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Optimisation of Protection in ICRP Recommendations – Broadening the Process

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ABSTRACT

The principle of optimisation has been described in several publications of the International Commission on Radiological Protection (ICRP), with the objective of keeping the magnitude of individual doses, the number of people exposed and the likelihood of occurring exposure, where these are not certain to be received, as low as reasonably achievable under the appropriate dose constraints, taking into account economic and societal factors.

A Task Group of ICRP Committee 4 has developed a report on the implementation of the optimisation principle. While this concept has remained relatively unchanged over time, its application has evolved considerably. Having begun as a process with its focus on quantitative techniques, mainly cost-benefit comparisons of protection options, the optimisation process is now viewed as a broader judgemental decision-making process. It should be based not only on quantitative, but also on qualitative approaches, to select the best protection approach under the prevailing circumstances. This reflects the increasing role of safety culture and stakeholder involvement in modern society. This view represents a consolidation of the Commission's recommendations concerning optimisation.

A basic requirement of the Commission's system of radiological protection is to optimise the level of protection achieved below source related dose constraints, whatever the exposure situation: normal, emergency and existing. The optimisation principle has been successfully applied in planned situations (specifically practices) where protective actions can be initiated already at the design stage. The Commission's intention is to extend this experience to the other two types of exposure situations.

The optimisation must be implemented through a on-going, cyclical process that involves the evaluation of the exposure situation to identify the need for action (the framing of the process), the identification of the possible protection options to keep the exposure as low as reasonably achievable, the selection of the best option under the prevailing circumstances, the implementation of the selected option through an effective optimisation programme, and subsequently a regular review of the exposure situation to evaluate if the prevailing circumstances call for the implementation of further protection actions. The lessons learned from a first cycle of the process provide input to next cycles when repetitive operations are performed, which is often the case in radiological protection.

INTRODUCTION

Optimisation of protection is one of the fundamental principles of the system of radiological protection since the 1970s. Its introduction in the recommendations of the International Commission on Radiological Protection (ICRP) was a direct consequence of the recognition of the so-called stochastic effects and the application of the linear, no-threshold (LNT) hypothesis. Although the concept has remained relatively unchanged over time, its application has evolved considerably. Having begun as a process with its focus on quantitative decision aiding techniques, mainly cost-benefit comparisons of protection options, optimisation has progressively evolved towards a more pragmatic approach including operational procedures and tools.

The Commission is currently revising its recommendations for a system of radiological protection. As part of this revision, a Task Group of ICRP's Committee 4 has developed a report on the optimisation of protection, taking into account the increasing role of equity, safety culture and stakeholder involvement in modern society.

This paper describes the key steps in the evolution of the optimisation principle over the last three decades, and presents the salient points of the latest developments regarding the principle in the revision of the recommendations. It also outlines some elements concerning their practical implementation.

THE ALARA PRINCIPLE

As long as the only known harmful effects of radiation were the deterministic effects, the limitation of exposure below the known thresholds for the appearance of these effects was considered sufficient to avoid any undesirable consequences of radiation. The introduction of the concept of optimisation in the ICRP recommendations in the 1950s was a consequence of the recognition, of the stochastic effects and the assumption that any increase in dose above the background dose can produce a proportional increment in the probability of incurring such effects, however small, without any threshold of dose (the LNT hypothesis). This led the Commission to adopt a prudent attitude and to recommend *"that every effort be made to reduce exposures to all types of ionising radiation to the lowest possible level"* (ICRP, 1955).

The adoption of this prudent attitude for the management of stochastic effects raised the issue of justification of the exposure. In a context of uncertainty, imposing a risk on a group of individuals is justified only if there is a clear societal benefit in return. Moreover, if an endeavour were to result in such a benefit, a second issue is how far one can reduce the risk and at the same time preserve the viability of the risk-causing activity. These considerations led the Commission to reword its first formulation and to recommend that: "all doses be kept as low as practicable and that any unnecessary exposure be avoided" (ICRP, 1959). This raised the issue of on which criteria to ground the decision.

Introduced in Publication 9 (ICRP, 1966), these criteria were described: *"As any exposure may involve some degree of risk, the Commission recommends that any unnecessary exposure be avoided, and that all doses be kept as low as is readily achievable, economic and social considerations being taken into account"*. It was also stated that the reduction of both individual and collective risk must be compared with the effort to achieve it. Therefore there was a need to quantify the risk and its reduction for the practical application of the principle. The adverb 'readily' was replaced by 'reasonably' in 1973 (ICRP, 1973).

In Publication 22 (ICRP, 1973), the Commission introduced the cost-benefit model and the monetary value of the man-sievert as quantitative decision aiding tools to achieve the optimised level of protection. For more than a decade, this model remained the underlying concept of all methodological and practical developments for incorporating optimisation into the management of public and occupational exposures. Quite soon, however, it appeared that the proposed cost benefit model, which mainly relied on the quantification of the avoided dose and the direct and indirect costs of the protection actions, was often inadequate to reflect the complexity of the exposure situations. This led to theoretical new developments concerning the use of multi-attribute analysis to better integrate social and other values (ICRP, 1983).

The Commission returned to a more pragmatic approach when it introduced the ALARA 'procedure' to assist operators in implementing ALARA (ICRP, 1989). This stepwise procedure aims at structuring the decision making process to identify and select the best protection options (Figure 1). The practical implementation of the procedure has greatly facilitated the diffusion of an ALARA culture, particularly for the management of occupational exposures.

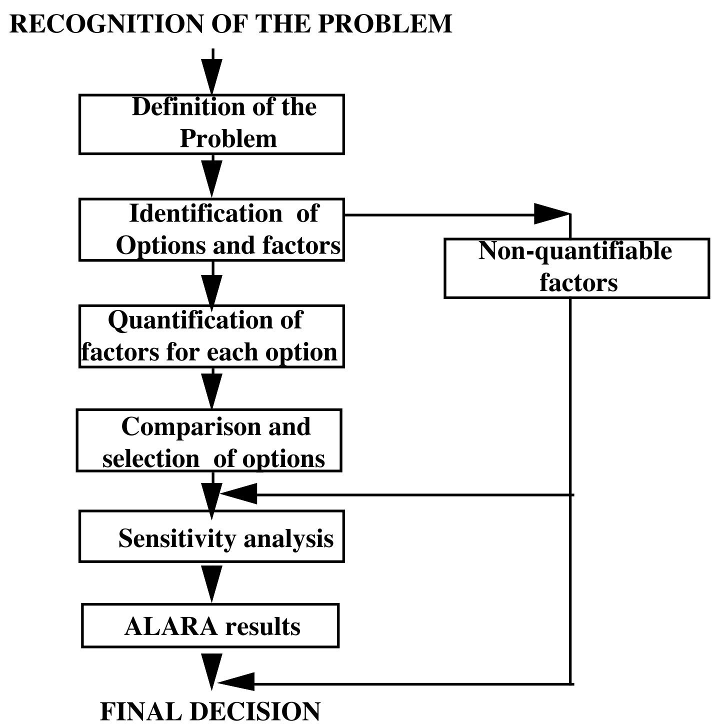

Figure 1. The steps of the ALARA procedure.

THE EVOLUTION SINCE PUBLICATION 60

In Publication 60 (ICRP, 1991), the Commission went beyond the strict cost-benefit model and emphasized the importance of informal processes and practical procedures to keep exposure as low as reasonably achievable. Moreover, the emphasis was placed on the equity issue raised by the uneven distribution of benefits and detriments in society. The optimisation of doses to a group of individuals must not be conducted in such a way that the risk is inequitably transferred to other groups or individuals (e.g., workers instead of the public, future generations instead of today generation, a worker or group workers instead of another etc.). To restrict such inequity the Commission introduced the concept of individual dose constraint serving as upper bound for the optimisation process. This is the concept, which has now become a corner stone of the new recommendations.

The respective roles of the principles of optimisation of protection and dose limitation were also defined in relation to the so-called tolerability of risk model (Figure 2). In this model, the limit is the upper level above which the individual risk is considered as unacceptable by society. Below the limit, the risk is defined as tolerable, and it is only when the protection is optimised that the residual level of risk is considered as acceptable.

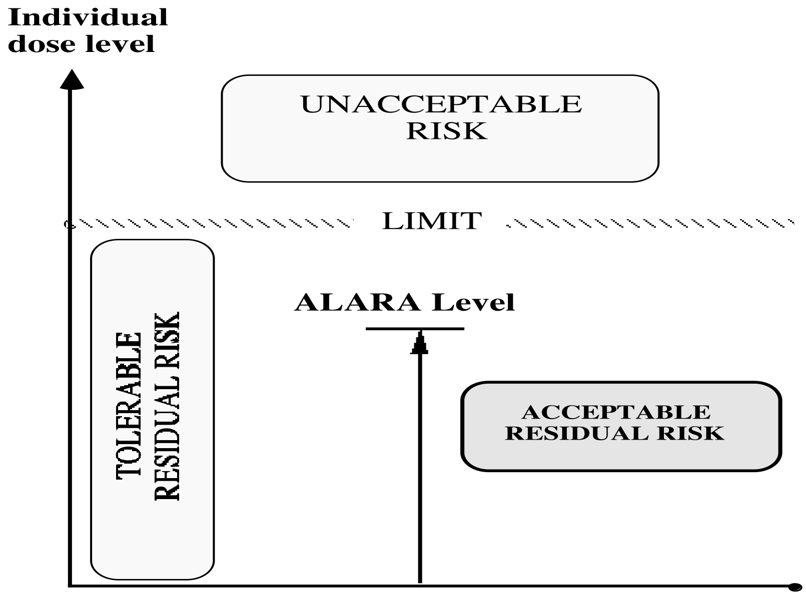

Figure 2. The tolerability of risk model.

Several ICRP publications during the 1990s emphasized the judgmental nature of the optimisation process and the need to go beyond the quantitative approaches developed earlier. This was more clearly stated in Publication 82 in which the Commission recognised the influence of the socio-political and cultural considerations in the final decision on the level of protection. As a consequence, the Commission anticipated that the decision making process *"may take into account attributes other than those directly related to radiological protection"* and *"will include the participation of relevant stakeholders rather than radiological protection specialists only"* (ICRP, 2000).

Following these considerations, analyses of practical experiences at the national and international level have allowed a better understanding of the challenges and benefits associated with greater stakeholder involvement in radiation protection decision making processes (NEA, 1998, 2001 and 2004). The Commission now considers the involvement of stakeholders to be an important input of optimisation, because it reinforces the safety culture and introduces the necessary flexibility in the management of the radiological risk that is needed to achieve more effective and sustainable decisions.

THE NEW ICRP PUBLICATION ON OPTIMISATION

In 2001, the Commission approved the formation of a new Task Group of Committee 4 to develop guidance on the principle and application of the optimisation of radiological protection. The objective of the Task Group was to review the principle of optimisation and the requirements for its implementation in relation to the revised ICRP recommendations. Particular attention was given to the role of individual dose constraints, the distribution of individual exposures, stakeholder involvement and application in regulation and operation. In 2005, the Task Group put a draft report for consultation on the ICRP website. A number of helpful comments were received, and a revised report was adopted by the Commission in March 2006 (ICRP, 2006).

The role of individual dose constraints is not defined precisely in the new document on optimisation, but it is developed in the draft 2006 recommendations. A key evolution of these recommendations is the abandoning of the distinction between practices and intervention and the application of the optimisation of radiological protection under a constraint – used previously only to control sources within practices – to all types of exposure situations. The concepts of practice and intervention have been replaced by three exposure situations:

- Planned exposure situations are every day situations involving the planned operation of sources including decommissioning, disposal of radioactive waste and the rehabilitation of previously occupied land. Practices in operation are planned exposure situations.

- Existing exposure situations are exposure situations that already exist when a decision on control has to be taken including background radiation and residues from past practices.

- Emergency exposure situations are unexpected exposure situations that occur during the operation of a practice, requiring urgent action.

In Publication 60, the Commission recommended for any source within a practice to keep the magnitude of individual doses and the number of people exposed as low as reasonably achievable, economic and social factors being taken into account (ICRP, 1991). It was also clearly stated that this process of optimisation should be constrained by restrictions on doses to individual so as to limit the inequity in the individual dose distribution associated with the source. This optimisation under a constraint is renewed for planned exposure situations, and is now also recommended for existing and emergency situations. This means that for all sources, for which a certain degree of controllability is conceivable, the relevant operators or authorities can set up individual dose constraints to be used as upper bounds for the implementation of the optimisation of radiological protection.

The Commission maintains the individual dose limits to restrict below the level of unacceptable risk, the total exposure to an individual resulting from all sources associated with planned exposure situations.

THE INVOLVEMENT OF STAKEHOLDERS

The involvement of stakeholders (i.e. parties who have interests in and concern about a situation) is seen as an important input to the optimisation process. It is a proven means to achieve the incorporation of values into the decision making process, the improvement of the substantive quality of decisions, the resolution of conflicts among competing interests, the building of shared understanding with both workers and the public as well as trust in institutions. Furthermore, involving all concerned parties reinforces the safety culture and introduces the necessary flexibility in the management of the radiological risk that is needed to achieve more effective and sustainable decisions concerning the optimised level of protection.

Generally, the operating management or a competent authority have clearly defined roles and responsibilities in the optimisation process. Other individuals and groups can also be considered as stakeholders. Examples include the exposed individuals (either workers or members of the public) or their representatives (trade unions or local associations), institutional and non-institutional technical support to the decision-making process (approved dosimetric services, qualified experts, formal technical services, public expert organisations, private laboratories), and representatives of the society, either by an elective process (elected representatives) or a participative process (environmental associations).

The extent of stakeholder involvement will vary from one situation to another. Depending upon the circumstances, it may not be necessary to involve all stakeholders, or types of stakeholders, in every aspect or phase of the optimisation process. Many radiological protection decisions will not be complex or socially contentious, and thus will not need broad stakeholder involvement.

Stakeholders may be particularly helpful for the identification of the attributes of the exposure situation and their relative importance, as well as for the identification of the protection options within the framing of the decision making process.

The involvement of stakeholders does not imply that operating management and/or authorities relinquish their responsibility to make the final decision, or their accountability for that decision. The responsibility for the final decision with respect to the adequacy of protection solutions lies with the operating management and/or the authority.

THE COLLECTIVE DOSE

The comparison of protection options is a key feature of the optimisation process, which must entail a careful consideration of the characteristics of the individual exposure distribution within a group of exposed population. One traditional way to characterise the distribution of individual exposures within groups for the purpose of comparing protection options in the optimisation process is by using the collective dose associated with this distribution.

In the case of occupational exposure, the collective dose is commonly used as a performance indicator to characterise the total exposure associated with the operation of installations over a given period of time or to a particular work. As doses are generally quite homogeneous, it is worthwhile to make use of the collective dose for the optimisation of radiological protection of the workers.

In the case of public exposure, the collective dose may be a useful input to the optimisation process when the individual dose distributions are relatively homogenous and well defined. However, when the exposures occur over large populations, large geographical areas, and long periods of time, the total collective effective dose (i.e. the summation of all individual exposures in time and space) is not a useful tool for decision aiding because it may aggregate information excessively and could be misleading for selecting protection actions.

To overcome the limitations associated with collective dose particularly for public exposure, the new ICRP publication on optimisation of radiological protection is proposing a new approach based on the so-called *collective dose matrix*. In this approach, each relevant exposure situation must be carefully analysed to identify the individual characteristics and exposure parameters that best describe the exposure distribution of the exposed population for the particular circumstance. Such an analysis results in the identification of various population groups with homogeneous characteristics to be considered within the optimisation process. In particular, a collective dose resulting from very wide range of individual doses should be disaggregated into a series of collective doses corresponding to homogeneous parts of the dose distribution (ICRP, 1997, 1998). The appropriate characteristics for defining the population groups corresponding to these doses must be made on a case-by-case basis according to the exposure situation (Figure 3).

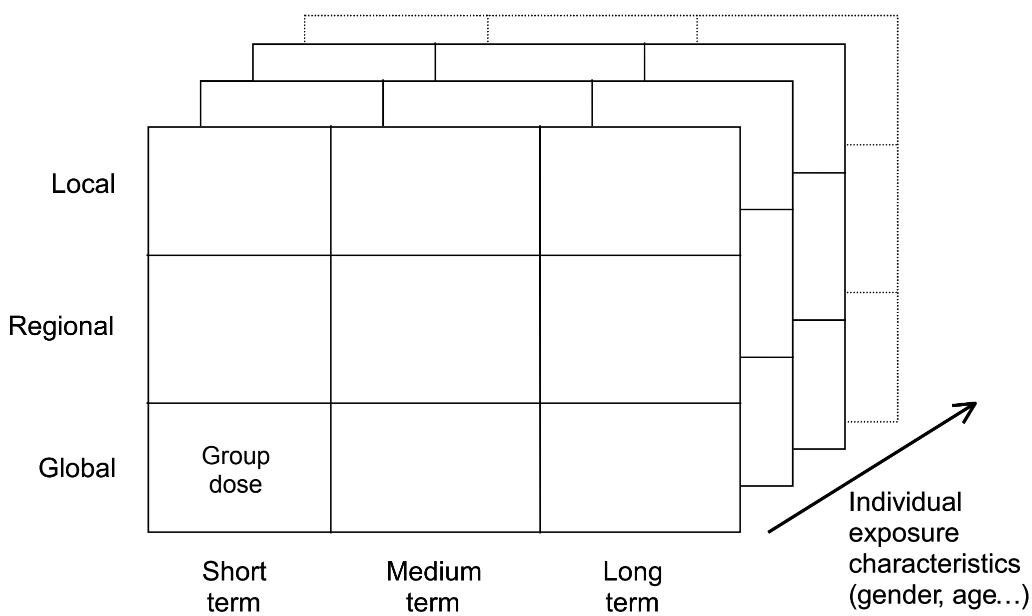

Figure 3. An example of a collective dose matrix (ICRP, 2005).

Each element of the matrix corresponds to a collective dose associated with a given group. Other characteristics, such as age, gender, socioeconomic categories or specific habits could be used in the matrix if judged relevant for the comparison of the protection options. The relative importance of each element of the matrix can then be weighted to reflect the economic and social considerations and values as well as the preferences of those involved in the optimisation process.

APPLICATION OF OPTIMISATION

Within the system of radiological protection both the operators and the appropriate national authorities have responsibilities for applying the optimisation principle. The implementation of the process of optimisation of protection is the responsibility of the operating management, subject to the requirements of the authority. Operating management makes decisions regarding the design, organisation, and ongoing implementation of the optimisation process. The authority promotes and may require optimisation as a way to reach the level at which licence to operate can be granted. It may also verify that optimisation of protection is effectively implemented during operation. The burden of proof of this implementation rests with operating management. The decision to authorise an exposure-causing activity, or the implementation of exposure-reducing measures and their implied residual doses, rests with the authority.

Commitment from all relevant parties, ranging from authorities to exposed individuals, to allow for an effective implementation of optimisation implies:

- Putting optimisation into regulation, willingness to enforce it, providing guidelines with proper balance between dialogue and control (Authorities);

- Defining a radiological policy, setting general goals, developing and adhering to procedures, delegating responsibilities, allocating means and resources, maintaining independence of radiological protection professionals from operation (Operating Management);

- Sharing information, maintaining vigilant attitude, training and retraining, and consciousness-raising in radiological protection (Individuals).

Procedures are necessary to clarify responsibilities for the implementation of the optimisation process. At the operational level, an organisational structure should be established to organise a dialogue between the professional disciplines involved in an operation, including co-ordinators, working groups, or committees, whether or not the resulting structure is dedicated solely to optimisation.

All aspects of optimisation cannot be codified; optimisation is more an obligation of means than of results. Except in cases of regulatory violation, it is not the role of the authority to focus on specific outcomes for a particular situation, but rather on processes, procedures and judgements. A strong dialogue must be established between the authority and the operating management. The regulation should provide guidelines designed to build such a dialogue. The success of the optimisation process will depend strongly on the quality of this dialogue.

TOWARDS IMPLEMENTATION

It is generally not the role of the Commission to develop methods and guidance and all the more so detailed procedures and tools for the implementation of its recommendations. This is done by international organisations like IAEA or NEA or expert bodies in the field of radiological protection.

There will certainly be new developments dealing with the way to involve stakeholders in the process and to make use in practice of the collective dose matrix (particularly in the case of protection of the public); furthermore there is a need to clarify and develop advice concerning the establishment and the use of dose constraints as a key part of the optimisation process.

With regards with the involvement of stakeholders, there are several ongoing activities to favour the engagement of the relevant stakeholders in radiological risk assessment and management. NEA has initiated an action to identify how the radiological protection authorities and experts bodies could structure themselves to favour the dialogue with stakeholders. The International Radiation Protection Association has also launched a series of international workshops to explore procedures and tools for the engagement of stakeholders in radiological protection. It may be expected that these initiatives, among others, will provide the professionals with adequate guidance and tools.

The European Commission has already sponsored a methodological work on the potential use of the dose matrix. In this study some of the issues involved in the development and use of such ‘matrices’ have been explored. In particular, practical issues regarding the disaggregation of collective doses in relation to individual dose rates and the temporal and spatial distribution of exposures have been addressed. Calculations have been undertaken to illustrate ways in which the estimated collective dose from routine discharges can be broken down.

For occupational exposure in nuclear installations, the operators have a long experience of setting dose constraints, either at the design or operation stages to support the implementation of the optimisation process. In some cases this result from a dialog between operators and the relevant authorities, but, most often it is an internal process, which relies on past experience and on an in depth analysis of the exposure situations. Dose constraints for protecting the public are generally established by regulatory bodies. In other domains related to industry (non destructive testing, NORM, etc.) and research, the use of the dose constraint is certainly less frequent for protecting the workers and there is a need to clarify the respective roles of operators and regulatory bodies. This will largely depend on the ability of the operators’ professional organisations to gather the relevant expertise. In the medical field, the development of reference levels for patient exposures by professional bodies in co-operation with the authorities appear to be a particular application of the dose constraint concept.

CONCLUSIONS

In its new draft the Commission has not drastically modified, neither the concept of optimisation of radiological protection, nor its role. There has an evolution and a consolidation of previous publications taking into account recent social evolution, particularly the increasing role of the stakeholders.

The optimisation of radiological protection remains the cornerstone of the radiological protection system proposed by the Commission to manage all types of exposure situations.

A fundamental key for the success of ALARA for reducing reasonably the radiological risk remains the development of a real, largely spread safety culture containing the ALARA concept. The acknowledgement that any level of exposure can induce a risk is the first incentive to ensure that all those involved in the optimisation process are accountable for its effective implementation. Furthermore, they should all adhere to a safety culture relying on their commitment, questioning attitude, and use of adapted tools and procedures.

An active safety culture supports the successful application of optimisation and both operational management and authority have essential roles in ensuring that such a culture is developed and maintained.

Finally the role of feedback experience exchange in improving the use of ALARA must be stressed as fundamental; therefore networks such as the European ALARA Network can play an important role in the successful implementation of ALARA in all European countries for all types of exposure situations.

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