COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS

Sub-Committee of Experts on the
Transport of Dangerous Goods

Thirtieth session
Geneva, 4-12 (a.m.) December 2006
Item 10 of the provisional agenda

ANY OTHER BUSINESS

Transport of radioactive material

Note by the secretariat

1. The Sub-Committee may wish to note that the International Atomic Energy Agency (IAEA) circulated, on 14 November 2006, a draft security guide entitled “Security of Radioactive Material during Transport” to its Member States for comments to be submitted by 120 days from the date of the note.

2. Copies of the note and of the draft security guide are attached.

3. As indicated in paragraph 117, the generic guidelines contained in the Guide are broadly consistent with the UN Model Regulations on the Transport of Dangerous Goods, with regard to the number of security levels and the security measures proposed, but the threshold values and some details of the security measures proposed differ from those in the Model Regulations. It would therefore be desirable that the Sub-Committee considers these differences at least once the final version of the IAEA Security Guide has been approved and published. The differences are summarized in the paragraphs below.

Scope

4. Since Chapter 1.4 and section 7.2.4 are not listed in paragraph 2.7.9.1 of the UN Model Regulations, the UN security provisions do not apply to excepted packages. According to the IAEA Security Guide, the security provisions would not apply to excepted packages, LSA-I and SCO-1 radioactive material (paragraph 115, first bullet).

Security levels

5. The Guide defines three security levels: the basic security level for which the same kind of general security provisions contained in 1.4.1, 1.4.2 and 7.2.4.1 of the UN Model Regulations would apply; the enhanced security level for which the provisions applicable to high consequence dangerous goods would apply; an additional level for which additional

security measures may be applied by a State (see paras. 434 to 447) (not provided for in the UN Model Regulations).

6. The guidance concerning the basic security level (paras. 404-420) contains general provisions as in the UN Model Regulations, but in certain cases these provisions are those required for high consequence dangerous goods in the Model Regulations (e.g. identification of consignors/carriers, security locks) or go beyond the provisions of the Model Regulations (written instructions, trustworthiness verifications).

7. For the enhanced security level (paras. 423-433), the security plan contains two elements not mentioned in the UN Model Regulations (measures to monitor the shipment, arrangements to define the transfer of responsibility for the security of the package, if appropriate). The provisions are more detailed than those in the Model Regulations.

Identification of high-consequence dangerous goods

8. The specification of the transport security threshold is not the same as in the UN Model Regulations. The UN threshold for high consequence dangerous goods is "radioactive material in quantities greater than 3000 A_1 (special form) or 3000 A_2 , as applicable, in Type B(U), type B(M) or Type C packages". The IAEA threshold would be "3000 A_2 in a single package" except for 25 radionuclides for which the transport security threshold is indicated in TBq (see page 33). A formula for mixtures of radionuclides has also been indicated (I.30).

IAEA
Atoms for Peace: The First Half Century
1957–2007
الوكالة الدولية للطاقة الذرية
国 际 原 子 能 机 构
International Atomic Energy Agency
Agence internationale de l’énergie atomique
Международное агентство по атомной энергии
Organismo Internacional de Energía Atómica

Wagramer Strasse 5, P.O. Box 100, A-1400 Wien, Austria
Phone: (+43 1) 2600 • Fax: (+43 1) 26007
E-mail: Official.Mail@iaea.org • Internet: http://www.iaea.org

In reply please refer to: J1-TM-28824 Circ.
Dial directly to extension: (+431) 2600-22492

2006-11-14

The Secretariat of the International Atomic Energy Agency presents its compliments to the Ministries of Foreign Affairs of Member States of the Agency and has the honour to request that they draw the attention of the appropriate Governmental authorities to review the following draft security guide:

Security of Radioactive Material during Transport: Guide.

This document is submitted in order to provide Member States the opportunity for a review and evaluation of the document. The English version is enclosed. Any proposed changes to this document resulting from the review by Member States will be taken into account in the finalization of the guide.

Comments on the document should be provided in accordance with the guidance given in the attached Explanatory Note. To the extent possible comments should be submitted electronically.

The Secretariat wishes to inform that in addition to the present document, the Secretariat is preparing additional documents on the security of waste and of radioactive sources respectively. These documents will be submitted to Member states’ review in due course.

The Secretariat of the International Atomic Energy Agency avails itself of this opportunity to renew to the Ministries of Foreign Affairs the assurances of its highest consideration.

Attachment

Explanatory Note for Security of Radioactive Material during Transport: Guide

The document for review, entitled, Security of Radioactive Material during Transport: Guide, was prepared within the Agency's Nuclear Security Plan and has already been reviewed through five consultants meetings and two Technical Meetings.

Since transport occurs in the public domain and frequently involves intermodal transfers, it is a potentially vulnerable phase of domestic and international commerce. Therefore, a uniform and consistent approach to security is desirable.

This guide applies to the transport of radioactive material, including nuclear material as defined in and governed by the Convention on the Physical Protection of Nuclear Material, which may pose a significant radiological hazard to individuals, society and the environment if the material is used in a malicious way.

The purpose of this document is to provide States with a Guide for implementing a State security regime to protect radioactive material in transport against sabotage or unauthorized removal or other malicious acts that could produce unacceptable radiological consequences. From a security point of view, a threshold is defined in determining which shipment or consignments need to be protected beyond prudent management practice. This will minimize the likelihood of theft or sabotage of radioactive material during transport. This is accomplished by a combination of deterrence, detection, delay and response, complemented by other measures for mitigation of consequences of such acts, including recovery.

Comments are requested in relation to the following:

- Relevance and usefulness: is the stated purpose of the Guide appropriate, and is it met by the document?

- Scope and completeness: is the stated scope appropriate, and is that scope adequately covered by the document?

- Quality and clarity: does the Guide represent the current consensus among specialists in the field, and are they expressed clearly and coherently?

Comments of an editorial nature will be considered; however, it should be noted that the document will be comprehensively edited by the Secretariat prior to publication.

Any comments made should be in English, should refer to the relevant paragraph or page-line number in the document being reviewed, and when appropriate should propose alternative text. Please use the attached comment form for documenting all comments.

Any comments should be received by the Secretariat by [120 days from the date of the note]. The responsible IAEA officer are Ann-Margret Eriksson Eklund, NSNS, and Michael E.Wangler, NSRW of the Department of Nuclear Safety and Security. They may be contacted for further information in connection with this subject at (0043)-1-2600-26638 and (0043)-1-2600-21260, respectively, or through e-mail at a.eriksson@iaea.org and m.wangler@iaea.org.

TITLE: SECURITY OF RADIOACTIVE MATERIAL DURING TRANSPORT: IMPLEMENTING GUIDE

COMMENTS BY REVIEWER Reviewer: Page.... of.... Country/Organization: Date:				RESOLUTION			
Comment No.	Para/Page-Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection

Nuclear Security Series
Guide

Security of Radioactive Material during Transport:

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

November
2006

Draft 2006-09-27R1

THE IAEA NUCLEAR SECURITY SERIES

Nuclear security issues relating to the prevention and detection of, and response to, theft, sabotage, unauthorized access and illegal transfer or other malicious acts involving nuclear material (including radioactive substances) and their associated facilities are addressed in the IAEA Nuclear Security Series of publications. These publications are consistent with, and complement, international nuclear security instruments, such as the Convention on the Physical Protection of Nuclear Material and the Amendment relating thereto, the Code of Conduct on the Safety and Security of Radioactive Sources, United Nations Security Council Resolutions 1373 and 1540, and the International Convention for the Suppression of Acts of Nuclear Terrorism.

CATEGORIES IN THE IAEA NUCLEAR SECURITY SERIES

Publications in the IAEA Nuclear Security Series are issued in the following categories:

- **Fundamentals** contain objectives, concepts and principles of nuclear security and provide the basis for security recommendations.
- **Recommendations** present best practices that should be adopted by Member States in the application of the Nuclear Security Fundamentals.
- **Implementing Guides** provide further elaboration of the Recommendations in broad areas and suggest measures for their implementation.
- **Technical Guidance** publications comprise: **Reference Manuals**, with detailed measures and/or guidance on how to apply the Implementing Guides in specific fields or activities; **Training Guides**, covering the syllabus and/or manuals for IAEA training courses in the area of nuclear security; and Service Guides, which provide guidance on the conduct and scope of IAEA nuclear security advisory missions.

DRAFTING AND REVIEW

International experts assist the IAEA Secretariat in drafting these publications. For Nuclear Security Fundamentals, Recommendations and Implementing Guides, open-ended technical meeting(s) are held by the IAEA to provide interested Member States and relevant international organizations with an appropriate opportunity to review the draft text. In addition, to ensure a high level of international review and consensus, the Secretariat submits the draft texts to all Member States for a period of 120 days for formal review. This allows Member States an opportunity to fully express their views before the text is published.

Technical Guidance publications are developed in close consultation with international experts. Technical meetings are not required, but may be conducted, where it is considered necessary, to obtain a broad range of views.

The process for drafting and reviewing publications in the IAEA Nuclear Security Series takes account of confidentiality considerations and recognizes that nuclear security is inseparably linked with general and specific national security concerns. An underlying consideration is that related IAEA safety standards and safeguards activities should be taken into account in the technical content of the publications.

FOREWORD

The destruction resulting from an improvised nuclear device or the economic and social disruption resulting from a radiological dispersal device could be enormous. Since 11 September, 2001, a new realization has emerged regarding the potential for malicious acts involving nuclear materials are well recognized. Recent evaluations of the potential consequences of a radiological dispersal device have identified the need to improve security of radioactive materials.

The Agency's nuclear security plan of activities 2006-2009, approved by the Board of Governors in September 2005 clearly states the need for a comprehensive approach to security of radioactive materials during transport.

Examination of the supply chain for large radioactive sources (those capable of causing serious consequences if used maliciously) shows that in certain circumstances these sources may be vulnerable to sabotage or diversion when they are:

1. in use at inadequately protected fixed facilities
2. being transported, during import, domestic transport, in-use (mobile applications), and export

While considerable attention and resources have been directed to improving the security of sources in facilities, there has been a less focused effort directed at security during transport. This is especially ironic since, by many measures, sources are most vulnerable during the transport. Transport of large radioactive sources is often an international activity involving movement through the public domain with minimal physical protection. The relative ease with which a package could be attacked or stolen during transport highlights the absolute need for adequate security during this vulnerable phase of the commercial supply chain.

Additionally, perception of the risk involved in transporting radioactive material has changed. Historically, the emphasis has been on transport safety, but now there is a recognized need to address security as a priority. The current concern about transport security may be due to the fact that the safety record for radioactive material transport has been very good but the rising threat of terrorism, including sabotage, is now better recognized. Transport is now recognized as a particularly vulnerable part of the supply chain.

This document provides a set of recommendations that can be used by regulatory authorities in Member States as a basis when setting up national regulations for security during transport of radioactive material.

It includes contributions from the participants in the Consultant Meetings, Technical Meetings held in October 2003 and January 2006 and individual contributions. Other relevant national and international standards were taken into account. The work undertaken by the participants in the Consultant's Meetings and other contributors to this endeavour is gratefully acknowledged.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

1.1 Background

101. Historically, the focus of IAEA publications on transport has been on transport safety. The IAEA Safety Standards Series include the *Regulations for the Safe Transport of Radioactive Material*, TS-R-1 (henceforth referred to as the *Transport Safety Regulations*), the latest version of which was published in 2005 [1] The IAEA *Draft Fundamental Safety Principles* [2] and the *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (BSS) [3] are relevant to transport safety and additionally include some limited security provisions.

102. Efforts were initiated in 2002 by the IAEA to provide additional guidance for security during the transport of radioactive material, based upon the new security requirements in the *Recommendations on the Transport of Dangerous Goods — Model Regulations* [4]. These model regulations were developed by the United Nations Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals. The *UN Model Regulations* recommend a basic security level with commensurate provisions for the transport of all dangerous goods, and an enhanced security level with additional provisions for those quantities of dangerous goods defined as 'high consequence' dangerous goods. These provisions became part of the *UN Model Regulations* in late 2003.

103 To that end, the IAEA convened a series of meetings to develop a defensible technical basis for establishing security levels for the protection of radioactive materials during transport and appropriate security measures commensurate with the potential radiological consequences that could result from malicious use of radioactive material. This document is the result of these efforts

104. The security regime for the transport of radioactive material defined in this document addresses the radiological concerns/hazards associated with the unauthorized removal, sabotage and other intentional malicious acts involving radioactive material (as opposed to the hazards of weapons useable nuclear material) and intend to complement the security regime established under the *Convention on the Physical Protection of Nuclear Material* [5], which addresses international transport of nuclear material and the Amendment relating thereto which extends inter alia to domestic transport.

1.2 Relationship with other documents

105. The *UN Model Regulations* provide the basis for dangerous goods transport security requirements implemented by States and international modal organizations. The dangerous goods transport security requirements are found in Sections 1.4 and 7.2 of the *Model Regulations.*

106. Existing international instruments and guidance for the security of nuclear material and of radioactive sources, including during transport, can be found in the:

- *Convention on the Physical Protection of Nuclear Material and Amendment of 8 July 2005* [5] and *The Physical Protection of Nuclear Material and Nuclear Facilities,* INFCIRC/225 Rev. 4 (Corrected) [6];

- *Code of Conduct on the Safety and Security of Radioactive Sources* [7] and a companion document, *Categorization of Radioactive Sources* [8] and Supplementary Guidance.

107. Other UN specialized agencies and programmes — e.g. the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO) and the United Nation Economic Commission for Europe (UNECE) and other intergovernmental organizations such as the Intergovernmental Organization for International Carriage by Rail (OTIF) — have taken similar steps to provide improved security during transport of all dangerous goods. IMO, ICAO and UNECE have also amended their respective international instruments — the *International Maritime Dangerous Goods Code* (IMDG), *Technical Instructions for the Safe Transport of Dangerous Goods by Air, European Agreement covering international carriage of Dangerous Goods by Road* (ADR), *Regulations concerning the International Carriage of Dangerous Goods by Rail* (RID), *European Agreement of Dangerous Goods by Inland Waterway* (ADN) — to reflect the security provisions of the *UN Model Regulations*, which became mandatory in international transport in 2005.

108. This document builds on the principles set forth in the previously noted security documents [5–8] and in the *Physical Protection Objectives and Fundamental Principles* [10] established by the IAEA for the physical protection of nuclear material and nuclear facilities.

109. The transport of nuclear material is governed by the CPPNM and subject to the recommended security measures specified in INFCIRC/225/Rev.4 (Corrected) [6]. The transport security measures recommended in this Guide are without prejudice to the provisions in INFCIRC/225/Rev.4 (Corrected), in particular Chapter VIII thereof. However, for some category III nuclear material there may be cases where the potential radiological consequences of the material warrant higher security measures than those specified in INFCIRC/225/Rev.4 (Corrected). For example, because of their radioactivity, some category III nuclear material packages may require the enhanced security measures called for in this Guide, which are more stringent than those in INFCIRC/225/Rev.4 (Corrected). In respect of these particular cases, this Guide recommends measures additional to those contained in INFCIRC/225/Rev.4 (Corrected).

110. The security measures specified in this Guide also complement the provisions of the *Code of Conduct* [7] and its supplementary document *Guidance on the Import and Export of Radioactive Sources* [11]. Also related are Security Series documents: *Security of Radioactive Sources [12]* and *Security of Radioactive Waste [13]*

1.3 Purpose and scope

111. Since transport occurs in the public domain and frequently involves intermodal transfers, it is a potentially vulnerable phase of domestic and international commerce. Therefore, a uniform and consistent approach to security is desirable.

112. These guidelines apply to the transport of all packages containing radioactive material — including nuclear material as defined in the *Convention on the Physical Protection of Nuclear Material* [5] — that may pose a significant radiological hazard to individuals, society and the environment if the material is used in a malicious way.

113. The purpose of this document is to provide States with guidance in implementing, maintaining or enhancing a State national security regime to protect radioactive material (including nuclear material) while in transport against theft, sabotage or other malicious acts that could if successful produce unacceptable radiological consequences. From a security point of view, a threshold is defined for determining which packages or type of radioactive material need to be protected beyond prudent management practice. The minimization of the likelihood of theft or sabotage of radioactive material during transport is to accomplished by a combination of measures relating to deterrence, detection, delay and response, complemented by other measures for mitigation of consequences of such acts, including recovery.

1.4 Overall approach

114. The guidance contained in Chapter 2 — general principles to be applied to the transport of radioactive material — is intended to be used by a State to develop a national security system.

115. Chapter 3 uses the radioactivity level of the contents of an individual package as the basis for defining security levels:

- For small quantities of radioactive material transported as excepted packages, as defined in TS-R-1 [1], and LSA-I material or SCO-I that can be transported unpackaged, no specific security measures are recommended beyond those required by the safety regulations, BSS [3] and **prudent management practices** already implemented by consignors and carriers;
- For any package with contents exceeding the excepted package quantity and material other than LSA-I and SCO-I that can be transported unpackaged, a **basic security level** should be applied that includes some specific security measures; and
- For radioactive material packaged in significant quantities, such that it is deemed to be ‘high consequence’ radioactive material, **enhanced security level** should be applied that includes both the basic security measures and enhanced security measures.
- In certain circumstances **additional security measures** may be applied by a State.

116. Chapter 4 sets out baseline measures and guidance for those States that may not already have a well defined and developed security system including a regulatory infrastructure and a threat assessment process. States with a well defined and developed regulatory infrastructure and threat assessment process may already have an adequate degree of security in place. However, those states may also find this guidance useful.

117. The generic guidelines presented in this document are broadly consistent with the *UN Model Regulations* with regard to the number of security levels and the security measures proposed, although the threshold values and some details of the security measures proposed here (in Chapters 3 and 4) differ from those in the *Model Regulations*.

118. The threshold values outlined in this document have been derived on the basis of the potential radiological consequences of malicious acts involving intentional dispersion of radioactive material. These activity thresholds have been calculated and

compared with existing approaches used in the *IAEA Transport Safety Regulations* and in the *Code of Conduct*.

119. While safety and security for the transport of radioactive material are usually addressed by separate IAEA publications, it is recognized that some of the measures designed to address safety can also complement security aims. For this reason, the safety measures and procedures already in place as a result of the broad and effective application of the IAEA *Transport Safety Regulations* at the modal level internationally and at the State level may already meet some security needs. Care should be taken to ensure that safety and security measures do not conflict.

2. DESIGN AND EVALUATION OF SECURITY MEASURES

201. In determining the security measures that should be implemented for radioactive material during transport, a number of topics need to be considered to prevent the unauthorized access to, theft of, or other malicious acts involving the material. For the security regime of a State to function well, the responsibilities of all parties involved must be clearly defined. The threat against which to protect the material should be established and well understood by all parties involved in designing the security measures to be applied during transport. Operators' security plans, where required, are considered the appropriate way to deliver the in-depth implementation of the security programme. Depending on potential consequences, some types and quantities of material could be more attractive targets for malicious acts than others. This should be effectively addressed by a graded system of security measures.

2.1 Definitions

202. The following definitions apply to this document. Definitions for terms not shown below that are provided in Section II of TS-R-1 and in the *IAEA Safety Glossary* [14] also apply.

- ***Competent authority***: Any national authority designated or otherwise recognized as such for any purpose in connection with this guidance document (adapted from [14]).
- ***Defence in depth***: A concept used to design security systems that requires an adversary to overcome or circumvent multiple obstacles, either similar or diverse, in order to achieve his objective.
- ***Design basis threat (DBT)***: Attributes and characteristics of potential insider and/or external adversaries who might attempt carrying out malicious acts involving radiological material including its unauthorized removal or sabotage, against which the security system is designed and evaluated.
- ***Graded approach:*** An approach/process by which the scope, depth and rigour of the management and engineering controls are commensurate with the magnitude of any hazard involved with the failure of the item or process.
- ***Guard:*** A person who is entrusted with responsibility for patrolling, monitoring, assessing, escorting individuals or transports, controlling access and or providing initial response.

- ***Malicious acts:*** During transport of radioactive material, may include wrongful act or activity intentionally done or engaged in without legal justification or excuse and which causes or is likely to cause death or physical injury to a person or damage to property or the environment.
- ***Operator***: Any organization or person authorized/responsible for radioactive transport security. This includes private individuals, governmental bodies, consignors, carriers, consignees.
- ***Positive identification***: Government issued photographic identification or biometric record, which positively identifies the individual.
- ***Radioactive material (including nuclear material)***: In addition to the definition provided in paragraph 236 of TS-R-1[1], material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity.
- ***Radioactive source***: Radioactive material that is permanently sealed in a capsule or closely bonded, is in a solid form and is not exempt from regulatory control (adapted from [7]).
- ***Sabotage***: Any deliberate act directed against radioactive material in transport which could directly or indirectly endanger the health and safety of personnel, the public and the environment by exposure to radiation or release of radioactive substances (adapted from [6]).
- ***Safety***: Measures intended to minimize the likelihood of accidents involving radioactive material and, should such an accident occur, to mitigate its consequences (adapted from [7]).
- ***Security***: The prevention and detection of, and response to malicious acts involving radioactive material.
- ***Threat***: Characterization of an adversary capable of causing undesirable consequences including the objectives, motivation, and capabilities, e.g. number of potential attackers, equipment, training, and attack plan.
- ***Trustworthiness***: Reliability of an individual, including characteristics that may be verified, when necessary, by background checks and checking criminal records.
- ***Vulnerability***: A feature or weakness that can bring about an undesirable consequence

2.2 General approach

203. The responsibility for the establishment, implementation and maintenance of a security system within a State rests entirely with that State. States should establish a legislative and regulatory framework gathering the security of radioactive material during transport that effectively integrates with the security system applied to such material while in use and storage.

204. Security measures taken during transport of radioactive material to protect it against malicious acts should be based on evaluating the threat to the material and its potential to generate unacceptable consequences.

205. Development of a radiological model to evaluate the potential radiological consequences resulting from malicious acts provides a logical and transparent basis for developing a graded and consistent system for specifying adequate levels of protection.

206. Consideration should be given to the impact on human health and to the potential for economic, environmental, or social harm and disruption resulting from malicious acts.

2.3 Basic security principles

207. The security principles embodied in this document have been adapted from those in the *Code of Conduct* [7] and those for nuclear material presented in *Physical Protection Objectives and Fundamental Principles[10], and in the Amendment to the CPPNM [5].*

208. For the transport of radioactive material, the basic principles for security should address:

- the responsibility of the State;
- responsibilities during transport;
- legislative and regulatory frameworks;
- the need to establish or designate a competent authority;
- responsibilities of those involved in transport (e.g. consignors, carriers and consignees);
- security culture;
- threat evaluation ;
- use of a graded approach;
- the concept of defence in depth;
- management systems;
- contingency/emergency plans; and
- confidentiality.

2.4 Transport security principles

209. The transport of radioactive material is usually an interim phase between production/use/storage/disposal of the material. The potential radiological consequences that the loss of control due to theft of radioactive material during use, storage or transport do not differ in principle; although the consequences of a potential sabotage might differ very much depending on the location of the radioactive material.

210. In view of the potential vulnerability of radioactive material in transport, the design of an adequate transport security system should consider defence-in-depth principles and use a graded approach to achieve the objective of preventing the material from being susceptible to malicious acts.

211. The transport security system should be designed taking into account:

- the quantity and the physical/chemical form of the radioactive material;
- the mode(s) of transport;
- the package(s) being used;
- measures that are required to:
    - deter, detect and delay unauthorized access to the radioactive material while in transport and during storage incidental to such transport to deter or defeat any attempt of malicious acts;
    - identify the actual possible malicious acts involving any consignment while in transport or during storage incidental to transport to enable appropriate response and allow recovery or mitigation efforts to start as soon as possible and;
    - provide rapid response to any attempts directed towards or actual unauthorized access to radioactive material, or to other malicious acts involving radioactive material while in transport or storage incidental to such transport;
- capabilities for:
    - recovering any damaged, stolen or lost radioactive material, and bringing it into secure regulatory control; and
    - minimizing and mitigating the radiological consequences of any theft, sabotage or other malicious act.

212. The achievement of effective transport security can be assisted by considering transport schedules, routing, security of passage, information security and procedures. In particular, and as far as is operationally practicable, general principles to be regarded as best practice are:

- regular movement schedules should be avoided;
- routes should be planned in such a way as to avoid areas of natural disaster, civil disorder or known threats;
- the total time that radioactive material is in transport and the number of modal transfers should be kept to the minimum necessary;
- advance knowledge of transport information and the security measures applied to the transport should be restricted to the minimum number of persons necessary;
- packages or conveyances containing radioactive material should not be left unattended for any longer than is absolutely necessary; and
- radioactive material in transport and in temporary storage incidental to transport should be subject to security measures consistent whith those to be applied to the material in use and storage.

2.5 Responsibilities

2.5.1 State responsibilities

213. The establishment of an adequate security regime for the transport of radioactive material is the responsibility of each State. The State should establish the basic requirements for legal and governmental infrastructures for transport security, including:

- designation of an independent regulatory body responsible for the implementation, application, inspection and enforcement of the legislative and regulatory framework, including effective sanctions.
- setting objectives for protecting individuals, society and the environment from radiation hazards including those that might result from a malicious act involving radioactive material during transport;
- development and integration of formal objectives and standards in security regulations;
- definition of its domestic threat and the prescription of requirements for the design and evaluation of the security system during transport;
- review of the security system on a regular basis in order to take account of advances in technology;
- procedure for submission and, where appropriate, approval by the regulatory body of a security plan prior to transport of radioactive material;
- development of a programme for verifying continued compliance with the security regulations through periodic inspections and ensuring that corrective actions are taken when needed;
- development of a policy to identify, classify and control sensitive information, the unauthorized disclosure of which could compromise the security of radioactive material in transport;
- determination of security clearance procedures for persons engaged in the transport of radioactive material, commensurate with their responsibilities; and
- reporting of security related events, including losses.
- establishment of criminal penalties related to security during transport;

214. The regulatory body should be provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities related to the security of radioactive material during transport and have the ability to enforce the applicable requirements.

215. In addition, the State should take appropriate measures to ensure the promotion of a security culture [19] for all involved in the transport of radioactive material.

216. For transport, States should establish appropriate mechanisms to cooperate, consult and — within the constraints of confidentiality — exchange information on security techniques and practices. States should assist other States in recovering should such aid be requested and should establish appropriate arrangements for the

exchange of information between shipping, receiving and transit States and with relevant intergovernmental organizations and promote cooperation to ensure that material during transport under their jurisdiction is adequately protected. The designated regulatory body should be identified and made known to other States and to the IAEA.

2.5.2 Operator responsibilities

217. All operators (e.g. consignors, carriers, consignees), and other persons engaged in the transport of radioactive material should fulfil security requirements for the transport of radioactive material commensurate with their responsibilities and the level of threat.

218. Contingency plans to respond to malicious acts involving radioactive material during transport including the recovery of lost or stolen material and for minimizing and mitigation of consequences should be established in advance by operators and by the State as necessary.

219. For international transport, operators should ensure in advance that any State-by-State variations in security measures are applied as the radioactive material package progresses on its journey and also clearly define the point at which the security responsibility is transferred.

2.6 Determination of security measures

220. A State may use a prescriptive-based or performance-based approach, or a combination, for defining objectives to be met or the security measures to be applied during transport of radioactive material. In whichever approach is adopted, the security measures to be applied should comply with the administrative and technical requirements prescribed by national regulation (prescriptive based) or should be evaluated against the prevailing threat or the State DBT (performance based).

221. The prevailing threat or the State DBT may vary quite widely according to the State or to the location concerned.

222. A State should continuously review the threats associated with the radioactive material in transport and evaluate the implication of any changes in those threats for the definition of the security measures.

223. The recommended basic steps required for defining security measures are:

- At the State level:
    - evaluating the potential consequences of malicious acts against radioactive material;
    - performing a threat assessment within the State, based on information from security and intelligence experts;
    - establishing the security levels to be applied to radioactive material packages or conveyances;
    - defining security objectives for each security level;
    - specifying administrative and technical requirements or specific security measures necessary to meet the security objectives; and

- verifying implementation by the operator of the security measures required by national regulations and in accordance with international obligations.

- At the operator level:
  - identifying the radionuclides and their activities in each radioactive material package and the mode (s) of transport to be used;
  - assigning the packages or conveyance to security levels; and
  - implementing security measures required by regulation or by the State DBT as defined by the objectives set by national regulation.

224. The overall effectiveness of the security measures may be ensured either by complementing existing safety measures with additional security measures identified through a specific vulnerability assessment based on the domestic threat or by applying already required measures capable of coping with the domestic threat.

225. It is recognized that the information and resources required for the application of a comprehensive threat and vulnerability assessment methodology may not always be available or may be deemed unnecessary in view of the potential radiological consequences of the material being transported. Under these circumstances, security measures may be established using only a prescriptive approach. This approach involves defining security levels and default security measures commensurate with the assumed level of threat and risk acceptance based solely on the potential (radiological or non-radiological) consequences of the malicious use of the radioactive material.

226. In such cases, the assignment of generic transport security levels based on the radioactivity in each package as elaborated in Chapter 3 and the application of the guidance in Chapter 4 provide an acceptable generic method for defining security measures that a State could use for transport operations.

3. ESTABLISHING RADIOACTIVE MATERIAL TRANSPORT SECURITY LEVELS

301. In order to specify the transport security levels in a manner that is easily understood and integrated into existing safety and security systems, it was essential to evaluate existing approaches being applied to radioactive materials (including nuclear material) and sources. Two documents were used for this evaluation:

- IAEA *Code of Conduct* and its companion document *Categorization of Radioactive Sources [8]*. Since these documents are being widely implemented to improve the safety and security of sources, the D values that were developed to define a dangerous source are suitable for specifying the transport security level threshold activity.

- IAEA *Transport Safety Regulations*. These regulations use radioactivity values, called A_1 and A_2 to specify the amount of radioactivity that can be transported in a non-accident resistant package. Since the A-values are well understood and engrained in the transport safety system, with appropriate numerical multipliers they might also provide a good basis for specifying the activity thresholds.

302 The categorization of sealed sources contained in the *Code of Conduct* is based on the development of D values for the Requirements in GS-R-2. [17] GS-R-2 specifies requirements for emergencies involving a dangerous source. These Requirements define a dangerous source as one “that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects”. The Requirements then go on to define a severe deterministic effect as one that “is fatal or life threatening or results in a permanent injury that decreases the quality of life”.

303 To apply the Requirements, an operational definition of a dangerous source was needed. This operational definition of a dangerous source is known as the D-value. The D-value is that quantity of radioactive material, which, if uncontrolled, could result in the death of an exposed individual or a permanent injury that decreases that person’s quality of life.

304 Since there was a need for a categorization of radioactive sources that was based upon the potential for sources to cause deterministic health effects, the D-values were also used as normalizing factors in generating the numerical relative ranking of sources and practices. Thus, the D-values were also used as the basis for the IAEA’s system for categorization of radioactive sources, parts of which became included in the *Code of Conduct* on the Safety and Security of Radioactive Sources. The *Code of Conduct* lists D-values for about 25 radionuclides.

305 For transport the Q system was developed as a methodology to evaluate a series of exposure routes, each of which might lead to radiation exposure, either external or internal, to persons in the vicinity of a Type A package involved in a severe transport accident. In terms of the BSS [3], the Q system lies within the domain of potential exposures. A potential exposure is one that is not expected to be delivered with certainty but may result from an accident involving a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

306 For potential exposures, 50 mSv has been used on the grounds that, historically, actual accidents involving Type A packages have led to very low exposures. In choosing this reference dose, it is also important to take into account the probability of an individual being exposed as the result of a transport accident, since such exposures may, in general, be considered as once in a lifetime exposures.

307 Neither of these approaches was entirely satisfactory from a security perspective. The Code of Conduct references sealed sources, which consider deterministic effects. The Q system uses the stochastic approach to health effects.

308 Since a malicious act involving radioactive material seized during transport may well involve intentional dispersion of such material over a large area, a radiological dispersal device (RDD) scenario was considered. An RDD is a weapon of denial, i.e. it denies use of the affected area. Therefore, the dispersal of a radionuclide at levels that require the relocation or resettlement of people from the affected area is an appropriate measure of an effective RDD. Other types of malicious acts and consequences have also been taken into account in setting the recommended thresholds in this chapter, such as the potential consequences from direct exposure to an unshielded radioactive source, plume, ingestion, and inhalation.

309. A scoping model was used to calculate the amount of radioactivity required to cause resettlement of persons from an area contaminated by an RDD. ICRP 82, *Protection of the Public in Situations of Prolonged Radiation Exposure* [15] and IAEA emergency response guidance [16] provide recommendations on dose levels for actions to be taken following radiological accidents. Details of the scoping model, and its assumptions and parameters, are provided in Appendix I.

310. The results of the scoping model were compared to both the A-values and the D-values. This comparison sought to identify multipliers of those values that would approach but not exceed the model results. Given the uncertainties and conservative approaches inherent in the model, it was not necessary that a rigorous correlation be found, but a reasonable one. It was found that correlation could be made with either set of values. Appendix I provide the basis for the activity thresholds.

311. As a result the following activity threshold values are recommended for enhanced security level:

- For radioactive sources and other forms of radioactive material containing radionuclides covered by the *Code of Conduct,* 10 D (this includes Category 1 and Category 2 sources)
- For all other radionuclides, 3000 A_2

312. Some radioactive material poses sufficiently low risk of radiological hazard that it does not present a security concern. This material includes very small quantities (excepted packages), and low activity concentration material and low level contaminated objects that can be transported unpackaged (LSA-I and SCO-I). No specific security measures are recommended for these materials beyond the basic control measures in the BSS [3] and in normal commercial practices.

313. Radioactive material between these two threshold limits should be protected at basic security level.

4. GUIDANCE FOR SECURITY MEASURES IN THE TRANSPORT OF RADIOACTIVE MATERIAL

401. For States where the information and resources required for the application of a comprehensive threat and vulnerability assessment methodology are not available, this chapter provides adequate baseline security measures that could be used to protect radioactive material against theft, sabotage, or other malicious acts during transport.

402. Section 4.2 below provides guidance for the basic security level and Section 4.3 provides additional guidance for transport of radioactive material above the threshold level specified in Chapter 3. These are measures based on the *UN Model Regulations* and should be considered by States and operators as representing a minimum set of standards. Section 4.4 provides additional guidance that States may wish to consider applying to the transport of particularly sensitive radioactive material or at a time of increased threat.

4.1 Prudent Management Practices.

403. Packages of radioactive material for which no additional provisions are identified in Chapter 3 (paragraph 306) require no more security measures to be applied than those basic control measures included in the BSS [3] and normal commercial practices.

4.2 Basic Security level.

404. For all packages of radioactive material defined in Chapter 3 as requiring at least basic security measures, the guidance in this section should be applied.

General security provisions

405. The competent authority should, at its discretion, provide information to operators regarding the potential change in the threat to radioactive material. Operators should take all threat information into consideration when implementing security measures. For international transport, the threat information for each State involved in such transport should be considered

406. All operators (consignors, carriers, consignees) and other persons engaged in the transport of radioactive material should consider security requirements for the transport of radioactive material commensurate with their responsibilities and the level of threat.

407. Radioactive material should be transferred only to appropriately authorized operator. In normal circumstances, it is sufficient that there is an existing business relationship between a carrier and consignee/consignor. Where such a relationship does not already exist, a potential carrier's/consignee's suitability/ability to receive or transport radioactive material should be established by confirmation with relevant national regulatory authorities, or trade/industry associations, that the carrier's/consignee's interests are legitimate.

408. When radioactive material is temporarily stored in transit sites (such as warehouses, marshalling yards etc.), appropriate security measures should be applied to radioactive material consistent with the measures applied during transport or use and storage.

409. The operator should have procedures in place that would initiate an inquiry about the status of packages that are not delivered to the intended recipient at the expected time. Through the course of the inquiry, if it is determined the package is lost or stolen, procedures should immediately be initiated to locate and recover the package.

Security locks

410. Unless there are overriding safety or operational considerations, packages of radioactive material should be carried in secure and closed conveyances; however, carriage of such packages individually weighing more than 500 kg that are sealed and secured to the conveyances may be transported on an open conveyance. The integrity of locks and seals should be verified before dispatch and on arrival.

411. In the event that packages need to be transported on open conveyances, it may be necessary for the State to consider — in view of the nature of the radioactive material or prevailing threat — whether additional security measures should be applied. Such measures may include providing guards, shielding the package to provide for pre-detonation in the event of a stand-off attack, and enhancing route surveillance or response capability. Packages should only be shielded following advice from safety specialists.

Security awareness training

412. Training for individuals involved in the transport of radioactive material should include elements of security awareness.

413. Security awareness training should address the nature of security threats, recognizing security concerns, methods to address such concerns and actions to be undertaken in the event of a security incident. It should include awareness of security plans (as appropriate) commensurate with the responsibilities of individuals and their part in implementing security plans.

414. Such training should be provided or verified upon employment in a position involving radioactive material transport and should be periodically supplemented with retraining.

415. Records of all security training undertaken should be kept by the employer and made available to the employee if requested.

Personnel identity verification

416. Each crew member of any conveyance transporting radioactive material should carry means of positive identification during transport. Some States may not have the ability to confirm biometric details. Therefore, for international transport, government-issued photographic identification may be the most appropriate method of identification.

Security verification of conveyances

417. Carriers should perform security inspections of conveyances and ensure that these measures remain effective during transport. In normal circumstances, and as appropriate to the mode of transport, it will be sufficient for the carrier of the conveyance to carry out a visual inspection to ensure that nothing has been tampered with or that nothing has been affixed to the package or conveyance which might affect the security of the consignment. Such an inspection will require no more than the carrier's own knowledge of his conveyance.

Written instructions

418. Operators should provide appropriate crew members with written instructions on any required security measures, including how to respond to a security incident during transport. At the basic security level, it is generally sufficient for these written instructions to contain no more than basic details of emergency contacts.

Security related information exchange

419. Operators should cooperate with each other and with appropriate authorities to exchange information for applying security measures, and responding to security incidents.

Trustworthiness

420. Persons engaged in the transport of radioactive material may be subject to trustworthiness verification by the operator commensurate with their responsibilities.

4.3 Enhanced Security level

421. For packages of radioactive material with contents meeting or exceeding the radioactivity threshold for enhanced security level specified in Section 3, the following security measures in this section should be applied over and above those for the basic security level.

Carrier/consignor identification

422. In implementing national security provisions for shipments of radioactive material, competent authorities should establish a programme for identifying consignors or carriers engaged in the transport of radioactive material packages needing the enhanced security level for the purpose of communicating security related information.

Security plans

423. All operators (consignors, carriers, consignees), and other persons engaged in the transport of radioactive material packages needing the enhanced security level should develop, adopt, implement, periodically review as necessary, and comply with the provisions of a security plan. The security plan should include at least the

following elements and should be modified as needed to reflect the threat level at the time of its application and any changes to the transport programme:

- Specific allocation of responsibilities for security to competent and qualified persons with appropriate authority to carry out their responsibilities;
- Records of radioactive material packages or types of radioactive material transported;
- Review of current operations and assessment of vulnerability, including intermodal transfer, temporary transit (i.e. in transit) storage, handling and distribution as appropriate;
- Clear statements of measures, including: training, policies (including response to higher threat conditions, new employee/employment verification), operating practices (e.g. choice/use of routes where known, use of guards, access to radioactive material packages needing the enhanced security level in temporary storage, proximity to vulnerable infrastructure), equipment and resources that are to be used to reduce security risks;
- Effective procedures and equipment, for timely reporting and dealing with security threats, breaches of security or security incidents;
- Procedures for evaluating and testing security plans and procedures for periodic review and update of the plans;
- Measures to ensure the security of transport information contained in the security plan;
- Measures to ensure that the distribution of sensitive transport information is limited to maintain security of the information. Such measures should not preclude the provision of transport documents and consignor's declaration required by TS-R-1 [1]; and
- Measures to monitor the shipment.
- Arrangements to define the transfer of responsibility for the security of the package if appropriate.

424. A State should clearly establish responsibility for, and ownership of, the security plan. This will normally be the operator having direct responsibility for the security of the radioactive material in any particular mode or phase of the transport. In the event that transports are subcontracted, it may be appropriate to ensure that contractual arrangements exist to require the development of and compliance with a security plan.

425. Information required in a security plan under these provisions may be incorporated into plans developed for other purposes However, security plans will, almost invariably, contain information that should be restricted to those who need to know it for the performance of their duties. Such information should not be included in plans developed for other purposes and which may be disseminated more widely.

426. When developing security plans, operators should ensure that appropriate response plans (as described by *IAEA Safety Standards Series GS-R-2* [17] or appropriate guidance) are considered.

Advance notification

427. The consignor should provide advance notification to the consignee of the planned shipment, mode of transport, and expected delivery time.

428. The consignee should confirm ability and readiness to accept delivery at the expected time, prior to commencement of transport and notify the consignor on receipt or non-receipt within the expected delivery time frame.

429. The consignor, if requested or required, should provide advance shipment notification to the competent authority of any receiving or transit State. At this level, notification that may be required for security purposes may be developed from advance notification already required for other purposes.

Tracking devices

430. When appropriate, transport telemetry or other tracking methods or devices should be used to monitor the movement of conveyances containing radioactive material. This simple tracking system will be able to track when a shipment has departed, and whether the mode of transport has changed, the material has been placed in interim storage and the consignment has been received. This information about status changes should be readily available to the appropriate parties (i.e. carriers, shippers and operators). This tracking system may be as simple as a bar code system that provides package location/status information. The tracking system in conjunction with a communications system and response procedures will allow the operator and the competent authority to react in a timely manner to a malicious act, including theft of radioactive material.

Communications from conveyance

431. During transport, the carrier should provide, in the conveyance, the capability for personnel to communicate to a designated contact point specified in the security plan.

Additional security provisions for transport by road, rail and inland waterway

432. The carrier should ensure, for transport by road, rail and inland waterway conveyances, the application of devices, equipment or arrangements to deter, detect, delay and respond to theft, sabotage or other malicious acts of the conveyance or its cargo and should ensure that these are operational and effective at all times.

433. The operator should maintain continuous attendance of the road conveyance during transport where possible; when non-attendance is unavoidable, the road conveyance should be secured such that it complies with the principals of protection, detection and response and preferably in a well-illuminated area that is not readily accessible to the general public.

4.4 Additional Security measures

434. In certain circumstances, States should consider enhancing the foregoing base-line security measures in view of their DBT, their assessment of the prevailing threat,

or the nature of the material being transported. In such cases possibly relevant only to certain categories or quantities of radioactive material or to particularly sensitive transports, States should require some or all of the following measures to be applied. This list is not exhaustive.

435. Additional training, beyond simple security awareness, may be provided to persons engaged in the transport of radioactive material to ensure that they have the proper skills and knowledge for implementing specific security measures associated with their responsibilities;

436. Radioactive material carriers may be subject to a regime whereby their operations are licensed, their security procedures are subject to audit and their security plans are subject to formal approval and periodic review by the competent authority;

437. Automated and real-time tracking methods or devices may be required in order to permit a transport control centre to remotely monitor the movement of radioactive material conveyances and packages and the status of the material;

438. Persons engaged in the transport of radioactive material may be subject to formal national security clearance commensurate with their responsibilities;

439. Guards may be required to accompany certain transports to provide for continuous effective surveillance of the package/conveyance. In such cases it will be important to ensure that they are adequately trained, especially if they are armed, suitably equipped and fully aware of their responsibilities;

440. An evaluation of the potential for sabotage and associated radiological consequences of a package design with regard to its mode of transport may be required by the competent authority. This should be done in close consultation with safety specialists;

441. Prior to loading and shipment, appropriately trained personnel may be required to conduct a thorough search of the conveyance to ensure that it has not been tampered with in any way which could compromise security;

442. Special attention may be given to the procedures that address points where security responsibility is transferred and at inter-modal transfer points;

443. Consideration may be given to using conveyances that are specially designed or modified to provide additional security features;

444. The response plan may be reviewed to ensure an adequate response to any attempts directed towards theft, sabotage or other malicious acts. In particular, coordination with response forces should be reviewed to ensure an appropriate and timely response to an incident;

445. Appropriate exercises may be carried out in advance of a transport of radioactive material to ensure that contingency plans are adequately robust;

446. Personnel with specific security responsibilities may be provided with written instructions detailing their responsibilities;

447. Additional measures, consistent with national requirements, may be taken to protect the confidentiality of information relating to transport operations, including detailed information on the schedule and route. In addition, it may be appropriate to ensure that secure communications are used during the course of the transport and that, where available, such measures offer redundancy.

4.5 International shipment

448. For air transport, shipment should be carried in accordance with the applicable security provisions (Annexes 17 and 18 of the *Convention on International Civil Aviation* and the ICAO *Technical Instructions for the Safe Transport of Dangerous Goods by Air*). For maritime transport, shipment should be carried in accordance with the applicable security level provision of the *ISPS Code* and of the *International Maritime Dangerous Goods Code* as required with the *Intervention Convention of the Safety of Life at Sea* (*SOLAS 74* amended). These provisions should be supplemented by the guidance in this document.

449. Before an international shipment is undertaken, the originating State should make adequate provisions to ensure the security requirements of the receiving State and any transit States will be met.

APPENDIX I

Detailed considerations in setting recommended security levels

I.1. This appendix outlines the detailed development of the model used to identify the quantity of radioactive material required to produce the baseline consequence. The model is not intended to predict the effects of a radiological dispersal device (RDD) but to define the quantity of a radionuclide that could result in the need for resettlement or relocation from an area. ICRP 82, *Protection of the Public in Situations of Prolonged Radiation Exposure* [15] and IAEA emergency response guidance [16] provide recommendations on dose levels for actions to be taken following radiological accidents and are used as the basis for the reference dose in the model. This is a conservative measure of the severity of an intentional dispersal incident since it identifies when an area might be denied use.

Malicious use of radioactive material

I.2. Potential malicious acts involving radioactive material cover a wide spectrum of possible scenarios. The following events represent some broad categories of possible malicious acts with the potential to result in significant radiological consequences:

- Covert placement of unshielded material in working/living areas or street locations where the public might be externally irradiated.
- Sabotage of radioactive material packages or shipments with the subsequent release and dispersal of radioactive material in the environment.
- Capture of a radioactive material package or shipment and the subsequent dispersal of the material using conventional explosives. The main radiological consequences from such an event, i.e. an RDD scenario, include both near- and far-field effects. In the vicinity of the explosion (near-field) there may be radioactive shrapnel and larger pieces of radioactive material dispersed in the area and imbedded in persons, buildings, etc. and also general contamination from vaporized or finely divided material. Persons in the area may inhale vaporized or finely divided material and may be contaminated on their skin and clothes. There may also be a rising plume that disperses vaporized and finely divided material (far-field) resulting in contamination of the area and persons in the area, as well as doses due to inhalation as the plume passes.
- Capture of a radioactive material package or shipment and the subsequent processing (e.g. transformation into a more highly dispersible form) with subsequent dispersal of the radioactive material in the environment (RDD scenario). The time and resources required for this action would increase the likelihood of successful intervention by security forces so this scenario is considered less likely than others.

I.3. The radiological consequences arising from these types of radiological attacks are extremely variable depending on, for example, the type and nature of the event and type and amount of radioactive material involved. Since the RDD scenario may be very attractive for adversaries to cause harm and can be undertaken with unsophisticated capabilities, it is considered a likely scenario. The RDD scenario is also considered appropriate in respect of evaluating the potential radiological consequences of a malicious act involving different radionuclides.

Establishing security levels

I.4. Since the transport of radioactive material occurs within the framework of the transport of other dangerous goods, it is desirable to be as consistent as possible with existing security requirements and guidelines, particularly the *UN Model Regulations* and the international modal regulations. Additionally, since some radioactive material is also covered by the *Code of Conduct* with its supplementing guidance, CPPNM together with its Amendment and INFCIRC/225 rev.4 (corrected), it is also desirable to be as consistent as possible with these documents. The security levels included in this document have been developed with these considerations in mind.

I.5. Since transport operations vary widely in how they are carried out (full load, consignments of individual packages, etc.) it is necessary to clearly define the basis for specifying security measures. There are two feasible bases for specifying what should be subject to enhanced transport security measures:

- per package — enhanced security provisions would be applied when any package in a consignment exceeds the threshold value. There are operational benefits to this approach, such as not requiring carriers to keep a tally of the total activity on the conveyance. However, this approach may not provide an accurate measure of the potential harm that a single diverted conveyance could be used to produce (since multiple packages could be present on a single conveyance).
- per conveyance — enhanced security provisions would be applied when the total activity on a conveyance exceeds the threshold. This approach ensures that the total activity on a single conveyance will not exceed the threshold without requiring the enhanced security provisions. However, it would be difficult to implement operationally.

After lengthy discussions at several IAEA Technical meetings, no consensus could be reached and the ‘per package’ approach was chosen for the time being.

I.6. There are some packages of radioactive material containing such low radioactivity that they present low radiological hazards and low security risks (consumer goods, very small quantities of radionuclides, very low activity concentration material, etc.). Because of the very limited potential consequences that could arise from their use in malicious acts, excepted packages (as defined in TS-R-1, paragraph 230), and LSA-I (as defined in TS-R-1, paragraph 226) and SCO-I (as defined in TS-R-1, paragraph 241) that can be transported unpackaged (TS-R-1, paragraph 523) need not be subjected to transport security provisions above those ordinarily applied to a commercial shipment. The normal commercial controls applied to shipments of excepted packages are appropriate for their very low potential consequences if used in a malicious act.

I.7. For packages exceeding the radioactivity level allowed in excepted packages, the potential consequences of their use in a malicious act vary greatly (many orders of magnitude). However, in order to specify appropriate transport security measures, packages must be grouped on the basis of their potential consequences. A small number of security levels are desirable for simplicity, but a larger number of security levels make it easier to 'tailor' the security measures more precisely to the potential radiological consequences of the material. On the basis of the result of several consultants meetings and the Technical Meeting to Address Guidelines for Security in the Transport of Radioactive Material (TM-25898, October 2003), it was agreed that two security levels should be used for specifying transport security measures for packages containing more radioactive material than that allowed in excepted packages. The use of two levels allows the security measures to be specified as simply as possible while identifying packages that warrant either 'basic' or 'enhanced' security measures.

I.8. The use of two transport security levels means that some quantitative measure must be used to specify which level a package is assigned (that is, the dividing line). This can be done by defining a radioactivity threshold since the potential consequences of the contents of a package are based on the radionuclide and radioactivity in the package. The use of a single radioactivity threshold is also consistent with the *UN Model Regulations* approach to dangerous goods transport. This threshold defines the dividing line between 'high consequence' (*UN Model Regulations* terminology) radioactive material packages and other radioactive material packages (down to the level of excepted packages, LSA-I, and SCO-I which do not warrant security measures above prudent management practices).

I.9. This approach results in a total of three transport security levels for packages that, on the basis of their potential consequences, are subject to:

- **prudent management practices —** this level consists of excepted radioactive material packages and radioactive material defined as LSA-I and SCO-I that can be transported unpackaged. No additional provisions are recommended other than those control measures included in the BSS [3] and normal commercial practices.
- **basic security level —** consignments consisting of packages analogous to other dangerous goods subject to the 'General Provisions' for dangerous goods security in the *UN Model Regulations* (packages that are below the specified radioactivity threshold);
- **enhanced security level —** consignments that include at least one package analogous to 'high consequence' dangerous goods as defined in the *UN Model Regulations* (a package that is above the radioactivity threshold).
- In certain circumstances **additional security measures** may be considered by a State.

I.10. The transport security levels are illustrated in Figure 1.

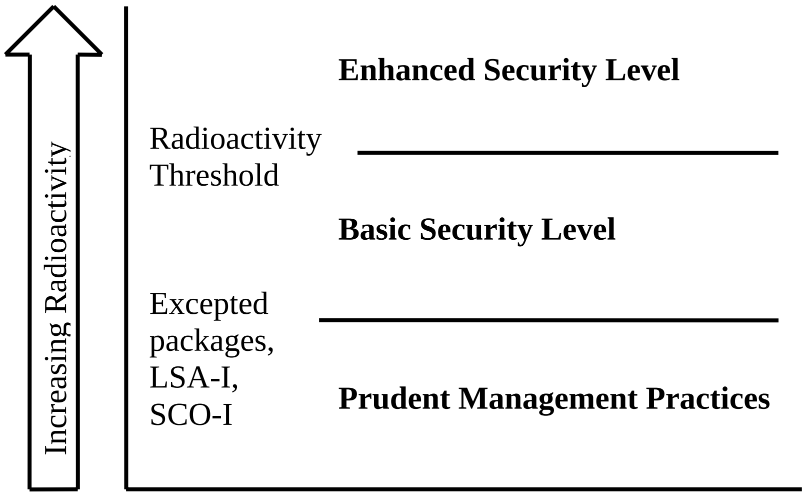

Figure 1. Incremental Transport Security Levels

Defining radioactivity threshold

I.11. In order to specify which packages should be transported under enhanced security measures, it is necessary to define the radioactivity level that would constitute ‘high consequence’ radioactive material.

I.12. Considerable analysis and modelling have been done to define a ‘dangerous source’ (see RS-G-1.9). This work identifies exposure scenarios and dose criteria used to define the quantity of a radionuclide that would constitute a danger to an individual (the ‘D’ value). A dangerous source is defined as one that could, if not under control, give rise to a severe deterministic health effect. A deterministic effect is a health effect of radiation exposure for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. A severe deterministic effect is one that is fatal, life threatening, or results in permanent injury that decreases the quality of life to an individual. The doses required to produce severe deterministic effects are much higher than the doses that are considered to cause stochastic effects (for which no threshold level of dose is assumed to exist and for which the severity of the effect does not increase for a higher dose, e.g. a cancer).

I.13. Since the intentional dispersal of radioactive material into the environment has the greatest potential to cause long term and widespread health, social, and economic consequences (relocation, resettlement, clean up, etc.) it was chosen as the basis for the model.

I.14. In order to apply the dispersal scenario quantitatively, a measure of the effects of such an event is needed. Since a radiological dispersal device (RDD) is not likely to cause massive immediate deaths and causalities induced by radiation exposure, this is not a good measure of consequences. Similarly, since the long-term health effects of an RDD will be mitigated by protective and remedial actions that may vary greatly, this is also not a good measure. An RDD is basically a ‘weapon of denial’ since it may result in the evacuation, relocation and resettlement of persons from an area. A measure of the effectiveness of an RDD should be based on the amount of denial that such as device can cause. If the population must be relocated or resettled out of an area, especially if they must be resettled permanently or for long periods of time until clean up is completed, then the device has been successful. Therefore, the model should be based on this measure of potential consequences.

Parameters for RDD scenario

I.15. Assessment and evaluation of the potential radiological consequences of an RDD require consideration of a number of processes involved in the dispersion of the radioactive material. A key consideration is the amount of radioactive material dispersed in the environment. This parameter can be characterized by the airborne release fraction (amount of material dispersed) and the respirable release fraction (RRF). The RRF is the fraction of material released in particles that are small enough to be inhaled (typically less than 50 µm). Particles in this size range are of particular interest since inhalation may be a significant exposure pathway for some radionuclides. These particles can be carried in a plume with resulting inhalation by persons in the plume, deposition onto the ground and other surfaces, and resuspension with subsequent inhalation at a later time.

I.16. The report of the consultancy meeting to Advise on the Development of Requirements for Security in the Transport of Radioactive Material, 21–24 October 2002, noted an RRF of around 10^{-5} for malicious incidents involving spent fuel casks subjected to high energy density device attacks. This was taken as a reasonable approximation for standoff attacks (rocket propelled armour piercing weapon or similar devices which are not easily defended against) on heavily shielded Type B packages. While smaller and less robust packages would release more of their contents, the fraction of material released from an act of sabotage would be less than that resulting from a dispersal action on the radioactive material itself.

I.17. Investigations (NUREG/CR-0743, Lange, et al 1994) [18] have shown that a wide range of RRFs (10^{-1}–10^{-3}) can result from the explosive fragmentation of radioactive material in solid form. Such an event can also result in distribution of approximately 10^2–10^4 solid fragments in an area of approximately 1 km^2. In such cases, cleanup of the fragmented material can be less difficult and time consuming than more finely divided particles.

I.18. Recognizing the range of possible airborne releases and RRFs, a release factor of 10% was chosen for use in a model of the potential effects of an RDD. This value represents a conservative estimation of the release fraction that would be widely dispersed, given the wide range in the type and nature of radioactive material being shipped in the public domain. For most material considered dispersible, an RRF of 10% would be a conservative estimate. [NUREG-1140, Nuclear Regulatory Commission, A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensee, US Nuclear Power Plants, USNRC, Washington, DC, 1988 and DOE-HP, US Department of Energy, DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Non-reactor Nuclear Facilities, DOE-HDBK-3010-94 (1994)]. All material that is released is assumed to be respirable so the release factor is the same as the RRF.

Modelling approach

I.19. There are several different ways that airborne dispersion of radioactive material can be modelled. The two most widely used methods and their advantages and disadvantages are:

- Planar uniform distribution model – with appropriate parameters this approach provides conservative results, is easy to understand, and is reliable.
- Dispersion model – this approach more closely models the actual distribution of contamination following a release but is dependent on assumptions about conditions present at time of release (meteorology, topography, intensity of blast, etc.).

I.20. The planar uniform distribution model has been used in many applications to assist in emergency planning and decision-making. Consequently, this approach was chosen to examine the possible effects of an RDD. Since the model assumes uniform distribution over a defined surface area, it is conservative in that it does not rely on predicting how the dispersion of material occurs. Comparisons of the results of the conservative planar uniform distribution model to contemporary airborne dispersion models (HOTSPOT and HPAC) confirms that the planar model is conservative (i.e. overestimates the consequences) yet provides acceptable results.

Radiological model

I.21. A model was developed by the Consultants Services Meeting on the Development of Guidelines for Security in Transport of Radioactive Material, 2–6 May 2005, for assessing the effects of radioactive material that is dispersed over a wide area, resulting in radioactivity being uniformly distributed over that area.

I.22. Land contamination clean up guidelines establish criteria to identify when intervention is warranted after a radiological event. Emergency preparedness guidance such as IAEA TECDOC-955 *Generic assessment procedures for determining protective actions during a reactor accident* [16] recommend criteria for when the general public should be relocated or resettled from the area contaminated by an event. These resettlement and relocation criteria are appropriate criteria to use when determining if an area has been sufficiently contaminated by an RDD for people to be removed (i.e. use of the area is denied). The ICRP 82 resettlement dose criterion of 1000 mSv/lifetime was selected since it was internationally accepted. This value provides a reliable measure of the severity of an RDD incident since it is a measure of when an area might be denied use.

I.23. The planar uniform dispersion model that was developed requires a number of parameters that must be specified. Building on previous applications developed by the IAEA to assess the emergency conditions following radiological accidents (TECDOC-955), several parameters were taken from that document. These include an occupancy factor and a building shielding factor for time spent indoors. By using the TECDOC-955 CF_4 factors (Procedure F2, Table F5), the long term dose conversion factors for deposition, it is possible to derive the radioactivity levels that — due to widespread dispersion — result in a dose meeting the resettlement dose criterion (i.e. the radioactivity thresholds).

I.24. For the size of the contaminated area, a value of one square kilometer is used. This represents a typical urban area with a population of about 10 000. This reference area of 1 km² is a conservative estimate in comparison with the size of a contaminated area predicted from sophisticated airborne release and distribution models.

I.25. With these starting assumptions:

Area	1 km^2
Release factor	0.1
Shielding factor	0.16
Occupancy factor	0.6

The following equation was developed to model the radioactivity required to cause the resettlement of the population from an area of 1 km^2:

$$A = \frac{D \times Area}{CF_4 \times RF}\left[\frac{1}{(OF \times SF) + (1 - OF)}\right] \times \frac{1TBq}{10^9\, kBq}$$

A = activity (TBq)

D = ICRP lifetime dose value (1000 mSv)

CF_4 = long term dose conversion factor for deposition ($\frac{mSv \cdot m^2}{kBq}$)

Area = surface area covered (10^6 m^2)

OF = occupancy factor (0.6)

SF = shielding factor (0.16)

RF = release factor (0.1)

Parameters that are automatically taken account by using the CF_4 factors from TECDOC-955 include:

- decay
- weathering
- surface roughness
- groundshine
- inhalation due to resuspension (with a resuspension factor of 10^{-6}).

Results of radiological model

I.26. Using a spreadsheet that incorporated the equation and parameters described above, the amount of radioactivity required to meet the dose criteria was calculated for a number of radionuclides. These activity values were compared with the D- and A-values described previously.

-

I.27. Recognizing that the *Code of Conduct* is being implemented by Member States, the approach embodied in the Code was examined to determine if it could be used for setting the activity thresholds for the radionuclides included in the Code. Reasonable correlation was found with 1000 D for beta/gamma emitters and 10 D for alpha emitters. Since a radioactive source containing 10 D is 10 times more dangerous than the reference "dangerous source" and is capable of producing severe deterministic effects, it was decided that a value of 10D should be used to define the enhanced transport security level for radionuclides included in the Code.

I.28. For radionuclides not included in the *Code of Conduct* another approach is needed for specifying the activity threshold. During the Technical Meeting, October 2003, Member States expressed a strong desire to specify the radioactivity threshold in terms of the traditional transport safety A-values. These values are calculated using the 'Q system' that has been incorporated in the *Transport Safety Regulations* for over 30 years (see TS-G-1.1, *Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material*).

I.29. The A_1 values are derived for special form (non-dispersible) radioactive material and the A_2 values are for 'other than special form' (dispersible) radioactive material. While the A-values are not based on exposure scenarios appropriate for representing the potential consequences of an RDD (they are derived from transport accident scenarios), the values are well ingrained in the transport community. Consequently, a multiple of the A-values was considered to be the desired way to express the radioactivity threshold. When the radionuclides covered by the *Code of Conduct* are taken out of consideration, the remaining radionuclides showed good correlation with a value of 3000 A_2 (since the A_2 value of a radionuclide never exceeds the A_1 value). Subsequently, it is recommended that for radionuclides not included in the *Code of Conduct*, a value of 3000 A_2 should be used to identify packages that are subject to the enhanced transport security measures.

Mixtures of radionuclides

I.30. For mixtures of radionuclides, determination of whether or not the transport security radioactivity threshold has been met or exceeded can be calculated by summing the ratios of activity present for each radionuclide divided by the transport security threshold for that radionuclide. If the sum of the fractions is less than 1, then the radioactivity threshold for the mixture has not been met or exceeded.

This calculation can be made with the formula:

$$\sum_i \frac{A_i}{T_i} < 1$$

Where:

A_i = activity of radionuclide *i* that is present in a package (TBq)

T_i = transport security threshold for radionuclide *i* (TBq)

Specification of the transport security threshold

I.31. To facilitate incorporation of the transport security measures, the following definition of 'high consequence' radioactive material is recommended:

1 3000 A_2 in a single package except for the following radionuclides:

Radionuclide	Transport Security Threshold (TBq)
Am-241	0,6
Au-198	2
Cd-109	200
Cf-252	0,2
Cm-244	0,5
Co-57	7
Co-60	0.3
Cs-137	1
Fe-55	8000
Ge-68	7
Gd-153	10
Ir-192	0.8
Ni-63	600
Pd-103	900
Pm-147	400
Po-210	0,6
Pu-238	0,6
Pu-239	0,6
Ra-226	0,4
Ru-106	3
Se-75	2
Sr-90	10
Tl-204	200
Tm-170	200
Yb-169	3

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, Safety Standards Series No. TS-R-1, IAEA, Vienna (2005).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Draft Fundamental Safety Principles, DS-298 [to be published].

[3] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

[4] UNITED NATIONS COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS, Recommendations on the Transport of Dangerous Goods — Model Regulations, Rep. ST/SG/AC.10/1/Rev.14, United Nations, New York (2001).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on the Physical Protection of Nuclear Material, Vienna (adopted 1979) +Amendment of 2005

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Physical Protection of Nuclear Material and Nuclear Facilities, INFCIRC/225/Rev.4 (Corrected), IAEA, Vienna (1999).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA, Vienna (2004).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Categorization of Radioactive Sources, Safety Standards Series No. RS-G-1.9, IAEA, Vienna (2005).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Physical Protection Objectives and Fundamental Principles, GOV/2001/41, IAEA, Vienna (2001).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidance on the Import and Export of Radioactive Sources, IAEA, Vienna (2005).

[12] IAEA Nuclear Security Series Document; Guidelines on the Security of radioactive Sources (to be published)

[13] IAEA Nuclear Security Series Document; Guidelines on the Security of radioactive Waste (to be published)

[14] IAEA Safety Glossary, http://www-ns.iaea.org/standards/safety-glossary.htm

[15] ICRP 82, Protection of the Public in Situations of Prolonged Radiation Exposure, ISSN 0146-6453, Annals of the ICRP, Vienna (1999).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic assessment procedures for determining protective actions during a reactor accident, TECDOC-955, IAEA, Vienna (1997).

[17] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, Safety Standards Series No. GS-R-2, IAEA, Vienna (2000).

[18] LANGE, F. et al. Experimental Determination of UO_2-Release from a Spent Fuel Transport Cask after Shaped Charge Attack, Institute of Nuclear Material Management (INMM), 35th Annual Meeting, Naples (FL), July 1994.

[19] IAEA Nuclear Security Series Document; Nuclear Security Culture (to be published)

[20] IAEA Nuclear Security Series Document; Guidance for the Development and Maintenance of a Design Basis Threat (to be published)

MEETINGS HELD TO PREPARE THIS PUBLICATION

1. Technical Meeting, 20-24 October 2003, IAEA Headquarters, Vienna
2. Consultant’s Meeting, 2-6 May, 2005, IAEA Headquarters, Vienna
3. Consultant’s Meeting 28 June – 1 July, 2005, IAEA Headquarters, Vienna
4. Consultant’s Meeting, 17-19 October, 2005, IAEA Headquarters, Vienna
5. Technical Meeting, 23–27 January, 2006, IAEA Headquarters, Vienna