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Advisory report on the justification for the use of full-body scanners

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1. INTRODUCTION AND ISSUE

In the aftermath of the foiled terrorist attack of late 2009[1] in an airplane from Amsterdam to Detroit, several countries announced their intention of fitting their airports with "full-body scanners". Other countries have, however, expressed their reservations on this subject.

At the international level, a great deal of attention is being devoted to the regulations and to the use of full-body scanners, mainly with the aim of detecting objects on passengers, whilst also considering broader applications. At the moment, there is certainly no general agreement over the use of full-body scanners.

At the European level, a group of experts (established under Article 31 of the Euratom treaty) drew up an overview of the situation in the different EU countries. Though full-body scanners were banned in Italy, a "backscatter" X-ray system is currently being used on a trial basis at Rome airport. In Germany, the Czech Republic, Luxemburg, France and Belgium, their use is not authorised at present. Poland is currently using a transmission system. The Netherlands and France are using systems based on non-ionising radiation.
In the Netherlands, these systems are used for certain destinations, including the United States (RISE, 2010 ; IARCS, 2010 ; EC, 2010 ; HERCA, 2010).

The Federal Agency for Nuclear Control (FANC) therefore expects that in the more or less near future, requests will be made for fitting Belgian airports with these scanners and possibly also other locations with an increased security risk, such as the buildings of the North Atlantic Treaty Organisation (NATO), the European Union (EU), etc.

In order to prepare for such requests, the FANC has submitted a proactive inquiry to the Superior Health Council (SHC) on the justification for the use of these devices. The FANC asks the SHC to examine the justification for deploying these devices, including those that do not rely on ionising radiation, as well as alternative techniques (sniffer dogs, pat- downs, etc.).

As regards the applications that use ionising radiation, the FANC also requests that particular attention be devoted to "doses to critical organs in critical subgroups of the population, such as the breast buds of very young girls". Should the SHC take the view that the use of these devices is justified, then the FANC requests that it should formulate the conditions (restrictive or not) under which these devices could be deployed.

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[1] Attempted terrorist attack of 25 December 2009 with chemical explosives hidden in underwear on Northwest Airlines flight 253 from Amsterdam to Detroit.

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In order to be able to respond to the request, an ad hoc working group was set up with experts on ionising and non-ionising radiation in the following fields: radiation protection, radiation dosimetry, risk analysis, genotoxicology, medical physics, nuclear measurements and safety culture.

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2. RECOMMENDATIONS

Despite the inquiry originally submitted by the FANC, the Council is not competent to decide whether or not groups of individuals should, in a particular situation, systematically undergo security screening. The justification for such a decision on the basis of international, national or local security considerations has to be provided by the competent authorities. Given the context in which this inquiry was made, the SHC therefore argues that the recommendations on this subject should be standardised on a European and/or international level.

It follows that the SHC does not focus on the macro-level justification in this advisory report, but, rather, on what it has itself pointed out as being the meso-level, i.e. on the issue whether " from a (physical and psychological) public health perspective, a particular type of technology may be implemented to carry out a security screening?"

The advisory report of the SHC will therefore only suggest important elements which the authorities will need to consider when making their decision. These elements concern the content of the notion "security", the aims of the technology, the types of application, its effectiveness and use, quality assurance, its health implications and adverse effects. It will also look at the psychological, ethical and legal aspects of this issue. The latter go beyond the scope of the questions submitted by the FANC and will only be discussed from a very general perspective.

Different body-scanning systems are currently being used. They involve the use of radiation of the electromagnetic spectrum: systems based on the "backscatter" X-ray method, systems that rely on the transmission of X-rays and systems that make active or passive use of millimetre waves.

1) When used correctly, "backscatter" X-ray systems entail but a low risk from radiation. Still, based on the variability of the doses reported on in the literature, the Council deduces that there is room for further optimisation, depending on the effectiveness required (implementation of the ALARA-principle – *As Low as Reasonably Achievable*). The applicant is therefore required to mention what are the possible consequences of a faulty system on radiation exposure and how they can be avoided in the justification dossier that is part of a potential request for authorisation.

2) The SHC advises against implementing X-ray transmission technology for the systematic general screening of large groups due to the greater exposure. The latter should only be authorised for individuals for whom there are serious grounds for suspicion.

3) (sub-)millimetre waves and THz radiation can have biological effects that are limited to the skin due to their weak penetration into the body. However, these effects were observed under less favourable conditions than the use of THz body scanners. It follows that it is very unlikely that exposure to radiation of the type used by full-body scanners should have any adverse health effects, including for specific groups such as individuals with a pacemaker and prostheses.

4) The SCH advises to follow up on and if possible to stimulate the development of the passive use of millimetre waves and devices based on the chemical analysis of swabs or air samples because these systems may entail smaller health hazards than those that make use of "backscatter" X-rays or active millimetre waves.

5) The SHC also argues that, in the event of the deployment of full-body scanners based on the use of ionising radiation, it should be mandatory to offer an alternative with equivalent effectiveness and which does not rely on ionising radiation, provided that such alternatives are available.

6) Moreover, the SHC advises that, in any event, all necessary guarantees should be sought, including those that concern appropriate training for the operators, written procedures and regular

quality controls for the device and that this should be monitored (in the authorisation requirements, if necessary).

7) The justification should not only assess the technology, but also its specific application. Thus, the advantages and disadvantages for each field of application of the technology (airport security, fight against theft in diamond mines, access to buildings, etc.) always fall to different groups. Similarly, it is usually one or several groups who profit from these advantages, whilst others have to face the disadvantages. These advantages and disadvantages may also be different in nature. It follows that the criteria and protocols that determine who should be screened, when and where, should always be included in the justification dossier for the application.

The Council points out that there is a lack of public data concerning the effectiveness of the different techniques used to screen for undesirable objects, which makes this justification all the more difficult.

8) The SHC also advises to verify, for each method and application, whether there is a potential additional risk for critical groups such as pregnant women, young women, babies, children and people with implants or other medical devices.

9) Psychological, legal and ethical issues play a crucial role in the debate over full-body scanners. Moreover, the SHC advises to demand guarantees as regards the right to privacy and physical integrity as well as the right to decline being exposed. There should also be proof that the scanning system is efficient enough for routine screening purposes. In addition, there should be an account of the manner in which the individuals to be screened will be informed about the nature and hazards posed by this procedure. Moreover, the Belgian Advisory Committee on Bioethics and the Belgian Privacy Commission should be requested for an advisory report on this issue to complement the SHC's own advisory report.

10) Finally, the SHC recommends that a "justification dossier" should be created for which this advisory report contains a few suggestions. Though such a dossier is not mandatory by law nor by the regulations that apply to applications relying on non-ionising radiation, the Council advises that such a dossier should be compiled in these cases as well.

3. ELABORATION AND ARGUMENTATION

List of abbreviations used

AFSSET	Agence Française de Sécurité Sanitaire de l'Environnement et du Travail
ALARA	As Low As Reasonably Achievable
ANSI	American National Standard Institute
BSS	Basic Safety Standards
EC	European Commission
EU	European Union
FANC	Federal Agency for Nuclear Control
HERCA	Heads of European Radiological protection Competent Authorities
HPA	Health Protection Agency
IACRS	Inter-Agency Committee on Radiation Safety
IEC	International Electrotechnical Commission
IRSN	Institut de Radioprotection et de Sûreté Nucléaire
ISO	International Organisation for Standardisation
NATO	North Atlantic Treaty Organisation
NCRP	National Council on Radiation Protection and Measurements
RGPRI	Règlement Général portant sur la Protection contre les Rayonnements Ionisants (general regulations aimed at protecting the population, workers and environment against the danger of ionising radiation)
RISE	Rising Pan European and International Awareness of Biometrics and Security Ethics
SHC	Superior Health Council

3.1 Methodology

This advisory report is based on a review of the scientific and grey literature as well as on the point of view of the experts.

3.2 Scope

The FANC expects that it will receive applications for the use of devices to screen individuals at checkpoints in the more or less near future. The FANC therefore submitted this request to the SHC. However, it broadened the scope of the inquiry by requesting that the Council's advisory report should also take into account alternative methods for screening for undesirable objects. As a result, the Council takes the view that there should be a brief account of the decision-making and justification process.

The decision-making process begins with putting on the agenda a societal issue and ends with the defining of a policy for tackling it. In the case at hand, there is a threat posed by certain individuals wishing to harm others and their property by using weapons or through other means. The decision made should be justified, i.e. the advantages to society of implementing the measures should ultimately outweigh its disadvantages. The justification will usually be an explicit component of the decision-making process.

A distinction should be drawn between different levels in the decision-making process mentioned above and thus in the justification for the political measures, which the Council refers to as the "macro", "meso" and "micro"-levels.

The macro-level is concerned with the basic assumptions on which to ground a policy for tackling the threat in question. After having gleaned information and analysed the threat, this policy may, for example, entail that all individuals who wish to travel by airplane or enter a particular "sensitive" building should be screened. It goes without saying that the SHC has no influence over such decisions. The use of a large-scale screening system and the prioritisation of its components go beyond the scope of the SHC's competence. This advisory report therefore does not discuss the macro-level, nor does it look at the justification for the basic assumptions behind such a policy.

The meso-level is concerned with the methods and technologies implemented to carry out the screening. The justification at the meso level may require the basic assumptions to be reconsidered. This is e.g. the case when it turns out that the screening procedure cannot be carried out or is unsafe for certain individuals for practical or ethical reasons. In such a case, a decision has to be made on access denial. The SHC's advisory report is mainly concerned with the justification at the meso-level and focuses on the technologies that rely on ionising and non-ionising radiation. The SHC also mentions other methods for carrying out security screenings, but does not provide a detailed analysis of them. In particular, the SHC expresses an opinion on the justification for certain practices in so far as they may have adverse effects on physical or mental health.

Finally, there is the micro-level. This concerns the screening of a given individual in a specific situation. The Council also devotes some attention to this level, but only to a limited extent.

As requested by the FANC, this advisory report not only looks at the use of full-body scanners in airports as a means of finding hidden objects and prohibited materials, but also discusses the more general issue of the potential use of these devices. With the justification for the implementation of screening methods for safety and security purposes not only involving considerations that pertain to the field of the health sciences, but also raising political and societal issues (including their justification at the macro-level), the SHC cannot deliver a general conclusive advisory report on the justification for the technology examined compared to alternative methods. However, this report does provide a description of the points of particular interest that are important to consider when assessing a justification dossier.

3.3 Overview of the methods that rely on radiation for full-body scanning

There are various imaging technologies that can be used to find hidden objects and suspect materials for security purposes (e.g. explosives or weapons). However, many of these applications are still at the research stage (e.g. the use of holographic imaging with terahertz (THz) radiation, ultrasounds, infrared, dielectric portals, quadrupole resonance analysis (RISE, 2010 ; Yinon et al., 2007). Several techniques have already been put on the market and are currently being implemented, including in airports, as a means of detecting suspect materials on individuals or in luggage. There are no or very few public data available regarding the effectiveness of these systems in detecting undesirable objects on individuals. There are systems available that rely on X-rays, i.e. the "backscatter" X-ray and X-ray transmission methods. Another technology uses millimetre waves (with a frequency between 30 and 300 GHz, wavelength 10 to 1 mm).

The electromagnetic spectrum below shows the range of frequencies and wavelengths for the various types of radiation.

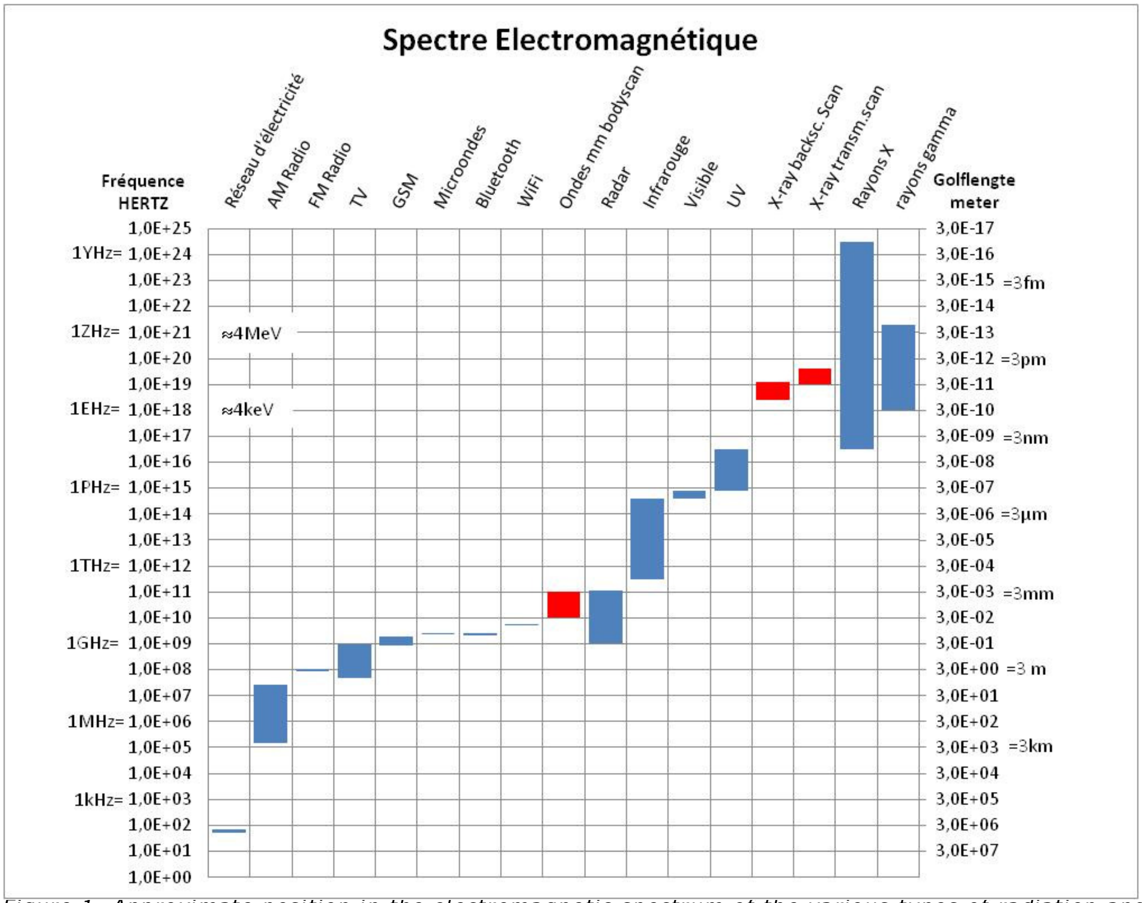

Figure 1. Approximate position in the electromagnetic spectrum of the various types of radiation and their applications. The ranges for full-body scanners that rely on millimetre waves and on X-rays are highlighted in red.

3.3.1 “Backscatter” X-ray method

“Backscatter” X-ray devices scan an individual's body by sweeping a "pencil beam" of X-rays with fairly low intensity and energy over it. This beam penetrates just a few mm to a few cm into light materials such as the body. The radiation that is reflected back (backscatter) is affected by the nature of the material onto which the beam falls. By measuring this backscatter, it is possible to generate an image of the objects on the scanned individual’s body. Details on the surface of that individual's body can also be visualised. Conversely, this technology does not allow to see what is inside the body.

During a typical scan (e.g. Secure 1000 Single Pose X-Ray System, Rapiscan Systems[2]), the flying spot on the screened individual’s body is approximately 8,5 mm x 8,5 mm large (IRSN, 2010). The high voltage of the X-ray tube is approximately 50 kV, which means that, after

[2] http://www.rapiscansystems.com/

filtration, the average energy obtained is about 30 keV. The tube current is 5 mA and the total scan time is around 3 seconds.

3.3.2 X-ray transmission systems

In units that rely on X-ray transmission, the scanned individual usually passes through a linear beam. Opposite the beam are detectors which are also placed in a straight line. This method corresponds to traditional X-ray imaging for medical purposes. Differing densities cause the beam to weaken to different extents, which makes it possible to see objects within the body as well.

These scanners use a high-voltage that is greater than that used for the backscatter system in order to scan the entire body, which means that the beam energy too is greater (approximately 140 – 220 kV and 0.1 – 4 mA) (Hupe & Ankerhold, 2007 ; IEC, 2010).

3.3.3 Active use of millimetre waves

Millimetre wave scanners rely on radio waves with a frequency just below the related sub-millimetre waves or terahertz radiation. Millimetre waves can only penetrate a fraction of a millimetre inside the body. Their photon energy is about one million times lower than that of X-rays and they do not cause any photo-ionisation in biological matter. However, they do penetrate non-conducting material such as clothing, paper, wood and brick, which means that it is e.g. possible to determine the contents of an envelope. By using two antennas that rotate around the body and the reflected millimetre radiation, a 360° model of the body can be reconstructed with which it is possible to visualize objects hidden within clothing. Many materials have a unique reflection spectrum, which also makes it possible to determine the nature of these objects (chemical composition) and thus to identify e.g. explosives.

3.3.4 Passive use of millimetre waves

The passive use of millimetre waves or terahertz radiation not only measures the radiation that is naturally emitted by all objects, and thus also by the human body, but also the radiation reflected by the body from the environment. Infrared photography is another example of this technology, albeit with a shorter wavelength. Devices that make use of this technique therefore do not produce any radiation themselves. This technology has already been commercialised and is implemented for public venue security. These systems produce a blurred image of the body, but hidden objects, whether metal or not, are clearly visible, especially if they are somewhat larger.

3.4 Overview of the alternative methods

3.4.1 Chemical analysis

When handling explosives, residue will always remain on the skin and clothing. Measuring devices have been developed with which these substances can be detected on these individuals, on a sample that was taken by wiping a swab over them or one collected from air that was vacuumed along them. These systems mainly rely on gas chromatography and come in two varieties: mass spectrometry or ion mobility spectrometry. Some of these measuring methods are still at the research stage. These methods are available as portable detectors or as security gates. Other known methods rely on chemiluminescence or electro-chemistry (Yinon et al., 2007). Yet, to date, these methods have lead to more false-positive or false-negative results than the other methods (Staubs & Matyjaszczyk, 2008).

3.4.2 Pat-downs

An alternative means of screening the surface of the body is the pat-down procedure, which is in this case performed by a security officer. This can be limited to a superficial search, as is often the case when the metal detector goes off in airports, but can, when there are serious grounds for suspicion, be enhanced to include a search of the body cavities. The possibility of implementing an intermediate procedure is currently being debated on in the United States, which would include both a superficial search and a search of "sensitive" body parts, in contrast to the superficial search that is being performed at the moment.

3.4.3 Dogs

Sniffer dogs, which are trained to detect drugs, are a well-known image in airports. They can also be trained to find explosives on individuals who have to be screened. It is hard to conceive how large groups of people could be screened by sniffer dogs whilst ensuring a smooth transit. Dogs do not appear to constitute an alternative to detect hidden objects such as weapons or knives.

3.5 Situation at the international level as regards full-body scanners that use X-rays

At the international level, a great deal of attention is devoted to the regulations and to the use of full-body scanners, mainly with the aim of detecting objects on passengers, whilst also considering broader applications. At the moment, the use of full-body scanners is by no means generally accepted.

At the European level, a group of experts (established under Article 31 of the Euratom treaty) drew up an overview of the situation in the different EU countries. Though full-body scanners were banned in Italy, a “backscatter” X-ray system is currently being used on a trial basis at Rome airport. In Germany, the Czech Republic, Luxemburg, France and Belgium, their use is not authorised at present. Poland is currently using a transmission system. The Netherlands and France are using systems based on non-ionising radiation. In the Netherlands, these systems are used for certain destinations, including the United States (RISE, 2010 ; IARCS, 2010 ; EC, 2010 ; HERCA, 2010).

The European Commission sent a communication to the European Parliament and the Council on the use of security scanners at EU airports (EC, 2010). What emerges from the Commission's communication is that many questions remain concerning the implementation of these systems and that alternatives to X-rays should be made available.

According to the current European *Basic Safety Standards* (BBS), the use of X-rays for non-medical purposes is authorised under exceptional circumstances only, provided that the security considerations prevail. There are, however, a few prior conditions: alternatives that rely on less ionising radiation have to be sought, an "informed consent" from the "users" is required and an alternative must be offered to anyone who expresses such a wish as well as to vulnerable groups such as pregnant women and children (p. 25: art 49 point f).

The current draft international BBS still lack some of these prior conditions. The text holds that, though the use of this technology is controversial, each country may decide on its own that the deployment of these systems is justified for security reasons.

HERCA (Heads of European Radiological protection Competent Authorities), which is an association of radiation protection agencies (to which the FANC participates), is also looking into this issue. This organisation has very recently published a statement that emphasises the need to abide by the principles of justification, optimisation and to implement dose limits when using full-body scanners that rely on X-rays (HERCA, 2010).

In the United States, the producers or full-body X-ray scanners are required to provide the authorities with evidence that their devices are safe. They can show that the use of the device abides by the American National Standard Institute and Health Protection Agency (ANSI/HPA) standard N43.17 (ANS, 2009). The basic principle is that the exposure of a given individual should not exceed an effective dose of 250 µSv over 12 months as a result of (repeated) screening.

In the light of the *National Council on Radiation Protection and Measurements* (NCRP) *Commentary No 16*, a distinction is drawn between systems for general use for which a reference effective dose is calculated that does not exceed 0,25 µSv per screening and systems for limited use for which the reference effective dose does not exceed 10 µSv (NCRP, 2003).

The systems for general use do not reach the limit (250 µSv) before 1,000 screenings or more within one year, which amounts to over two screenings a day, as is e.g. the case for the potential screening of crew members. According to the ANSI/HPA, it is unlikely that the reference effective dose limit (250 µSv) for adults should be exceeded as a result of being screened by means of these systems. Using these systems therefore requires but few administrative inspections. They can therefore be deployed without needing to keep track of either the number of individuals scanned or the number of scans per individual within one year.

Moreover, the standard holds that, for these systems with limited use (where the reference effective dose does not exceed 10 µSv per screening), administrative inspections and procedures are mandatory to show that, for each individual, the reference effective dose is under or equal to 250 µSv within one year.

The standard describes how the reference effective dose should be calculated, with this calculation being made for a reference adult. Thus, routine screening of children is unadvisable and should only be carried out after further analysis.

In addition, the ANSI/HPA describes the requirements for the construction and deployment of full-body scanning systems, including the providing of information to the staff and persons to screen, staff training, preventive maintenance, radiation measurements, documentation, registration and final dismantling.

The *International Electrotechnical Commission* (IEC) has also drawn up a standard for scanning systems that rely on X-rays [IEC62463] (IEC, 2010). This document sets the standard requirements and specifies what general characteristics, general test procedures, radiation properties, electric and mechanical characteristics are needed, what the impact on the environment and the safety requirements shall be. It also provides examples for methods that can be used to determine the dose to the full body or part of the body for each scanning procedure.

Given the discrepancies between the different national regulations and the international efforts made towards achieving more generally acceptable and accepted standards as well as the international context within which full-body scanners are mostly used, it would be preferable for these standards to result in European, or even international regulations.

3.6 Role of the SHC as regards the justification for full-body scans

As explained above, the SHC plays a meso-level part in the justification for full-body scans, more precisely as regards the justification that pertains to the use of ionising and non-ionising radiation. Its expertise is limited to showing their effect on physical and/or mental health.

The justification for an act implies that it offers an advantage to individuals and/or society and that these advantages outweigh the disadvantages, taking into account the distribution of the advantages and disadvantages among those concerned. This not only has to do with advantages and disadvantages that are quantifiable, but also those that are not. The responsibility for deciding whether or not a given act is justified goes beyond the scope of radiation protection and rests with the authorities. This is a strongly developed principle as regards the implementation of ionising radiation, as is apparent from the following quotation from the *Règlement Général sur la protection contre les Rayonnements Ionisants* (RGPRI, General Regulations aimed at protecting the population, workers and environment against the danger of ionising radiation), but can also be used for other applications (see section 3.1).

The RGPRI mentions the following as regards the justification: *Les différents types de pratiques impliquant une exposition aux rayonnements ionisants doivent, avant leur première autorisation ou leur adoption pour utilisation généralisée, être justifiés par les avantages qu'ils procurent, après avoir pris en compte l'ensemble des avantages et des inconvénients, y compris dans le domaine de la santé. A cet effet, une étude de justification doit figurer dans les dossiers de demande d'autorisation en application du présent règlement. L'autorisation accordée tient lieu de preuve de justification* (i.e. "The different types of practices that can result in exposure to ionising radiation should, prior to their initial authorisation or deployment for generalised use, be justified in terms of the advantages that they confer, after having taken into account all their advantages and disadvantages, also as far as health considerations are concerned. To this end, a justification study shall be included in the authorisation application dossier, in accordance with the requirements of these regulations. The authorisation granted serves as proof for their justification") (RD 20 July 2001).

At the Belgian level, the justification shall therefore take into account all the advantages and disadvantages, including the uncertainties and non-quantifiable advantages and disadvantages. The main advantage aimed at by full-body scanners is increased security for the population. Assessing the effectiveness and use of full-body scanners in enhancing physical security lies largely beyond the expertise of the SHC.

The justification should not only assess the technology, but also the specific application.
Thus, the advantages and disadvantages in each field of application of the technology (airport security, fight against theft in diamond mines, access to buildings, etc.) always fall to different groups.
Under given circumstances (museums, mines, etc.), it is sometimes one or several groups of individuals who profit from these advantages, whilst others have to face the disadvantages. These advantages and disadvantages may also be different in nature.

In view of these considerations, this advisory report does not pronounce upon the issue whether full-body scanner technology is justified or not, but suggests important elements to take into consideration for the final assessment. These elements pertain to the concept of "security", the goals and types of application, its effectiveness and use, quality assurance, health effects, side effects and psychological, ethical and legal aspects.

3.7 Previous advisory report of the SHC on this issue

In 2001, the SHC issued the advice that, for the time being, the authorisation for putting on the Belgian market a backscatter X-ray device should not be granted and that, in the meantime, the company concerned should be requested to submit a more extensive dossier in order to fill some of the gaps and be in a position to carry out an assessment. The SHC recommended that the company concerned should be required to submit a comprehensive justification dossier, clear exposure data based on sufficient scientific evidence, an account of the safety of the device itself and an adaptation of the dossier to the Belgian context and regulations. To the knowledge of the Council experts, this company has not submitted a new dossier.

3.8 Important elements for justification

Each justification dossier should at least devote sufficient attention to the following aspects, which will provide the authorities with sufficient data to decide whether or not the practice suggested is justified or not.

3.8.1 Goal of the application

A first element is the goal of the application, i.e. the content of the "security" concept. The first implementation that comes to mind for full-body scanners are anti-terrorist measures in airports. As mentioned in the inquiry submitted by the FANC, this technology can also be deployed under other circumstances and for other purposes. For example, it may be used to monitor the access to official buildings with increased security risk, ports, train stations or energy plants. Aside from anti-terrorism, financial considerations can prevail, e.g. the fight against theft in diamond centres or damage to artwork. In these situations, weighting the potential benefits against the health risks is more difficult.

For this element, it is therefore crucial to assess the magnitude of the risk or threat, whether the intended application allows to reduce it and, if so, to what extent, given the limitations of each method. The metal detectors find metals, the "backscatter" X-ray techniques detect superficial objects with characteristics that differ from skin, etc.

3.8.2 Types of application

The types of application are another important factor, given the fact that they also determine the number of scans performed. Who will be scanned? In airports: all passengers or a few passengers based on (what?) criteria, transit passengers, cabin crew, airport personnel? In large buildings: all members of staff, each time they enter and leave the building, all visitors? For some of these types of application, the number of scans performed on a single individual could reach a thousand a year, which would mean that e.g. the dose received through the "backscatter'" X-ray method would not longer be negligible.

3.8.2.1 <u>Effectiveness</u>

This factor concerns the reliability of the results obtained by using the device. Clearly, there is no single method that can be used for all screening purposes and a choice has therefore to be made. Security screening aims at authorising access to individuals who do not pose a security threat and detecting objects that do. The device will not be able to provide an absolutely definite answer on this subject. The settings chosen for the device and the interpretation of the image produced (automatic and/or by an operator) may lead to a number of false positive results (rejected despite there being no security threat) and false negative results (authorised despite there being a threat). On the whole, reducing the fraction of false negative results increases the fraction of false positive results, and vice versa.
Moreover, there is a lack of public data concerning the effectiveness of the different techniques used to screen for undesirable objects, which makes this justification all the more difficult**.**

3.8.2.2 Use

Use or efficiency is concerned with reaching a sufficient effect at minimal cost. What is the price tag for reaching the security level aimed at? This of course includes the cost of an effective system, but user friendliness, maintenance, quality assurance, flow and others also affect the cost of using the chosen technology.

3.8.2.3 Quality assurance

Given the prevailing uncertainties and risks when using a scanner and the considerable number of individuals involved, particular attention will need to be devoted to the method proposed at the technical and organisational level by the applicant/ user for quality assurance when assessing the justification for a specific application. Amongst other things, appropriate operator training, written procedures and periodical quality inspections for the device are of key importance (ISO9001, 2008). In the event of an authorisation being granted, the latter should impose the necessary conditions for inspections and quality assurance. Relevant sections of the ISO 9001:2008 and 17025:2005 standards may be used as guiding principles in this context.

3.8.3 Health effects

The health effects concern both somatic and psychological effects, as well as the uncertainty over this issue. The effects concern both individuals and the community, and involve both beneficial and adverse effects. The psychological effects include an enhanced sense of security, but also increased anxiety over potential long-term damage. The uncertainty resides in the fact that the damage involves an element of chance or risk (for example the risk of contracting cancer from exposure to ionising radiation) as well as the fact that the knowledge available is too scarce to make any health statements in certain areas (for example on non-ionising radiation).

3.8.3.1 "Backscatter" X-ray method

As regards the "backscatter" X-ray method, the effective dose (in which the local doses are converted into a corresponding dose to the entire body) to the scanned individual provides a measure for the radioactive load and the risk of cancer. Yet it is precisely this method that raises the question whether the local dose to the skin and the eyes does not require particular attention. The literature mentions effective dose values (amongst other things, depending on the settings chosen for the device) situated between 0,02 (McDonald et al., 2010) and 0,1 µSv (IRSN, 2010) received by scanned passengers (front and back). In terms of the effective dose, this amounts to the additional radiation load received within a few minutes during a long-distance flight, even if this load is sustained through another type of radiation and is distributed evenly over the body. In individuals working in the vicinity of these scanners without additional protection, the dose sustained is estimated to be 0,01 µSv per scanned individual (IRSN, 2010). If 500 individuals are screened each day, the annual dose for this worker would lie between 300 and 1,000 µSv a year (EC, 2010). This exposure is close to the dose limit for the general population. Though the risk is low, the variation in the scan-induced dose shows that there is room for optimising the dose. A faulty installation can have an impact on the health effects, which is why this too needs to be assessed.

For instance, if the pencil beam remains on the same spot during the entire procedure as a result of a malfunction, and, what's more, the operator performs several scans because he/she fails to get an image, the local radiation load can rise to a dose between 1 and 4 mSv per scan.[3]

[3] At an intensity of 5 mA and a normal exposure of 150 µs per point, the air absorbed dose at each point is between 0,05 and 0,19 µGy (IRSN, 2010). For a scan time of 3 seconds with a fixed beam, this yields an air absorbed dose between 1 et 3,8 mGy per scan over a surface of approximately 8,5 mm x 8,5 mm, which roughly corresponds to a (local) equivalent dose between 1 and 4 mSv.

Such dose values have to be avoided, especially for organs such as the thyroid gland, the eyes, the genitals and mammary gland. In case of malfunction, the high tension and current can also reach higher values, which can increase the effective dose.
Still, a recent theoretical risk analysis study does provide reassuring results for traveller exposure as regards the use of the "backscatter" X-ray method (Metha & Smith-Bindman, 2011). In any case, the precautionary principle needs to be abided by, as the exposure to various sources of ionising radiation can increase for a variety of reasons.

3.8.3.2 X-ray transmission systems

X-ray transmission systems use higher radiation energy and the effective dose values for passenger screening are said to lie between 0,1 and 5 µSv (EC, 2010). Especially for higher resolution scanners (2 to 5 µSv per scan), the annual dose limit for the general population may be exceeded for individuals who are frequently scanned.

3.8.3.3 Active use of millimetre waves

Millimetre wave technology relies on non-ionising radiation. The current systems use a frequency of approximately 30 GHz. There is a European recommendation that aims at limiting the power density of electromagnetic radiation in the range between 2 and 300 GHz to 10 W/m² for the general population and to 50 W/m² for the workers to avoid local heating of the skin (EC, 1999; 2004). The full-body scanners that are commercially available induce a power density that is much weaker (<1 mW/m²), which means that, based on current knowledge, no adverse effects from the millimetre waves used by full-body scanners are to be feared (AFSSET, 2010). Yet there remains uncertainty over other potential effects (apart from heating) of (sub-)millimetre wave technology. This type of radiation is strongly absorbed by water, causing it to penetrate just a few hundred micrometres into the body and restricting its effects to the skin. However, these biological effects have not been carefully studied yet. As a result, alarming reports are sometimes spread on this subject. Millimetre waves do not cause cancer themselves, and it seems rather unlikely that they should increase the risk of skin cancer and increase tumour growth (Ryan et al. 2000 ; Gallerano, 2004).

However, (sub-)millimetre waves can clearly have biological effects that are limited to the skin due to their weak penetration into the body (Wilmink et al., 2010). Yet, these effects are usually caused by long exposures to greater powers than those used for full-body scanners, which means that it is still believed that there is no hazard involved in exposure to millimetre waves used for full-body scans.

3.8.3.4 Passive use of millimetre waves

In the case of passive use of millimetre waves, the device emits no radiation itself, but measures the radiation emitted by the body or reflected by the body from the environment. It follows that the use of this technology is not expected to lead to any adverse health effects.

3.8.3.5 Alternative methods

The health effects of alternative methods probably do not concern somatic conditions as much as they do the psychological effects that are inherent to any screening method.

3.8.4 Side effects

Any technology can have (unintended) side effects. These effects may be financial (e.g. a drop or, on the contrary, an increase in the number of flights, less or more visitors in buildings liable to be targeted by terrorist attacks), societal (confidence in the authorities or others) or a combination of both. An example for these societal side effects are the increased possibilities of collecting information on individuals by linking the information obtained from the screening to personal data.

3.8.5 Psychological issues

The (negative and positive) psychological effects of the different screening methods need to be taken into account. They can differ from one individual to another. Thus, some individuals will feel less threatened by being screened by sniffer dogs or through chemical means rather than by full-body scans or pat-downs. Others will find the dogs highly threatening. Religious and cultural issues also affect the manner in which the screened individuals experience the scans. The psychological or psychosocial issues involved in the deployment itself of more or less extensive security screenings, regardless of their nature, belong to both the macro- and meso-levels, and therefore lie beyond the scope of this advisory report.

3.8.6 Ethical issues

Security screening, especially when it relies on advanced technology, mainly raises privacy concerns. Though for routine screenings, the necessary software is implemented to safeguard individual privacy, it is nonetheless often technically possible to examine, store and send original images and data. In addition, these privacy concerns may also be tainted by religious or cultural issues as well as the medical situation of the screened individual (prostheses, incontinence devices, amputations, etc.). There is also an ethical side to the factors of effectiveness and use. The individuals who will be screened have a right to clear, comprehensible information on the nature of the procedure and the potential risk it entails. They also have the right to decline being scanned if they consider the exposure useless and must be offered the possibility of being screened through alternative means that are acceptable to them and which provide the same results. The ethical issues are therefore an important factor that needs to be taken into account when deciding whether the use of a given full-body scanning device is justified under given circumstances.

3.8.7 Legal issues

There are quite a few legal issues that should be handled at the international level. They not only concern technical and radiation protection issues, but also the overall psychosocial and ethical context, privacy concerns, the storage of data, etc.

As far as compliance with the RGPRI is concerned, the use of full-body scanners that rely on X-rays does not deviate from the regulations that are currently in force. However, as far as worker protection is concerned, it can be argued that if systems that rely on the “backscatter” X-ray method are used correctly and the application dossier provides enough evidence that incidents will be avoided, the dose to the operators will be low enough for there to be no professional exposure.

4. Conclusions

The Council is not competent to decide whether groups of individuals should, in a particular situation, undergo security screening, be it systematically or not. The justification for such a decision on the basis of international, national or local security considerations has to be provided by the competent authorities. The SHC therefore argues that the recommendations on this subject should be standardised on a European and/or international level.

In this advisory report, the Council therefore does not focus on the macro-level justification, but, rather, on what it has itself pointed out as being the meso-level, i.e. on the issue whether “ from a (physical and psychological) public health perspective, a particular type of technology may be implemented to carry out a security screening?” In particular, this report reviewed the technologies that rely on ionising and non-ionising radiation. Though alternative methods were mentioned in the above, the Council has not been in a position to assess them, the data on the effectiveness and scope of these methods being unavailable. Moreover, there are not enough data on which to base an assessment of the effectiveness of radiation producing technologies.

As other international authorities have done before, the Council concludes that the X-ray transmission technology should be deployed with restraint for full-body scans. This should be done on the basis of solid arguments that support its significance both for individuals and for society as a whole.

When deploying the “backscatter" X-ray technology, the public health risks attendant on exposure to ionising radiation are smaller. However, the Council believes that, should this technology be considered justified in view of its significance to security, current data show that there is some room of optimisation by abiding by the ALARA-principle introduced in ionising radiation hygiene.

As regards technologies based on (sub-)millimetre waves (a type of non-ionising radiation), there are no direct indications that there are any health risks attendant on their deployment. However, this type of radiation can have real biological effects, which is why caution and care must be exercised when using it.

These issues will have to be dealt with in a “justification dossier” for which the Council has made a few suggestions. Though such a dossier is not mandatory by law nor by the regulations that apply to applications relying on non-ionising radiation, the Council advises that such a dossier should be compiled in these cases as well.

Moreover, the Council requests that there should also be attention devoted to the ethical concerns raised by the use of full-body scanners. The Council has formulated a few suggestions for providing a suitable response to these concerns. It is important to pay heed to the different cultures and religious beliefs, the individuals’ physical integrity and to guarantee the right to privacy.

Finally, the Council concludes that the justification at the meso-level examined depends on the situation, i.e. on the context in which these devices are deployed. Thus, the justification for using full-body scanners as an anti-terrorism measure in airports is different from that for using them to prevent damage to valuable artwork in museums. The advantages and disadvantages of deploying this technology are not the same in both cases, and therefore differ for the parties involved in each of these two situations.

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6. RECOMMENDATIONS FOR FURTHER RESEARCH

The consequences of exposing individual organs (skin, breast buds of very young girls, etc.) to radiation by performing a “backscatter” X-ray scan, especially with potentially faulty devices, do not appear to be known to date. A study on this subject could provide useful additional data.

There is a lack of data on the effectiveness of the various methods that rely on radiation or alternative methods in detecting undesirable objects. Should such data exist, then it would be advisable for them to be made public, at least to those who are tasked with assessing their justification. If they don’t, then studies on this subject would be useful.

7. COMPOSITION OF THE WORKING GROUP

All experts joined the working group in a private capacity. The names of the experts of the Superior Health Council are indicated with an asterisk*.

The following experts took part in drawing up the advisory report:

EGGERMONT Gilbert*	Radiation protection	VUB
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The working group was chaired by Mark LOOS , the scientific secretary was Katty CAUWERTS.

About the Superior Health Council (SHC)

The Superior Health Council is a federal body that is part of the Federal Public Service Health, Food Chain Safety and Environment. It was founded in 1849 and provides advisory reports on public health issues to the Ministers of Public Health and the Environment, their administration, and a few agencies. These advisory reports are drawn up on request or on the SHC's own initiative. The SHC takes no decisions on the policies to follow, nor does it implement them. It does, however, aim at giving guidance to political decision-makers on public health matters. It does so on the basis of the most recent scientific knowledge.

Apart from its 25-member internal secretariat, the Council draws upon a vast network of over 500 experts (university professors, members of scientific institutions), 200 of whom are appointed experts of the Council. These experts meet in multidisciplinary working groups in order to write the advisory reports.

As an official body, the Superior Health Council takes the view that it is of key importance to guarantee that the scientific advisory reports it issues are neutral and impartial. In order to do so, it has provided itself with a structure, rules and procedures with which these requirements can be met efficiently at each stage of the coming into being of the advisory reports. The key stages in the latter process are: 1) the preliminary analysis of the request, 2) the appointing of the experts within the working groups, 3) the implementation of the procedures for managing potential conflicts of interest (based on the declaration of interest, the analysis of possible conflicts of interest, a referring committee) and 4) the final endorsement of the advisory reports by the Board (ultimate decision-making body). This coherent set of procedures aims at allowing the SHC to issue advisory reports based on the highest level of scientific expertise available whilst maintaining all possible impartiality.

These advisory reports are submitted to the Board. Once they have been endorsed, they are sent to those who requested them as well as to the Minister of Public Health and are subsequently published on the SHC website (www.css-hgr.be), except as regards confidential advisory reports. Some of them are also communicated to the press and to target groups among healthcare professionals.

The SHC is also an active partner in developing the EuSANH network (European Science Advisory Network for Health), which aims at drawing up advisory reports at the European level.

In order to receive notification about the activities and publications of the SHC, you can send an e-mail to info.hgr-css@health.belgium.be.

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