries have signed the Treaty. Moreover, France, according to her own declaration, wishes to act as though being a party to the Treaty, and a ratification of the Treaty by Spain is to be expected before her entrance into the European Communities. For the rest, a realistic consideration must in any case be based on the assumption that a country unwilling to sign the NPT or a similar agreement would see little occasion to take part in international institutional plans for the prevention of proliferation: international cooperation, if to be effective, brings with it a greater loss of sovereignty than does the signing of the NPT, and the discriminating character of the differentiation between nuclear weapons states and non-nuclear weapons states is common to both steps. The assumption of applicability of the NPT to all of the cooperating states has an important influence on the yardstick by which the legal and political efficiency of forms of cooperation are to be measured: since the NPT already implies an obligation under international law of the non-nuclear weapons states to a renunciation of the manufacture of military nuclear explosive devices, international institutional plans must include an additional assurance going beyond this commitment if they are to be justifiable from the proliferation aspect. The short 3-month term of notice of withdrawal (NPT, Art. X) should be taken into account, however. In addition it should be investigated whether the permissible sanctions of the Treaty members, in the case of a violation of the NPT, have the same effectiveness as sanctions against cooperating partners who have broken contract.

7.1 **National Models**

The concept "national" as used here is not determined by proprietary relationships but rather by the respective applicability of a national legal order.

7.1.1 **National Facilities with International Safeguards (NPT)**

A facility of the nuclear fuel cycle is operated under national law and with purely national management. Since the state operating the facility is assumed to be party to the NPT, the facility is subject to the nuclear material control system described in section 2.1.1. The installation's capacity is exclusively intended to meet national needs as the state does not propose to offer services of the facility to third party states.
This model is to be judged positively under the majority of the assessment criteria. This holds particularly for political independence, assurance of supply, prevention of undesired transfers of technology, furthering of technology, assurance of planning, the health aspect, safety and environment, as well as the criterion of political acceptance. With respect to economic efficiency the assessment depends upon the respective size of the nuclear energy program of the country involved. For a state possessing know how over the entire fuel cycle the assessment under this aspect is also positive. Considering the ever-increasing burden due to control measures — which are in themselves not called into question — those non-nuclear weapons states which are to be counted among the supplying countries must insist that the nuclear weapons states also assume comparable burdens in their civil nuclear energy programs in order to create identical bases.

Taking into account the analysis of the various forms of proliferation (Section 1.6) it may be concluded that this model does not cover optimally all proliferation paths, even when giving due weight to the obligations arising from the NPT.

Having regard to vulnerability to sanctions, the assessment depends upon the contractual obligations of the state under consideration. The short three-month term of notice of withdrawal of the NPT (Art. X) must, however, once again be pointed out.

7.1.2 As in 7.1.1, but with membership in Euratom

Supplementary to the model described in Section 7.1.1, the operating country is subject to additional conditions through membership in Euratom. Certain legal boundary conditions are then to be considered: The proprietary right to nuclear material resides with Euratom; Euratom alone possesses the authority to acquire and distribute nuclear material; member states are in addition subject to Euratom control procedures.

When comparing with Section 7.1.1, differences arise mainly with respect to the criteria of political independence, proliferation hindrance and sanction vulnerability. With entry into the EC, rights of
sovereignty are relinquished to a considerable extent. Regarding proliferation hindrance the additional contractual ties to Euratom, which have an undetermined duration and can basically not be terminated, are to be contrasted with Section 7.1.1/7.3/. Here also one cannot, when taking into account the forms of proliferation pointed out in Section 1.6, speak of a minimization of proliferation risk. It should be regarded, too, that Euratom forms a politically comparatively homogeneous regional group of states, that in past years a member state withdrew from specific arrangements without suffering the imposition of sanctions, and that negotiations are about to come up regarding changes in essential terms of the Treaty. On the other hand it must be said that Euratom is bound to the IAEA and that the Treaty violations mentioned are not relevant to proliferation.

In the following models we will no longer expressly differentiate between Euratom membership and non-membership. However, the preceding considerations can be accordingly applied to all models to come.

7.1.3 National facility with financial participation of and obligation to a third party state

We consider here a form of cooperation ensured through agreement under international law and based upon a nationally operated nuclear facility, whereby a third party state ("recipient state"), because of agreements with the operating state, is presumed to have a right to certain services of the facility (for example in the areas of reprocessing or enrichment) in exchange for financial obligation. The recipient state has no decision-making authority as regards the operation of the facility nor any other rights of collaboration within the facility.

In this type of cooperation the laws of the operating state itself would be applicable to its obligations to provide services. This is in any case valid under international private law if no specific arrangement to this end is made in the contract, and its execution is the responsibility of undertakings organized according to private law.
There is no legal order which would, under these legal conditions, permit a recipient state to control the activities of the operating state within the facility for reasons having to do with proliferation. This conclusion is evident as far as the observance of the agreement is concerned; only the provision of services, but not the arrangement of the facility with which the services are produced, is owed. But also in the case of a (liable or non-liable) failure to provide services, the recipient state may only resort to means which do not involve surveillance of the installation; this is true both for a claim for fulfillment of contract and for a compensation claim. In the latter case it could perhaps not be precluded that, in the framework of an examination of liability, the recipient state could establish the non-fulfillment of obligations on the part of the operating state due to the facility being no longer operated for peaceful but rather for military purposes. However, it seems most improbable that an operating state intent upon secretiveness would indeed allow such a situation to arise. Moreover it is hardly conceivable that a deciding court, in the hearing of evidence, would be able to investigate more closely the activities of the operating state. Although possibilities along these lines cannot be excluded theoretically, the legal context discussed here offers so little guarantee for the detection of clandestine activities of the operating state that no essential advantage as regards proliferation may be seen when comparing with the model previously discussed. It goes without saying that such a form of cooperation also offers no basis for physical intervention should the installation be openly changed to serve military purposes.

In such a form of cooperation it must also be taken into account that the financial support of the operating state by the third party state can, in certain circumstances, make it financially easier for the operating state to construct more efficient installations and thereby to achieve a technological as well as marketing advantage. For a financially weak non-nuclear weapons operating state, such cooperation would thus be more conducive to proliferation than hindering to it. Also with respect to the other assessment criteria no new aspects appear in relation to the previous model. To be sure it must be taken into account that, by means of the contractually guaranteed claims of the recipient state - assuming these guarantees to be politically adequate - that state can be kept from constructing its own facilities, thus reducing the number of sensitive installations. This can have a proliferation - restricting effect, but also be economically useful. The latter depends very much on the individual case, however.
Existing institutions in this category: Cogema (Compagnie Générale des Matières Nucléaires), France.

7.1.4 **As in 7.1.3 with contractual commitment to peaceful use**

It is conceivable, under the conditions of Section 7.1.3 above, that the recipient state would obtain the contractual assurance of the operating state that the facility in question would at no time and under no circumstances be allowed to be used for weapons production.

It is, however, questionable to what extent a commitment of this kind would bring with it advantages from the point of view of proliferation. It is necessary to distinguish whether the operating state would openly or covertly offend the conditions of the agreement:

- In the instance of clandestine action, the commitment would only be effective if the recipient state had sources of information regarding this illegal behaviour other than the operating state itself. To this extent, the recipient state would possess the same information basis as every member state of the NPT. The central commitment of non-nuclear weapons states to peaceful applications exists there as well. At most it should again be pointed out that the NPT, in Art. X, provides for a comparatively short term of notice of withdrawal and a more lasting, proliferation hindering engagement might be created through bilateral arrangements.

- In the case of overt action no particular differences exist for NPT member states (apart from term of notice).

As to the assessment with respect to the rest of the criteria no difference is perceptible.

There exists in Europe no institutional undertaking which would fall into this model category.

7.1.5 **National facility with international operating personnel**

As next model to be investigated we consider a facility subordinate to national decision-making authority. The entire facility is thus subject to the laws of the operating country. The element of international cooperation comes through the requirement that, within this national operation, staff from third party states is employed. This is to be ensured by means of an agreement
under international law. We leave the question open whether the finances are also shared by third party states.

This form of cooperation is relevant to the proliferation question if the foreign operating personnel, according to contractual agreement, are at all times active at locations within the installation where diversion of fissionable material or misuse of the equipment is technically possible. This assumption goes beyond the existing safeguards system based upon INFCIRC/153 with permanent inspector presence.

If, under the circumstances described, a diversion of material without the knowledge of foreign personnel were impossible, it would have to be asked, from the proliferation standpoint, whether the parties to the agreement could rely on the knowledgeable foreigner to pass his information on to his country of origin or to an appropriate international authority:

If the foreigner were a normal employee within the operating state, no guarantee would exist for the passing on of the information. A legal obligation to inform third party states could be included within the working contract. It would nevertheless be open whether or not the interests of the partners to the agreement would be served in this way. To bring about an improvement in the reliability of information, within this model, one could consider occupying all of the above mentioned positions each with two foreign employees. An indirect international control would be thus created whose acceptance, for reasons political and economic, may not generally be assumed.

A different assessment might be made if the foreigner were to work under contract with his native country or with another employer (such as the IAEA). Conflicts between the employee's duty to inform and his personal interests would play a smaller role here than in the previous case. Here again every sensitive position could be occupied by two foreigners who would have to guarantee the flow of information around the clock as well as during vacations and periods of sickness.

The assessment of this model with respect to proliferation depends whether, in the case of an illegal elimination by the operating state of the foreign personnel as information source (for example by arrest, lockout, expulsion, threats), legal steps could be taken effectively guaranteeing the interna-
tional flow of information. We refer here to the discussion in Section 6.2 above.

For this model of cooperation, new, predominantly negative, aspects arise with respect to some of the other assessment criteria:

Assurance of supply and, possibly, political independence are affected in that foreign personnel – in a breach of contract – may be withdrawn suddenly (without notice) and without the host state being able to provide for replacements. This situation likewise affects assurance of planning in so far as a certain inertia is introduced through the internationalization of the personnel. The varied origin, education and language of the personnel acts to the detriment of efficiency. In some instances the laws applied will play a negative role in the smooth operation of the facility.

Should the international operating staff have access to sensitive technology, the problem arises of proliferation via the spreading of relevant sensitive know-how (technology transfer). It may even be the case that such spreading of know-how would cancel entirely the other proliferation deterring advantages of the model. An undesired technology transfer is encouraged in this model to precisely the same extent to which proliferation is discouraged.

Regarding the situation in Germany it is to be remarked that, in accordance with the rights of the EC, a large number of foreign personnel from EC countries is active in German facilities.

Existing institutional models in this category: SNR-300.

7.1.6 National facility under international management

A model of cooperation which provides for no international operating personnel, but rather for international representation in management must be assessed differently. By management is meant those persons which are not involved in the carrying out of operational procedures, but rather with the direction of the entire facility, including conception, organization and administration. The legal form of management may vary. It is possible that
the members of management enjoy a working relationship with the same holder of rights as the employees of the installation. It is also conceivable that an independent holder of rights be created for management. The extent to which private and public holders of rights are involved and interwoven with one another is also a variable. In the use of forms of organization under public law it is to be observed that in some countries an employee is also required to be a citizen of that country. In some cases an organizational form under public law would require a modification of existing civil service regulations. The working relationship of foreign members of management could be with the operating state, with individuals under public or private laws in accordance with the laws of the operating state, with a foreign country or with some judicial person or with an international (a supranational) organization (as for example IAEA, OECD, Euratom).

The value of international management for hindrance to proliferation is essentially determined by how precisely the surveillance of on-going operations can be carried out technically by foreign members of management. It is self-evident that clandestine operations are made difficult through the participation of foreign management personnel loyal to their contract. Their function under contract could however be hindered in two ways:

- First it would have to be established by some technical means that all decisions, including decisions of national personnel which are in breach of contract, be made and carried out by all members of management together.

- In the second place it would be necessary to determine whether, through the individual action of employees, steps directed toward proliferation could be made without the knowledge and involvement of management.

On the other hand, as in the case of Section 7.1.5, a differentiation within this model can be made as to whether or not management has access to sensitive technology. Practical experience (Eurodif) in any case shows that it is also possible, with organizational means, to prevent access by foreign management to sensitive know-how with the object of discouraging technological transfer. The application of this model to a non-nuclear weapons state could impair its proliferation - deterring value.
When contrasted with the model of Section 7.1.5, within the framework of the assessment criteria, disadvantages become apparent only with respect to political independence and, perhaps, acceptance, since international representation in management implies to a certain extent a loss of sovereignty. However, the fact that the operating personnel would be purely of national origin is advantageous for the operational efficiency as well as for the assurance of supply and planning of the installation.

A decisive difference to the preceding model is, however, that the determinative of the facility could only be altered with difficulty by international management.

Existing institutions in this category: Eurodif (European Consortium for Uranium-Enrichment by Gaseous Diffusion, France, Italy, Spain, Belgium).

7.1.7 Multinational undertaking

Within the spectrum of conceivable forms of cooperation may be found, between models of purely national operation and the creation of an international organization, other legal constructions which may be designated as multinational. Undertakings of this kind have in common with national models the fact that the founding and operation of the facility is subject to national laws.

Such undertakings approximate international organizations in so far as the facility rights are distributed among several holders (private or public) which, in turn, have been created within various national legal systems, and which as holders of rights to multinational undertakings, are still subject to these legal systems.

Depending upon the construction of such multinational undertakings, when viewed from the proliferation standpoint, differences become evident relative to the national models with internationalized operating or management personnel discussed above.

The changed situation regarding proprietary rights may have a more favourable effect compared to a national model with international management only if
the rights of management in a national undertaking are strongly restricted by questions of proprietary rights. Decisive in this connection is whether management, in given circumstances, would have the legal authority to resist directives of the owner which would encourage proliferation.

It will be first assumed that, both for national as well as for multinational models, most constructions will not provide for the independent right to refusal of such directives. A differing assessment arises nevertheless: The possibility for the legal issuance of directives by the owner of a national facility which may promote proliferation must be judged as being far more serious from a proliferation standpoint than the existence of such an authority in multinational proprietary constructions, since in both cases concrete actions could not be taken without management or operating personnel. A more comparable assessment with regard to proliferation would arise if, in an international agreement for a national model, both the internationalization of operational and management personnel and the prohibition of owner directives to management encouraging proliferation were provided for. In this connection, the possibility, on the one side, of an illegal directive by a national decision-holder and, on the other, the actual impossibility of such a directive within the context of internationalization of proprietary rights would have to be assessed. From the legal point of view the difference is not very large, since the owner is always forced to realize his directives via management. However, even with restriction through agreement under international law of the directive authority of a national decision-holder a differing assessment may result for purely psychological reasons.

With regard to its proliferation-deterring effect a multinational undertaking is, in our opinion, preferable to a national model, even one with a restriction of the directive authority of the owner which is binding under international law. Of relevance to the legal and political assessment of multinational undertakings of this kind is whether their interest and structure is laid down in a private contract between part-owners subject to the laws of the host state, or in an international agreement among the participating states. Possible changes in the content of a private contract by the host state with the aid of a new formulation of private law must be considered here as much as the possibility of international sanctions, which arise only
in cases of offences against international norms.

Whether the foreign part-owner has public or private status may also lead to differing assessments. From a legal standpoint no great differences are apparent for the case of illegal action on the part of the host state. In practice it might however be significant psychologically whether or not the partner had indeed public status.

Additional differences with respect to the criterion of proliferation deterrence may arise, depending on whether or not the foreign country is a nuclear power.

With regard to the other assessment criteria a differentiation as to whether the host state is the Federal Republic of Germany or some other European country would appear important. In the first case the following new aspects arise when compared to the preceding forms of cooperation: Increased proliferation deterrence appears in connection with proprietary relationships insofar as the host state sees itself confronted with additional barriers against an intended misuse. In some instances the danger of misuse would be increased if, going beyond the right to operate and make use of a facility, the multinational undertaking possessed right to utilization of its products. Regarding the other criteria certain disadvantages may be recognized, especially in the areas of efficiency, assurance of planning, and political independence. For the situation in which some other European country plays the part of host state, differences with respect to proliferation deterrence arise only when this host state is also a nuclear weapons state. However, from the point of view of the Federal Republic of Germany considerable disadvantages within the areas of political independence and assurance of supply and planning are to be reckoned with.

Precisely which countries comprise the cooperating partners in the model is important for the question of technology transfer. If the partners consist of technology-holders (Urenco) no technology gradient results. Otherwise in some circumstances (see Sections 7.1.5 and 7.1.6) technology transfer, and with it possible proliferation, can occur.

A stepwise opening of access to sensitive technology at a rate in which this technology would in any event develop within the affected country is also conceivable in this regard.
Existing institutional models in this category:
Urenco (Uranium Enrichment Company; Germany, The Netherlands, United Kingdom).

7.1.8 Multinational undertaking with renunciation of sovereignty of the host state

An additional move in the direction of a cooperative model of strictly international character would be if the host state of a multinational undertaking, in accordance with an international agreement, were to renounce its sovereignty for the territory of an installation through national legislation, and at the same time commit itself to make changes in the relevant laws only with the consent of the partners to the agreement.

This commitment under international law would have, from the proliferation aspect, the important advantage that the operating state would no longer be in a position to nationalize the facility without offence against international norms. Moreover, the operating state could not, by means of constructional or environmental regulation, for instance, force operations to a practical standstill. This is of central importance for the assurance of supply and planning of the participating states.

It would seem reasonable to shape the legal relationships among host state and involved foreign partners in such a way that encroachments on the part of the host state encouraging proliferation would be discouraged. With the aid of a host state agreement it would be possible to define legally that degree of independence of the undertaking from the host state which seems mandatory for the assurance of supply required by the member states. An organizational structure must be aimed at which cannot be crippled through simple directives or measures on the part of the host state. An alternative structural solution would appear doubtful from the assurance of supply viewpoint.

1) Security organs

Since security measures must be directed also against interference of the host state, organs of the host state hardly need to be considered. On the other hand it would not seem opportune to employ security organs of a third party state. In the final analysis it could be left to the undertaking it-
self (or perhaps to an international organization) to provide the necessary protection.

Since the exercise of sovereign power requires the consent of the host state, this would be subject to regulation in the international agreement.

In this connection procedures would also have to be established determining which security organs are to be responsible for maintenance of security and order as well as for prosecution within the territory of the undertaking. The same considerations are valid here for the securing of the grounds of the installation against interference from outside. Thus, at least when the host state is a non-nuclear weapons state, this responsibility could be transferred to the undertaking.

2) Laws applicable in the field of technical safety

The functioning of the undertaking and, with it, the assurance of supply, would also depend on the host state not having the authority to interfere in the operation of the facility for technical reasons. The applicability of national procedures regarding safety of technical installations within a state's sovereign territory would thus be affected. In the agreement therefore, such procedures (the supervision of which is in part the responsibility of the TOV in the Federal Republic of Germany, for example) would in some circumstances have to be revoked in the agreement and replaced with the authority of the undertaking to make its own laws within its territory.

3) Construction laws applicable

Also the applicability of national legal procedures affecting construction within the territory of the undertaking would have to be excluded within the agreement. It would have to be avoided that the host state possesses the legal authority to impede the operation of the facility by means of changes in constructional regulations.

4) Environmental laws applicable

The agreement would have to contain similar arrangements for environmental regulations. Here one might designate in the agreement the laws of the host
state as being the minimum standard. From the standpoint of security of supply such an environmental clause would not be entirely without consequence however: the possibility would then remain that the standards of the host state could be raised to such an extent that the organization's operation of the facility would be hampered or even rendered impossible.

5) Fire brigade

The agreement could authorize the undertaking to establish its own fire department. The use of a fire brigade of the host state would be problematical from the point of view of the member states for the same reason as the use of security organs.

6) Customs and currency laws applicable

The undertaking would have to be in a position to import necessary materials without hindrance of the legal procedures of customs and currency. Therefore a regulation of this matter within the agreement would be called for.

7) Water, sewage, and electricity

It should also be considered to what extent the host state could cede to the undertaking the regulation of such areas as sewage, water and electricity supply. Also to that extent the undertaking's ability to function independently would be better guaranteed by having such responsibility. Thus it might be advisable that the agreement deal with these matters as well.

8) Status of the organization's personnel

The freedom of travel of the personnel as well as their status with respect to freedom of movement and criminal liability within the territory of the host state would also be subject to regulation.

From the standpoint of proliferation, this model would not possess the advantages of an international organization to be described later. Nevertheless the renunciation of sovereignty by means of international agreement and as documented by national legislation may represent a considerable additional threshold for proliferation going beyond all models discussed so far.
Whether a model of this specific type will find political realization appears very doubtful, however, when one considers the criteria of political independence, political acceptance and, especially, social acceptance. A relinquishment of sovereignty in such an area as environmental law, for example, would hardly be worthy of discussion in view of its political sensitivity. This indicates that the large-scale relinquishing of sovereignty implied in the preceding outline will play no significant role in practical present day discussions.

A contractual form would however be conceivable in which an attempt is made to strike a balance between the political interests of the host state on the one side and the anti-proliferation interests of the international community and the supply requirements of the contract partners on the other. Along these lines one could, for instance, imagine a giving up of sovereignty only within a subset of the above-mentioned areas. Thus the application of laws could be performed by the sovereign institutions of the host state after all, or the authority for regulation of environmental matters could to a great extent be left with the host state. Other solutions less restrictive to the vital interests of the host state could be sought in a model in which the legal responsibilities in all the areas discussed remain with the host state, but in which changes in the national laws were coupled with certain material or formal preconditions. A commitment under international law by the host state not to make arbitrary changes in the relevant laws would, for example, be in this spirit. Alternatively, periodic consultations for the assessment and improvement of the relevant laws could be agreed upon among the partners to the contract; in the case of disagreement, formal procedures for their resolution would have to be provided. Another variant would be to couple the admissability of legal changes within the regions in question to a consideration of international standards; in the erection of such standards, attention would be given to positions taken by existing organizations such as the IAEA or the International Energy Agency.

The realizability and the assessment of an institutional model such as described here would very much depend on which of the areas discussed were made the object of a renunciation of sovereignty; it would also be of considerable significance whether competence within these areas should be given to the undertaking, or whether the competence should remain with the host state and pro futuro be bound to the formal or material preconditions already men-
tioned. According to the concrete form chosen, a model of this kind could, in its various shades, emphasize international interests or the partly opposed interests of the host state.

An overall assessment of this model can thus not be made. It appears however that the model, because of its essential structure, allows sufficient flexibility for the reconciliation of the interests of the involved parties and can be described as being fundamentally realistic and responsive to the problems involved.

7.1.9 Summary

Model 1: The host state of a national/7.5/ undertaking is party to the NPT. The three month term for notice of withdrawal of the NPT plays an unfavourable role from the proliferation and sanction vulnerability aspects, whereas on the other hand international contractual obligations going beyond partnership in the NPT must not be forgotten.

Model 2: The host state is in addition a party to Euratom. Entrance into the EC implies a considerable abrogation of sovereignty. As far as proliferation deterrence is concerned, there exists the additional contractual commitment to Euratom which can basically not be terminated (except under extraordinary circumstances) and has an indefinite duration.

Model 3: The operation of a national facility proceeds under financial participation as well as claims to services of a third party state. A possible incentive to proliferation arose in the case of a non-nuclear weapons state as operating state. On the other hand the renunciation on the part of a recipient state of construction of its own installation in exchange for rights guaranteed under contract was recognized as having a discouraging influence on proliferation. A cooperation of this kind would have both technological and economic advantages for the operating state.

Model 4: The guarantee under international law on the part of the operat-
ing state to use the facility in question for peaceful purposes only does not lead to an assessment different from that of model 3.

Model 5: An installation subject to national law is, according to an international agreement, permanently operated with international personnel. Besides having the opportunity to prevent a diversion of fissionable material or the misuse of the installation, the foreign operating personnel also will have access to sensitive technology. The problem of proliferation via technology transfer then presents itself. A resistance to proliferation for the operating state would then have to be contrasted with a comparable incentive to proliferation among the third party states involved.

Disadvantages may be seen for the operating state in the areas of assurance of supply and planning (for example an illegal withdrawal of foreign personnel without due notice) and efficiency (e.g. differing languages, origins and education of the personnel). In this connection political independence is also affected. For all of these reasons the political acceptance of such a model must not be taken for granted.

Model 6: The installation is permanently operated under international management.

An essential difference from the preceding model is that the determination of the installation can be altered by the international management only with great difficulty. Here also the problem of technology transfer arises. However, the example Eurodif demonstrates the possibility of denying foreign members of management access to sensitive know-how. An application of the model in a non-nuclear weapons state would be to the detriment of its value as a discouragement to proliferation. Because a certain loss of sovereignty is involved, disadvantages are apparent as regards the criteria of political independence and acceptance.

Model 7: Within a multinational undertaking the associated rights are distributed among several holders (private or public) which have been created under various national legal systems and which are still subject to these systems. Essential for the legal and political assessment is whether the purpose or structure of the undertaking can be altered by means of new legislation within the host state, or whether purpose and structure are set down in an international agreement among the states involved (possibility of sanctions). If the Federal Republic of Germany were to play the role of host state, for
example, an increased resistance to proliferation arises but at the expense of planning assurance, efficiency, and political independence. Moreover the possibility of proliferation through technology transfer to partner states must be mentioned. Should a European nuclear power play host to the facility, proliferation will be discouraged. However, Germany could then reckon with considerable disadvantages with respect to political independence and assurance of supply and planning.

Model 8: A formal renunciation of sovereignty within the territory of a multinational installation coupled with the commitment to change the relevant national laws only with the consent of the partners to the agreement would have the important advantage, from the proliferation aspect, that the operating state would not be able to nationalize the installation without at the same time committing an offence under international law. Of central importance to the assurance of supply and planning of the countries involved is that the operation of the facility could no longer be hindered through changes in national legislation. In this connection, the necessary independence of the undertaking from the host state could be brought about through the creation of installation-owned rights in the areas of technical safety, construction, environment, customs and currency, water, sewage and electrical supply, through installation-owned security organs as well as through regulation of employee status.

A contractual form could be conceived of in which a balance is sought between the political interests of the host state on the one hand and the antiproliferation interests of the international community and the supply requirements of the contract partners on the other. A renunciation of sovereignty for a subset of the above areas would also be conceivable. Thus the application of laws might be performed through national organs of the host state, or the responsibility for environmental questions might, to a great extent, be left with the host state. Other solutions less crucial to the vital interests of the host state could be sought along the lines of a retention of authority within all the above-mentioned areas by the host state, but with a coupling of changes in the relevant laws to certain preconditions of a material or formal nature.

This model would appear to allow, on the basis of its essential structure, sufficient flexibility to strike a balance among the involved interests. It may therefore be considered as being basically realistic, responsive to the problems involved, and worthy of further discussion.
7.2 Cooperation by means of an international organization

7.2.1 Possible structures of an international organization

7.2.1.1 Introductory remarks

a) The law applicable to an international organization

As opposed to the national models discussed so far, international organizations are characterized by the fact that their activities, as stipulated in the necessary international agreements, are carried out by an independent juridical personality. The laws of the state within whose sovereign territory the international organization is operating are only applicable for the business of the international organization to the extent to which they are referred to in the foundation agreement or so-called site agreement, in which the legal relationship between the organization and the host state is regulated; the laws of the host state can also be applicable if the international organization concludes agreements with the host state in which no special reference is made as to the law to be applied /7.6/.

The enhanced legal independence of an international organization from national law has, from various aspects, significance for the stability of the relationships created. First of all, the national law generally tailored to certain frequently used private or public organizational forms within the state is not basically applicable; the autonomous law, established by an international agreement and the relevant statutes and created for purposes peculiar to the organization, is operative from the outset. This law is developed further by the institutions of the international organization, but not by the courts of an affected country. In this way the danger is set aside that the legislature of the operating state could, after beginning of operations, gradually or through one act, change the applicable laws so much in its own favour and to the detriment of other member countries that the originally intended legal form of cooperation is subverted.

b) The organs of an international organization

Consistent with the usual structure of international organizations, a "legislative" and an "executive" body could also be created for the case in
hand. It would be the legislative responsibility to make essential and fundamental decisions regarding the work of the organization. The executive would have the task of carrying out these decisions in practice.

Regarding the constitution of the "legislative" body, it would appear reasonable to accord every country involved the right to appoint a representative. It need not be discussed here whether or not the voting procedures should provide for a weighting of the individual states according to their degree of financial participation. The "legislative" body would have the authority to appoint the executive and to control its activities. Considering the special significance and responsibility associated with the executive's function, a permanent institutionalized form of control going beyond the more general, periodic control of the legislative body might be appropriate. This could be achieved through the appointing by the legislative body of a permanent representative having exclusively controlling functions and, perhaps, the authority to convene extraordinary legislative sessions at short notice.

In order to avoid an overly strong executive - and with it the possibility of misuse of authority - it would be desirable to provide the executive with relatively little latitude, i.e. the directives of the legislative body should often be spelled out in great detail.

\(c\) **Scope of a constituting agreement**

The first step in the creation of an international organization is the conclusion of a constituting agreement among the states involved. There exists no established catalogue of areas to be regulated in such a founding agreement. Normally the contract will, however, set down the purpose and essential tasks of the organization, will specify the most important bodies within the organization and will contain provisions regarding the duration of the agreement (and of the organization), terms of notice for withdrawal, as well as rules of procedure for alterations of the agreement. It is not necessary that the agreement regulate all details. These could be left to the bodies created in the agreement itself.

For the case of an international organization serving the purpose of reprocessing or enriching nuclear material, it would be necessary to establish, in addition to the actual aim of the organization, the following:
a) budgetary arrangements
b) tasks of the organization in the field of research and development
c) questions relating to transfer of technology
d) obligation of member states, especially toward third party states
e) coming into force, duration and cancellation of the agreement.

7.2.1.2 The Budget of the Organization

In establishing the budget, important questions would arise regarding provision of the large amount of capital required for reprocessing or enrichment. Basically, no other procedure could be followed than to calculate the expected advantages to be derived by the individual member states and specify their contributions to the total budget accordingly. It would be reasonable, after a certain transitional period, to use as basis the actual claims of the separate states. It would, moreover, hardly be acceptable for each member state to have the freedom to choose the extent to which the services of the organization would be made use of. Within a particular planning period a change in original plans based upon previous data for each state would no longer be reversible; the costs would either have to be recalculated according to actual usage or, in spite of the new claims, carried by that member state which altered its intentions. Here it must be remembered that the periods of planning for projects of this type are relatively long; they are of the order of several decades. The enormous costs which must be provided for these installations would not justify a redistribution according to real claims to service. The assurance of planning of the international organization must therefore receive priority over constant flexibility for single member states. In effect, this would mean that, with entry into the organization, the member state, for budgetary reasons, would have to commit itself at least to a mid-term energy policy without the option of reversing its decision. From the standpoint of assurance of planning for the member states the consequences are negative. The extent to which the possibility of cancellation of membership by one or more member states would influence the question of assurance of supply will be discussed later.
7.2.1.3 The organization's tasks in the field of research and development

One should begin with the obligation of the organization to provide the member states with the required enriched or reprocessed fuel. The supplying would have to take place within an agreed time limit. This task, along with the non-proliferation aspect, would lead in turn to further obligations. Thus the organization would have to agree to keep operational the technical facilities necessary for the fulfillment of its obligations. Similarly the organization would be required, both for reasons of cost and of ecology, to maintain the facilities at the most modern level of technology.

In order to fulfill these tasks it could well be necessary that the organization set up its own research and development program. The organization could also have recourse to sources of information originating on the outside. However, for economic and political reasons it could not rely on cooperation with member or third party states to achieve access to most recent technology without a research program of its own.

One could, to be sure, require of the member states an obligation to provide information. The realization of such a regulation would, however, lead to an effective loss of incentive for public and private holders of rights within the member states to carry out research and development outside the organization. Competition within a free market economy would be seriously hampered if every important technological improvement had to be passed on at once to the international organization. In such a situation research in the peaceful use of nuclear energy (with its extraordinarily high costs) would be carried out by national public research installations by and large to the benefit of the entire group of member states. There would be no guarantee that the burden would be shared in the same way and with the same resources by all members. Under such circumstances, it could not be precluded that - just because of the high costs involved - research on the national level would be given a relatively low priority. An additional problem would arise if the organization were committed to pass on the results of such research to other member states. From the standpoint of the member states themselves it might be convenient politically for them to interpret their large financial contribution as due compensation for such a commitment on the part of the organization to disseminate information. If this were the case the proliferation restricting influence of the organization would to a large ex-
tent be neutralized by technology transfer. Thus from the mere standpoint of proliferation, an obligation to transfer knowledge gained through research back to the member states should be excluded. Whether an international organization of this kind would be acceptable to a large number of member states appears questionable, however. In conclusion, these considerations point toward an organization which obligates itself to ensure the required technological progress by means of a self-financed research and development program.

For this model one must consider in detail the consequences for the operation of an international organization which would arise out of the existence of private research and production facilities. Essentially two paths could be followed. On the one side one could weigh the possibility of extending the commitment to pass on information to include private installations. However, for constitutional reasons (protection of property) this solution might not be permissible in some countries; at best it could be conceivable through a complicated system of compensation which would be almost impossible to put into practice. If, on the other hand, the private sector is not included in the obligation to exchange information for these reasons, a situation might well arise in which the international organization no longer operates at the most modern technological level. The purpose of the international organization would in any case require that reprocessing and enrichment by national installations operated on a private basis be forbidden. However, it would have to be considered how many subareas of technology having no direct relation to enrichment or reprocessing are of relevance for the various facilities of the organization. In some instances a technological gap could be avoided through an intensive research effort on the part of the organization, but in other instances such a technology gap might have to be tolerated. The cost would be comparably high in both cases, however.

If one takes into account all of the above considerations it must be concluded that an international organization serving the objectives described would have to create its own comprehensive development program for the entire field associated with the technologically necessary installations. Experience gained so far by the IAEA has indeed shown, according to their own declarations, that research objectives - in contrast to commercial objectives - can be assumed relatively efficiently by international organizations. More-
over it is clear that the dimensions of such a research program, as regards management, personnel, installations, financial aspects and especially regarding its significance for the countries involved, are in no way comparable with those of projects carried out so far.

For the reasons mentioned, an international organization would have far-reaching implications for the private sector. Although private involvement in this sector would not have to be forbidden completely by means of national regulations, the remaining spectrum of permissible activities would surely be significantly restricted.

If one undertakes an assessment of an international organization with regard to its tasks in the field of research and development, the considerations above clearly point to possibly negative aspects as regards economic efficiency, assurance of planning and, in some cases, also of supply. The reservations which arise here seem, in fact, so serious as necessarily to influence an overall assessment of the international organization in a negative direction, having regard to the above-mentioned criteria /7.7/.

7.2.1.4 Protection of Sensitive Technology

a) Persons originating from non-nuclear weapons states could, as employees of an international organization, become cognizant of sensitive technology. Among the responsibilities of the organization would be the prevention of any negative consequences for proliferation that might thus arise. From a technical point of view it would be necessary to establish for each case how many persons in an organization of this kind must necessarily be imparted technological knowledge of the sort whose proliferation could not be deemed desirable from the international standpoint.

The legal contribution which could aid in the prevention of undesirable technology transfer consists of the inclusion of discretion clauses within working contracts concluded between the organization and its employees. An immediate dissolution of the working relationship would be a possible sanction, for example. It is a matter of judgement how effective such clauses are to be assessed, considering the very
high rewards that might be offered the cooperative informant by non-weapons states desirous of information.

b) From the economic standpoint a regulation of industrial rights in favour of the participating countries and the undertaking is necessary.

7.2.1.5 **Duties of Member States**

In the constituting agreement, the non-nuclear weapons states would promise to allow every form of reprocessing or enrichment to be carried out by the organization, and renounce all activities of their own within this area. At the same time these states would have to undertake a commitment not to commission any other third party state or other technology-holder with such tasks. The agreement would also foresee procedures for imposition of sanctions in cases of violation of this commitment. Here a certain difficulty may be seen in finding appropriate forms of sanction. The cessation of cooperation by the organization could easily cause the state in question to perform its own enrichment or reprocessing in future. Either as an alternative or in addition to such a sanction, a breaking-off of economic relations on the part of the member states would be conceivable.

The exclusive operation of sensitive installations by the international organization leads to problems as regards existing facilities and the legal status of nuclear weapons states. In the spirit of equal treatment of member states it would seem proper to prohibit all operations of such facilities on a national level; with any other solution a wide acceptance could hardly be expected. On the other hand the economic consequences of the destruction of existing installations cannot be mistaken. In summary it would appear most reasonable not to destroy existing installations, but rather to incorporate them into the international organization.

A more difficult question to answer is whether or not the nuclear weapons states should also undertake a commitment to carry out all relevant activities through the organization. Purely as regards the purpose of the organization, the non-proliferation of nuclear weapons, a commitment of this kind would not be called for. On the other hand the economic, scientific and political consequences of a discriminatory treatment of weapons states
and non-weapons states in this area must be considered. No great effort of thought is required to point out the disadvantages of such discrimination, especially for the industrialized non-nuclear weapons states. These disadvantages are self-evident for the Federal Republic of Germany and for Japan. The restricted flexibility in planning, the consequences for scientific and technological progress, the associated economic disadvantages, the consequences of a certain political dependence on the continuing existence and good favour of the organization along with its member nations would be manifest. These consequences could be in some cases so serious that one could speak with justification of countries with basically different status. It is a question of judgement, whether such a sacrifice, in addition to the renunciation of nuclear weapons, could be expected of industrialized states. Much can be said for involving the present nuclear powers in similar commitments in order to achieve a balance among the advantages and draw-backs of a non-proliferation policy. Experience gained up till now with the willingness of a nuclear weapons state to submit to IAEA controls is, to be sure, not insignificant in this connection.

7.2.1.6 Coming into Force, Duration and Cancellation of the Agreement

a) The agreement could come into force as soon as the necessary facilities are provided by the international organization. Thus the existence of a workable installation would be a precondition.

A temporary solution could nevertheless be found in which countries with existing installations agree to meet existing demands of the remaining states up until the organization is created. Here one would have to investigate whether and to what extent such a provisional coverage of demand would be technically possible.

b) The possible duration of the constituting agreement would have to be seen in close relationship with the planning assurance of the countries involved. Such assurance could not be guaranteed by short duration. Therefore no fixed period would be desirable but rather one whose length was tailored to the reactor program in question.

c) In this way the modalities for cancellation would arise automatically.
A cancellation would be possible at the earliest after conclusion of the reactor program. For reasons of planning assurance of the other member states a relatively long advance notice of cancellation would be necessary.

Still longer terms of notice of withdrawal might be provided for reasons of proliferation hindrance. It appears questionable, however, whether such long terms of notice would find political acceptance. In the case of the NPT, in spite of its purpose of non-proliferation, a term of notice of three months was agreed upon.

7.2.2 Variant Forms for the Law Applicable to the International Organization

The legal relationships between the state upon whose territory the international organization is active (host state) and the international organization would obtain very special significance. For reasons of non-proliferation it would be especially important that neither host state nor some third party state take control of the installation and misuse it for military purposes; threats from sub-national groups or from individuals would also have to be excluded as far as possible. For reasons of assurance of supply it would be essential, on the other hand, that the legal relationships between host state and organization ensure a continuous and undisturbed operation of the organization.

7.2.2.1 International Organization without Renunciation of Sovereignty on the Part of the Host State

Within the framework of an international organization, the form of cooperation least restrictive for the host state would be one in which the host state agrees to the operation of the installation in a contract binding under international law, but in which the international organization is granted no additional rights and in which the host state legislates and enforces all other laws applicable within the territory of the installation.

With such a subordination of the organization to the laws of the host state only a limited guarantee would be provided for a proliferation resisting influence on the host state.
The authority of the host state (as established legally in this construction) to make subsequent changes in the laws pertaining to the organization and its de facto authority by means of its own security organization, to bring about (illegally) activities encouraging to proliferation would be hardly designed to create international confidence in such installations. Nevertheless the acceptance of the installation by the host state would be better guaranteed for this construction than for one having a stronger antiproliferation effect but requiring the relinquishment of still more authority in favour of the organization.

It is remarkable that the creation of such an international organization has in effect a less favourable influence on non-proliferation than would a national model with abrogation of sovereignty (see 7.1.8).

7.2.2.2 International organization under treaty with host state

In a host state treaty it would have to be established which rights of sovereignty are to be passed on the organization. Hereby all those areas would have to be investigated which were discussed above (Section 7.1.8) in connection with the question of whether the host state could or should make renunciations of sovereignty in favour of a multinational undertaking. The reservations already mentioned regarding an extensive renunciation of sovereignty and having to do with the criteria of political independence, political acceptance and social acceptance may also be mentioned here.

In an assessment of such an international organization under treaty with the host state a positive judgement would certainly be reached as regards the proliferation criterion. As far as the other criteria are concerned it would have to be remarked that, apart from the disadvantages issuing from the structures of the organization themselves (see 7.2.1), a long term political acceptance on the part of the host state could not be taken for granted. As a result additional negative influences on assurance of planning and supply would arise.

7.2.2.3 International organization located on extraterritorial ground

At the extreme of the international spectrum one further model may be con-
sidered in which a state forgoes its sovereignty over a certain territory in favour of a new holder of sovereignty. Within this area the new holder of sovereignty could erect and operate the installation. A host state agreement would be superfluous in such a model as the organization would no longer be active on sovereign territory of a foreign country. The corresponding legislation by the abrogating state would be necessary as well as a taking over of sovereignty by the organization.

It should, however, be pointed out that an extraterritorial solution of this kind differs less from the above discussed model of an international organization with host state agreement as might appear at first glance. Differences would arise for example with respect to the jurisdiction which in the case of an international organization could in some circumstances remain in the host state. From the point of view of the host state it would also be of importance that the organization would possess its authority only during the lifetime of the agreement. For the rest, however, no great differences between the two models may be discerned.

In the present model an additional assurance of proliferation is created when compared with an international organization under treaty with the host state. The negative assessment based upon the other criteria remains essentially unchanged.

7.2.3 Summary

The rights of an international organization are characterized by an independent constituting agreement valid under international law, in which the legal relationships between international organization and host state are set down. The increased legal independence of the international organization thus obtained reduces the danger that legislative bodies within the operating state will change the applicable laws to the detriment of third party states taking part in the agreement. In the constituting agreement aims, essential tasks, organs, duration, terms of withdrawal and rules of procedure can be established.

The following variants of laws applicable for the international organization may be considered:
- international organization without abrogation of sovereignty by the host state,
- international organization with host state agreement,
- international organization on extraterritorial ground.

For an international organization founded for the purpose of reprocessing or enrichment of nuclear material, regulations on the following subjects must be established:
- budget,
- tasks of the organization in the field of research and development,
- technology transfer, and
- duties of member states, especially with regard to third party states.

The enormous costs which must be made available for the installation operated by the international organization compel the member states to forgo flexibility and commit themselves to long-term planning covering a period of several decades. In effect this implies that a member state must commit itself to at least a mid-term energy policy for budgetary reasons.

In order to prevent the proliferation and development of sensitive technology in the developing countries as well as to improve efficient operation of the installations, the international organization must set up its own comprehensive development program for the entire relevant area of technology. With this, wide reaching consequences result for the private sector which could lead to a general prohibition or at least a considerable restriction of certain kinds of research.

Moreover, among the duties of the member states must be included a renunciation of any form of reprocessing and enrichment whatsoever. This exclusive operation of sensitive installations by the international organization creates problems for existing installations and for the legal status of the nuclear weapons states. The economic, scientific and political consequences of a discriminatory treatment of nuclear weapons and non-nuclear weapons states are to be kept in mind. It requires no great effort of thought to point out the disadvantages of such discrimination particularly for industrialized non-nuclear weapons states.

If one takes all these considerations into account and attempts to assess
an international organization with regard to its tasks in the field of research and development, one is aware of negative aspects for the factors of efficiency and assurance of supply and planning, and the feasibility of a model involving an international organization appears very doubtful.

7.3 International Organization for the Storage and Distribution of Nuclear Fuel

Within the nuclear fuel cycle especially the following functions could in principle be assumed by an international organization:

a) Purchase and sale of fissile material,
b) the enrichment of fissile material,
c) the reprocessing of spent fuel elements and the recycling of fissile material,
d) the storage of excess fissile material, especially of excess plutonium, and
e) the storage of spent fuel elements.

Institutional models for facilities for enrichment (b) and for reprocessing (c) have already been discussed in detail in Sections 7.1 and 7.2. In this Section therefore institutional models for the areas (a), (d), and (e) will be discussed whereby here only the model of an international organization is of relevance as this is already prescribed in the IAEA statute Article XII A.5. for excess fissile material.

The obstructions to the realization of a model of an international organization for reprocessing and enrichment facilities which were discussed in Section 7.2.1 are not present to the same degree for international organizations which perform no actual operations but rather simply administer storage areas. Above all the difficulties associated with research and development, in the protection of sensitive technology and as regards security of planning, do not arise.

In the use of an international organization for the purchase and sale of fissile material as mediator between the interested parties it would appear questionable whether proliferation of nuclear weapons could be prevented. Resistance to proliferation could at most be strengthened in so far as a
potential nuclear weapons state could be prevented from the construction of a weapon by cutting off its supply of uranium. In this connection it should be considered whether or not all supplier countries make a commitment to sell their uranium exclusively through the international organization. Either as an alternative or additionally, all buyers of uranium would have to promise under contract to make their purchases only through the organization. The question is, however, to what extent the international organization's monopoly would contribute to non-proliferation in each individual case.

A country which had attempted unsuccessfully to divert fissile material for military purposes would have to reckon with considerable difficulties in obtaining further fissile material in the presence of such a monopoly. Therefore it is difficult to judge the preventative value of such a possibility. From the standpoint of proliferation it would be very important to know how much uranium had already fallen into the hands of a country at the time of discovery of its military intentions. This would depend upon whether the stockpiling of uranium by an individual country were possible and what quantity of uranium would be sold by the organization at any particular time. It would be conceivable that the organization sell only that amount necessary to cover immediate need - thus avoiding the situation in which a country at some stage could come into possession of a considerable stockpile of uranium.

The deterrent effect of such a marketing organization would, moreover, be dependent upon two conditions: Firstly, states possessing deposits of uranium ore within their own territory would not be affected, and secondly the effectiveness of such a model would be seriously hampered if the "discovered" state operated its own reprocessing facilities. An internationalization of the entire, world-wide uranium mining industry appears at the present time to be unrealistic, even international control is hardly conceivable considering the known projects. It must thus be assumed that an international organization having a monopoly in uranium sales could have a certain favourable influence on non-proliferation but only for those states possessing no uranium resources of their own, and moreover, that this influence would also be conditional on the renunciation of reprocessing.

The same considerations valid for the "discovered" state hold also for a country which openly admits its attention to construct nuclear weapons.
With regard to the storage of excess fissile material it should be remembered that the IAEA, according to Article XII A.5. of the IAEA statute, already has the authority to recall and store excess fissile material from member states. If in future practical discussions regarding the realization of this authority should concentrate themselves on the storage of excess plutonium, the activation of this clause in the IAEA statute would come into question; the IAEA has made no use of this clause up until now. No further discussion of the storage of excess plutonium by an international organization will be undertaken in the following, as one can refer to the existing model of the IAEA in this regard.

Similar considerations are valid for spent fuel element storage. The non-proliferation effect consists here in the controlling of the amount of spent fuel; the delivery to reprocessing facilities occurs according to regulations which are subject to considerable influence by the international organization. The natural decrease in radioactivity of the spent fuel elements, which leads to a considerable simplification of the subsequent chemical isolation of plutonium, can similarly be controlled to a sufficient extent by the international organization. The arrangements for the storage of spent fuel elements correspond to those already discussed for international organizations having a monopoly in the distribution and storage of excess fissile material and can in principle be carried over.

The non-proliferation effect of an international organization for the storage of spent fuel elements depends in detail upon the extent to which the states represented in the organization operate reprocessing facilities and on the extent to which the international organization can assume responsibility for the reprocessing or final storage of spent fuel. In this regard, arrangements can be made which take into account the relationships discussed.

Up until now there exist no organizational forms which fall into this category.
References and Comments (7 Discussion and Assessment of Conceivable
Institutional Models and Assignment to
Existing Institutional Forms)


/7.2/ To this end the Treaty of Tlateloilo is equated with the NPT.

/7.3/ Art. 208 of the Euratom Treaty excludes cancellation of the Treaty on any grounds whatever. For a cancellation permitted under extraordinary circumstances, see /7.4/.


/7.5/ "national" means subject to a national system of laws.


/7.7/ A stimulating brief discussion of the potential involvement of the IAEA in the construction and operation of multinational reprocessing centers is found in D.A.V. Fischer, Role of the IAEA in Multinational Fuel Cycle Centers, in: International Arrangements for Nuclear Fuel Reprocessing, (A. Chayes, W.B. Lewis, ed.) (1977), pp. 189-200; the relevant legal and economic aspects are not extensively covered by this paper; see also Regional Nuclear Fuel Cycle Centers (Vienna: International Atomic Energy Agency, 1977).
The paths of proliferation identified in the present study - violation of contractual obligations, withdrawal from international commitments, diversion of nuclear material, misuse of nuclear facilities, completely concealed development of nuclear weapons without violation of a treaty - lead to the consideration of institutional models for installations of the nuclear fuel cycle as complementary measures to IAEA and Euratom safeguards. With regard to the situation of the Federal Republic of Germany, the definition and development of models were aimed at finding organizational forms which do not only minimize proliferation, but also fulfill other criteria, such as political independence, assurance of supply and planning, economics, the different aspects of technology transfer, health, safety, and environment, as well as political acceptance in the host state and capability to impose sanctions.

In developing advanced institutional models, such as the ones presented here, the starting point consisted of a summary and analysis of existing forms of international cooperation in the field of nuclear energy with participation of the Federal Republic of Germany. The conclusion was reached quickly that none of the existing or conceivable models of international cooperation relevant to installations of the nuclear fuel cycle can fully satisfy the quoted criteria. This is due to the numerous interdependencies of the criteria used for assessment. For this reason, within the scope of the study, it was attempted to identify a model which - in the authors' opinion - presently constitutes a realizable optimum. In doing so, it had to be taken into account that the NPT and Euratom Treaty already provide certain barriers for proliferation, and in so far represent quantifiable prerequisites for advanced institutional models. However, for the Federal Republic of Germany as a member of Euratom, it has to be emphasized that none of the measures shown and discussed under the aspect of non-proliferation can be taken either unilaterally or without approval of Euratom /8.1/.

The increase of non-proliferation effects on the basis of the institutional models developed here applies also to the scenario "concealed diversion of nuclear material", the detection of which is already guaranteed by technical safeguards under IAEA and Euratom Treaties. Hence, the application of these mo-
dels should be effective complementarily to nuclear materials safeguards, in order to prevent an unnecessary and additive application of controls as well as to achieve a mitigation and reduction of technical control measures and to improve operational efficiency.

In the analysis of advanced institutional models it is basically necessary to distinguish between national models and various international commitments on the one hand and international organizations with differing structures on the other. In the course of the study different viewpoints arose with respect to production facilities of the nuclear fuel cycle and to the treatment of nuclear fuel in special storage installations.

With regard to storage and sale of nuclear fuel it was concluded that establishing an international organization or reactivating existing international organizational forms would be an acceptable solution.

For the sensitive facilities of the nuclear fuel cycle - enrichment, reprocessing, and MOX-refabrication plants - the conclusion of this study was that for a number of reasons the realization of international organizations imposes problems difficult to solve. Therefore such organizations should stand back in the practical discussion. With regard to the national models this study did not arrive at clear conclusions. Nevertheless, as a result of a conscientious investigation, it became evident to the authors that the model of a multinational undertaking, based upon an agreement under international law and with the waiving specific sovereign rights, is most likely to comply with the different criteria, when some priority is given to proliferation resistance. Because of its intrinsic structure, this model allows sufficient flexibility in reaching compromises among the interests involved and may be regarded in further discussions as being both basically realistic and, from its starting point, consistent with the desired objective. It became clear, however, that a national installation tied into the multiple network of the NPT and Euratom Treaty and the related controls and conditions, although inferior to the above model with regard to proliferation resistance, appears more preferable when measured against other criteria.
Comments (8 Outlook and Recommendations)

/8.1/ Compare on this topic the opinion of the Court of Justice of the European Communities dated 14th November, 1978, case no. 1/78.
ANNEX

Existing Forms of International Cooperation
with Participation of the Federal Republic of Germany

S U R V E Y

A. Fundamental Agreements and Conferences

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   II. Processing/Enrichment
   III. Reactors: Cooperation and Undertakings
   IV. Reprocessing/Final Disposal
   V. Research and Development

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Notice

This review displays the most important international agreements of the Federal Republic of Germany and some contracts under private law, the objective of which is also international cooperation. It is based exclusively on published sources, with the consequence that a number of unpublished governmental agreements and cooperation contracts between private firms or research establishments are not included. With regard to the latest developments completion and revision is called for. Deficiencies already identified are characterized by the word "open".

The dates given refer to the signing of the respective agreements. In so far as a larger lapse of time exists with respect to the signing, the dates of coming into force in the Federal Republic of Germany is added. If possible the official sources are quoted. Otherwise, the records were taken from:

H. Haedrich Europäische Atomverträge (1966)
H.T. Adam Les organismes internationaux spécialisés
Vol. 1 (1965)
Vol. 2 (1965)
Vol. 3 (1967)
Vol. 4 (1977)
G. Erler/H. Kruse Deutsches Atomenergie recht
Collection of unbound sheets,
3rd ed. (1978)

The individual agreements/contracts are grouped according to the various sections of the nuclear fuel cycle. Even if they fall under several sections they are mentioned only once according to their major objective.
A. Fundamental Agreements and Conferences

1. IAEA Oct. 26th, 1956 BGBI. II 1957, p. 1357
2. Euratom Mar. 25th, 1957 BGBI. II 1957, p. 1018
   for D: Jun. 5th, 1974 BGBI. II 1974, p. 785
6. Treaty banning nuclear weapon tests in the atmosphere in outer space, and under water Aug. 5th, 1963 BGBI. II 1964, p. 906
7. Treaty on the principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies Jan. 27th, 1967 BGBI. II 1969, p. 1967
8. INFCE Oct. 19th-21st, 1977

B. Agreements/Contracts, Undertakings and Projects within the Area of the Nuclear Fuel Cycle

I. Supply/Trade in Nuclear Fuel

   Agreement on cooperation Euratom/USA Nov. 11th, 1958
   Revised May 22nd, (see below)
   Supplementary agreement Jun. 11th, 1960 ABl. Apr. 29th, 1961, No. 31
   Last revision Sep. 20th, 1972 O.J. May 22nd, 1974, No. L 139
b) Euratom/Canada Nov. 18th, 1959 ABl. Nov. 24th, 1959, p. 1165
   (new version)
e) Euratom/Brazil Sep. 9th, 1961 ABl. Mar. 31st, 1969, No. L 79/7
   f) Euratom/Australia 1979
   negotiations under reservations of France concerning bilateral deliveries
   g) Euratom Supply Agency
      aa) Statute Nov. 6th, 1958 ABl. Dec. 6th, 1958, p. 534
      bb) Regulations of the
         - Agency supply/demand May 5th, 1960 ABl. May 11th, 1960, p. 777
         - Commission "small quantities"Nov. 29th, 1966 ABl. Dec. 28th, 1966, p. 4057

1) With regard to the situation in supply compare page 38, chapter 4.
2) d) and e) refer to cooperation agreements, in which the regulations on supply play only a minor role; see also notification of the Commission of the European Communities dated June 22nd, 1979, KOM(79) 331, final version. - In KOM(79)23, final version dated Feb. 5th, 1979, p.12, South Africa, Namibia, and Niger are quoted as also being supplier countries to the Community.
General contractual conditions of the Agency
Support in the supply of common projects on the territory of
the member states
- Council
Resolution on the supply with enriched uranium
Jun. 4th, 1974  O.J. Jun. 14th, 1974, No. C69/1

h) Nuclear Suppliers Group ("Club of London")
London
Agreement on guidelines
Jan. 27th, 1976
Successive meeting
Jun.3rd/4th, 1976 Increase in number of members
from 7 to 14
Accession of CH
Apr. 20th, 1977

II. Processing/Enrichment

1. Survey

In force : Jul. 19th, 1971  NL, D, UK
BGBI. II 1971, p. 927

aa) CENTEC
BNFL, UCN, Nuklearer Verfahrenstechnik
Agreement dated Aug. 5th, 1971 (unpublished)
Seat at Almelo (NL)

bb) URENCO
BNFL, UCN, Uranit
Agreement dated Aug. 31st, 1971 (unpublished)
Seat at Marlow (UK)

cc) URENCO-CENTEC
Association of both companies in October 1973 (unpublished): facilities at Capenhurst and
Almelo; a third facility is planned to be built at Gronau (D)

b) EURODIF (F)
Statute dated Mar. 27th, 1973
Plant at Tricastin (Pierrelatte)

aa) Extension
Agreement between CEA (F), ENEL (I), A.B. Atomenergi (S), National Uranium Enterprise (UK),
Sybesi (B), Nov. 27th, 1973 (unpublished)
25 % of the CEA share (Sofidif)
Jan. 2nd, 1975 (unpublished)

bb) Access of Iran

Otherwise the needs are covered by supply contracts with USSR and ERDA(USA).

1) AdG 1976, 27626 A; R. Loosch, Das internationale Programm zur Beurteilung
des Kernbrennstoffkreislaufs INFCE, ATW 1978, p. 34; G. Mayer-Wöbse,
Die Vereinbarungen der Nuclear Suppliers Group im Lichte des NV-Vertrags,
ATW 1978, p. 570; on the question of interpreting the NPT with respect
to the peaceful use of sensitive technology see M. Shaker, The Treaty
on the Non-Proliferation of Nuclear Weapons: A Study Based on the
Five Principles of UN General Assembly Resolution 2028 (XX) (1976),
pp. 271-328; recently G. Mayer-Wöbse, Rechtsfragen des Exports von
2) Compare with respect to access of seven more states, in particular of
GDR, Poland, and CSSR: Bulletin Presse- und Informationsamt der Bundes-
regierung Nr. 6, Jan. 17th, 1978, p. 45; also AdG 1976, 27816 A.
3) ATW 1976, p. 557.
2. Comments

a) URENCO-CENTEC
In September 1974 URENCO was reorganized: the total group was divided into URENCO (UK), URENCO (NL) and the holding company URENCO-CENTEC.\textsuperscript{1)} URENCO (UK) is under the management of BNFL; the Capenhurst plant is financed to 75\% by the British partner. URENCO (NL) is managed by the German and Dutch shareholders, each one paying 43.75\% of the expenses arising from the Almelo plant. The rest of the financial burdens associated both with the Capenhurst and the Almelo plants are shared by the German/Dutch partners on the one hand and by the British partner on the other.

In January 1976 Ultra-Centrifuge Nederland and Uranit GmbH founded\textsuperscript{2)}, URENCO Nederland Operations BV, each one holding 50\% of the shares\textsuperscript{2).}

In the case of URENCO the purpose of research plays a major role. On the other hand the facilities are starting to operate reliably and are expected to be in profitable operation from 1982 onwards.\textsuperscript{3)}

b) EURODIF
From the foundation of EURODIF as a stock corporation of CEA (F) until now, companies from four countries have joined - apart from Iran joining through the foundation of the Iranian-French company "Sofidif" thus holding 25\% of the CEA share of EURODIF -. The French CEA has kept 47.5\% of the original capital, the Italian company holding 22.5\% and the companies from Sweden, Spain and Belgium holding 10\% each. The Swedish company withdrew from the undertaking on March 20th, 1974, its share of capital falling to the lot of the remaining companies. In the meantime CEA holds 52.78\% and thus the majority of stock with EURODIF.

In the future a large portion of the demand for separative work will be covered by the utilization of diffusion plants and some of the German utilities committed themselves to take delivery of EURODIF material. However, economic and technical advantages of the gas ultracentrifuge process\textsuperscript{4)} caused the Federal Republic of Germany, the Netherlands, and the United Kingdom to withdraw from the originally planned participation in EURODIF.\textsuperscript{5)}

III. Reactors: Cooperation and Undertakings
(without Research Reactors)\textsuperscript{6)}

1. Survey

\textsuperscript{1)} "URENCO-CENTEC-Partnership", see AdG 1975, 27172 A.
\textsuperscript{2)} ATW 1976, p. 54.
\textsuperscript{3)} See also U. Ehrfeld, Urananreicherungs-Prognose, Prozesse, Planungen, ATW 1975, p. 259; ATW 1976, p. 103; W. J. Schmidt-Küster/M. Popp, 2o Jahre Kernenergieentwicklung in der Bundesrepublik Deutschland, ATW 1975, p. 21.
\textsuperscript{5)} AdG 1975, 27172 A.
\textsuperscript{6)} Research reactors are mentioned below, see Part B V.
a) Euratom: Joint Undertakings in the sense of Article 45 and the following of the Euratom Treaty
- SENA (F, B) Sept. 9th, 1961 AB1. Oct. 9th, 1961, p. 1173
- KKW Obrigheim GmbH AB1. Aug. 9th, 1966, p. 2681
  AB1. Sep. 9th, 1975, No. L251/42
  O.J. Dec. 5th, 1974, No. L325/9
- SEMO (F, B) Nov. 26th, 1974 O.J. Dec. 1st, 1975, No. L311/38
  May 20th, 1975
- SNR KKW-GmbH (SBK)1) O.J. Jun. 12th, 1975, No. L152/8
  May 20th, 1975
- JET: see below, section V c)

b) Other multilateral projects
aa) Agreement on maximum flux reactor (D, F)
  Revised Jul. 6th, 1971 BGBI. II 1971, p. 1089
  Accession of UK Jul. 19th, 1974 BGBI. II 1976, p. 244
  Revised Jan. 27th, 1976 BGBI. II 1977, p. 80
bb) "Bugey" Agreement Jan. 3rd, 1974
  Agreement on the cooperation between EdF (F), ENEL (I), RWE (D), in connection with the construction of two FBR.
  -- foundation of NERSA in May 1974
    J.O. May 14th, 1974 p. 5136
    Group of companies (stock corporation) with respect to the construction of the French FBR at Bugey (Rhône)
    (EdF 51 %, ENEL 33 %, RWE 16 %)2)
  -- foundation of ESK in October 1974
    Group of companies (GmbH) with respect to the construction of the German SNR at Kalkar (RWE 51 %,2) ENEL 33 %, EdF 16 %).
cc) "Superphénix"
  -- BMFT/Ministère de l'Industrie et de la Recherche Feb. 13th, 1976 (Nice)
    Communiqué on the cooperation in the field of advanced reactor systems.
    -- Successive agreements: protocols of Bonn dated May 18th, 1976; contracts between undertakings and research centres: Paris, May 5th, 19773)
    -- Cooperation on r&d in the field of LMFBR: CEA, KfK, Belgonucléaire, CEN (Mo1/B), ECN, NERATOM, TND (Petten/NL).
    -- Cooperation between industrial groups with respect to development and construction of a standard type FBR, the respective experimental types being developed under Italian participation in D resp. F.

1) see below part B III 1 b, bb foundation of ESK.
2) By May 20th, 1975 RWE became shareholder of SNR KKW-GmbH (SBK), which in the meantime holds the 16 % share of NERSA. It is the task of SBK to construct, equip and operate SNR with participation of companies from D, B, NL, and UK (AB1. Jun. 12th, 1975, No. L 152/9).
3) see R. Hüper, Atom und Strom 1978, p. 103.
-- Common utilization of know-how and granting of licenses by a pool company (SERENA). SERENA is a subsidiary company of SYFRA (CEA and NOVATOME) and KVG (INTERATOM 51%, KFK 19%, Belgonucléaire 15%, NERATOM 15%)\(^1\) which are also companies for utilization of know-how.

-- cooperation on development of HTR.

dd) BMFT/ERDA

Umbrella Agreement in the field of concepts and technology of gas-cooled reactors.

Feb. 11th, 1977 BGBl. II 1977, p. 345
accession of CH (AWF) and F (CEA)
Sep. 30th, 1977

c) Bilateral agreements and projects

D/F

agreement on exchange and cooperation in the field of safety research for LWR
Sep. 28th, 1978 BGBl. II 1978, p. 1300

BMFT/USAEC

agreement on reactor safety research and reactor development
Mar. 6th, 1974 BGBl. II 1974, p. 741

BMFT/ERDA

Agreement for research and development in the field of liquid metal-cooled breeder reactors
Jun. 8th, 1976 BGBl. II 1976, p. 1449

GfK/UKAEA

cooperation in the field of SNR development
Nov. 30th, 1976 see ATW 1977, p. 56

D/Argentina

umbrella agreement with respect to research and technological development
- contract with Siemens on the construction of a reactor of the MZFR-type, 1968\(^2\)
- contract with KWU, 1979

D/Brazil

aa) contracts

- umbrella agreement on scientific research and technological development
Jun. 9th, 1969 BGBl. II 1969, p. 2118
- agreement on the peaceful use of nuclear energy
Jun. 27th, 1975 BGBl. II 1976, p. 334
in force: Nov. 18th, 1975
- agreement on the safety of nuclear facilities
Mar. 10th, 1978 BGBl. II 1978, p. 950

bb) "joint ventures"

- NUCLEN (unpublished)
Software-technology-transfer, engineering NUCLEBRAS (Brazil) 75 %, KWU (D) 25 %
- NUCLEP (unpublished)
manufacturing of heavy components
NUCLEBRAS 75 %, VEDEST (A) 8 1/3 %, GHH (D) 8 1/3 %, KWU 8 1/3 %
- NUCLEI (unpublished)
uranium enrichment
NUCLEBRAS 75 %, INTERATOM 10 %, STEAG (D) 15 %
- NUCLAAM (unpublished)
prospecting and mining of uranium
NUCLEBRAS 51 %, Urangesellschaft (D) 49 %.

\(^1\) The group of Companies, NERSA, is the client for Superphénix, which is constructed by INB, NOVATOME, and NIRA. The cooperation under SERENA is achieved in such a way that CEA/KFK and INTERATOM bring their know-how into SERENA, while the construction companies NIRA, INB, and NOVATOME pay license fees.

\(^2\) see H.Frewer, Aufgaben ..., ATW 1977, p. 412 and 416.
2. Comments

On a): The "Joint Undertakings" - except for JET - represent national companies, which obtain a special status by having adopted the rules of the Euratom Treaty. They have to transfer know-how to Euratom and in turn, by decision of the Euratom council, acquire special privileges. 1) Some of the joint undertakings are shared by partners from several member states, such as the French-Belgian projects SENA and SEMO.

On b): Multilateral Projects
The participation and rights of utilization of know-how are defined in the agreements on the German-French-British maximum flux reactor project. All of the three states party to the project are represented in the managing groups. In contrast, the contractual structure with respect to the FBR project "Bugey"/"Superphenix" is less transparent.

In the period of 1976 to 1978 a series of agreements on the development of FBR were signed, with a total of eight countries (D, F, B, NL, I, UK, USA, Japan) participating. The major agreements refer to the modalities of utilization of common know-how and cooperation with respect to construction as well as the common research and development (R & D) on FBR in general. A German-French agreement with Japan (June 1978) will secure the exchange of know-how in different fields of FBR research until 1983; the same applies to an agreement between KfK and UKAEA.

Far-reaching consequences arise from the handing over of know-how and from the granting of rights of use by the pool company SERENA. 2) SERENA acquires know-how from the participating research centres and passes it over to the reactor construction companies NIRA (I), NOVATOME (F), and INB (D, B, NL). At first sight this structure seems to be favourable, because the know-how transfer is no longer hampered by the restrictions hitherto known. However, France maintains a lead of about 5 to 7 years over the rest of the European states in the field of FBR technology. 3) French policy, up to the present, has shown evident reserves with respect to communicating FBR know-how to her partners. 4) In this connection it could be noteworthy that the French company SYFRA now and in the future holds the major share of SERENA (up to now 65 %), even if, under certain conditions, it is expected to drop to 51 %. The Federal Republic of Germany maintains a lead in the field of HTR technology; however, this cannot be taken into account, as France is comparably much more interested in FBR technology. Hence it is uncertain, if SERENA will represent a model for the comprehensive exchange of know-how which will be acceptable to all parties.

With respect to the construction of Superphenix the German partner faces another problem: Germany has committed herself to construct the SNR-300; however, she will not be able to fulfil her obligations to France without considerable delay. 5)

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1) Seldomly published; see ABl. Jun. 12th, 1975, No. L 152/11.
3) AdG, 1976, 27867 A.
4) ATW 1976, p. 103; W. Müller, Mehr Kooperation mit Frankreich, ATW 1976, p. 169.
5) See H. Fischerhof, Kein Schneller Brüter für die BRD, ATW 1978, p. 568; with respect to the Dutch participation see ATW 1976, p. 552.
On c): Bilateral Agreements and Projects.

IV. Reprocessing/Final Storage

1. Survey

a) Reprocessing
aa) Eurochemic Dec. 20th, 1957 BGBl. II 1959, p. 621

On decision of the General Assembly dated June 4th, 1974 (BGBl. II 1975, p. 1182) extension of the project by another 5 years, according to Art. 172 of the Eurochemic statute.1)

bb) United Reprocessors Ltd (URG)
foundation in October 1971; association under private law, of the three European reprocessing companies BNFL, CEA, and DWK.
BNFL facility placed at Windscale
CEA facility placed at La Hague
100 % subsidiary to CEA (stock company), which is now the operator of the reprocessing plant.
DWK commercial plant being planned

cc) Euratom (see also part V)
- Euratom is not an operator of commercial plants, but participates in research projects of OECD/NEA, IEA, IAEA, and ISO.2)
- Cooperative agreement between Euratom and the USA dated Nov. 8th, 1958 (AB1. 1959, p. 312), (and successive agreement); under Art. III D the USA committed themselves to reprocessing services.
- Cooperation under the Euratom/Brazil agreement dated June 9th, 1961 (Art. III).

dd) Bilateral agreements
- D/Brazil Jun. 27th, 1975 BGBl. II 1976, p. 335
- D/USA agreement dated Jul. 3rd, 1957 Art. VIII E and the following agreement dated Dec. 20th, 1974 on technical exchange and cooperation BGBl. II 1975, p. 269
- and others (open)

b) Final Disposal
BMFT/USAEC conditioning and disposal of radioactive waste materials, Dec. 20th, 1974 BGBl. II 1975, p. 268

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2. Comments

On a): Eurochemic
During the past years this undertaking, which was founded to undertake tasks in the field of reprocessing, was essentially engaged in research programs on final disposal\(^1\) (confinement of calcinated products of highly active waste in a metal matrix).

On b): URG\(^2\)
During or immediately after foundation certain capacities were agreed upon in order to support beginning reprocessing industries. The goal was to avoid establishing overcapacities and to achieve as high as possible a degree of flexibility with respect to the market. Consequently, it was decided first to start up operation of plants at Windscale and La Hague, whereas DWK was not to start up operation of a plant before the early eighties.\(^3\) As a matter of fact there existed considerable competition between the facilities, which at that time were financed largely by the governments.

At present, the German utilities place their reprocessing orders and make contracts directly with COGEMA/BNL, as was communicated by KEWA (DWK). KEWA (DWK) is simply negotiating on behalf of the utilities with regard to the – unpublished – contracts, however, the utilities are put directly under obligation and given authority.\(^4\)

V. Research and Development

a) Euratom
Joint Research Centre (JRC)

b) Euratom programs among others:
- decision of the Council: recycling of plutonium in LWR
- decision of the Council: utilization and disposal of radioactive waste
- decision of the Council: high-temperature materials
- decision of the Council: fusion and plasmaphysics
  O.J. Apr. 3rd, 1976, No. L90
- resolution of the Council: decommissioning of nuclear facilities
  and KOM(78) 167 final version

\(^1\) loc. cit.
\(^3\) W. Müller, Reprocessing ..., ATW 1975, p. 333.
\(^4\) ATW 1978, p. 434 (COGEMA).
- proposal of the Commission to the Council: 2nd five year program (1980 - 1984) on the conditioning/utilization of radioactive wastes
  Mar. 1st, 1979 KOM (79)81 final version


Within the scope of the Euratom research projects a series of research and cooperation agreements were concluded with international authorities (e.g. NEA, IEA, IAEA) as well as national research establishments, which usually did not result in founding joint establishments (with the exception of several projects in the framework of the JRC being placed at Geel, Petten, Karlsruhe, and Ispra as well as of the research reactors with international participation).\(^1\) The JET project appears to be an exception.

Euratom, member states, Sweden, Sitterland
term of validity: 12 years beginning at Jun. 1st, 1978 placed at Culham (UK)
The expenses are borne by Euratom (80%), UK (10%), and the cost of the member states (totaling 10%).
Associated states by agreements with Euratom:

d) OECD (without Eurochemic)
- research reactors (in the framework of NEA)
    BWR extended until Dec. 31st, 1981
    expiration Mar. 31st, 1976\(^3\)
bb) programs
- European-American nuclear data committee EANDC
  NEA, 2nd activity report (73), 51
- European-American committee on reactor physics EACRP
  NEA, loc.cit., 52
- NEA Computer Program Library
  agreement OECD/Euratom
  May 20th, 1964 C (64) 69
  placed at Ispra having OECD administration
- NEA Neutron Beta Compilation Library
  agreement OECD/CEN
  May 20th, 1964 C (64) 70
validity extended for indefinite term by exchange of letters
- International Commission on Radiological Protection decision of the Council Dec. 18th, 1968 C (73) 138

\(^1\) Provision of Euratom personnel for the operation of the reactor BR2 at Møll(B) on the basis of the agreement dated Feb. 24th, 1977 (see O.J. Jan. 31st, 1979, No. L 23/331); operation of the reactor HFR at Petten (NL) (loc. cit., p. 287); provision of facilities in connection with the reactor ESSOR in Italy (loc. cit., p. 289).


\(^3\) See answer of the Commission of the European Communities, O.J. Apr. 5th, 1976, No. C 79/33.
e) Others
- Euratom/IEA (OECD): three agreements on exchange of information, on research, and on reactor safety
  Jun. 1976 unpublished
- Euratom/USA, B, D, IRL, I, L, NL BGBI. II 1974, p. 1124
  Sep. 19th, 1974 O.J. Nov. 18th, 1974, No. L307/19
  exchange of research data

C. Safeguards and Non-Proliferation

1. Survey

   This agreement refers to the exchange of information only, but not to
   the adaptation of the safeguards systems.
   EURATOM/IAEA
   agreement on the verification of Euratom-safeguards with respect to
   LWR's and reprocessing facilities.
   Sep. 20th, 1977 11th General report
   (approval by the Council of
   the European Communities, No. 406.
   of the European Communities)

b) B, DK, D, IRL, I, L, NL, Euratom, IAEA:
   Apr. 5th, 1973 BGBI. II 1974, p. 795
   Agreement in implementation of Article II, (1) and (4) of the Treaty
   on the Non-Proliferation of Nuclear Weapons (NPT)²
   Date of coming into force in D: Jun. 5th, 1974.
   Commission of the European Communities:
   Regulation No. 3227/76 in force:
   and the following
   Safeguards agreements between all member
   states and Euratom Feb. 1977

c) Euratom, UK, IAEA Sep. 6th, 1976 12th General report
   of the European Communities, No. 394.
   Safeguards agreement including the adopting of IAEA safeguards harmoni-
   zed with Euratom safeguards³)
   INFCIRC/263

   of the European Communities, No. 394.
   Safeguards agreement with considerable limitations. Under this agree-
   ment only a few (non-military) nuclear facilities are put under IAEA
   safeguards. Furthermore, the efficiency of safeguards under this agree-
   ment is limited due to the fact that F reserved her right to decide,[4]
   which facilities shall or shall not be safeguarded by IAEA/Euratom.

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1) See report of Mitchell, member of the European Parliament, on the
2) The law of application with respect to this agreement came into force on
3) With respect to the problem of duplication of safeguards activities see
   J. Arnold, Zur Zulässigkeit von Doppelkontrollen nach NV-Vertrag und
   Verifikationsabkommen, ATW 1978, p. 572. Before renewing her supply
   agreement with Euratom in connection with deliveries to Euratom member
   states Canada insisted on Euratom and, in particular, also UK and F
   signing safeguards agreements with IAEA.
e) Brazil, D, IAEA  Feb. 26th, 1976  INFCIRC/237  Safeguards agreement for the first time also with respect to technology transfer.

f) Argentina, D, IAEA  Jul. 22nd, 1977  INFCIRC/250  Safeguards agreement with respect to the agreement between the Argentine Atomic Energy Commission and RBU on the delivery of finished and tested reactor fuel elements.

g) Convention on the physical protection of nuclear material.  Nov. 1977  Accession of Euratom  1)  open, see KOM(77) 520, Oct. 20th, 1977

D. Other Agreements

a) General cooperation

- D/India  
Agreement on cooperation regarding the peaceful use of Atomic Energy and Space Research  
Oct. 5th, 1971/ BGBI. II 1972, p. 1013  
May 19th, 1972

- D/Indonesia  
Agreement on cooperation regarding the peaceful use of atomic energy  
Feb. 24th, 1977

- D/Iran  
Cooperation in the field of the peaceful use of nuclear energy  
Jul. 4th, 1976/ BGBI. II 1978, p. 284  
Nov. 21st, 1977

- D/Canada  
Cooperation in the field of the peaceful use of the atomic energy  
Dec. 11th, 1957/ BAnz. No. 46/58, Mar. 7th, 1958  
Dec. 18th, 1957

- D/Rumania  
Cooperation in the field of the peaceful use of nuclear energy  

- D/USA  
Cooperation in the field of safety of nuclear facilities  
Oct. 1st, 1975

- D/Spain  
Cooperation in the field of the peaceful use of nuclear energy  
Dec. 5th, 1978/ BGBI. II 1979, p. 133  
Dec. 13th, 1978

- and others (open)

b) Security in transport

- agreement dated Dec. 20th, 1957  BGBI. II 1959, p. 585  
on the establishment of a security control in the field of nuclear energy; furthermore, a protocol with regard to the establishment of a court to deal with matters in the field of nuclear energy.

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1) See the opinion of the Court of Justice of the European Communities dated Nov. 14th, 1978, case no. 1/78.

2) Unless previously quoted.
Convention on Third Party Liability in the Field of Nuclear Energy (Paris)  
Jul. 29th, 1960  
revised  Jan. 28th, 1964  
Supplementary agreement of Brussels  
Jan. 31st, 1963  BGBI. II 1975, p. 957

Convention relating to Civil Liability in the Field of Maritime Carriages of Nuclear Material (Bruxelles)  
Dec. 17th, 1971  BGBI. II 1975, p. 1026

Convention on the Liability of Operators of Nuclear Ships  
Aug. 1st, 1963

Atomic vessels, agreements on the use of territorial waters and ports  
"Savannah", D/USA Nov. 29th, 1962  
"Otto Hahn"  
D/NL Oct. 28th, 1968  BGBI. II 1969, p. 1121  
D/Liberia May 27th, 1970  BGBI. II 1971, p. 963  
D/Portugal Jan. 29th, 1971  BGBI. II 1972, p. 57  
D/Argentina May 21st, 1971  BGBI. II 1972, p. 69  
D/Brazil Jun. 7th, 1972  BGBI. II 1974, p. 686

International Convention concerning the carriage of goods by rail (CIM)  
Apr. 1st, 1967

IATA-regulations on the transport of radioactive material by aircraft  
Erler/Kruse, Vol. II, B 42

Universal Postal Convention  

European Agreement concerning the International Carriage of dangerous goods by road (ADR)  
Jun. 27th, 1972

Commission of the European Communities  
1st program in the field of transport of radioactive material  

c) Security in Border Areas  

agreements between D and other states (open)