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SPECIAL ARTICLE

X-RAY CONTROL OF BORDERS AND OF INTERNAL SECURITY

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***Objective*: Security control with X-rays means exposure to ionising radiation and creates the possibility of access to personal privacy. Internal security concerns the police and secret services. The used technologies and their possibilities are described.**
***Material and method*: Observations and additional information have been collected. The exposure dose has been measured.**
***Results*: Several technical set ups are in use: Transmission imaging (fluoroscopy), backscatter imaging, computed tomography and several combinations. The search of persons concerns the interior of the human body, its surface and the clothing together with the luggage. One looks for weapons, explosives and drugs. The exposure dose is low compared to the exposure dose by a flight or due to a holiday in a country with higher environmental radiation by external sources like Finland.**
***Conclusion*: In the future, the security control will increase. Using X-rays creates the possibility to inspect privacy.**

Key-words: Forensic radiology – Radiology at Large.

Background

A tourist travels for pleasure, a manager for money, a terrorist for attack. Travellers and carriers transport admitted and prohibited goods. Travel and transport can be the target of terrorist attacks; both can be part of the preparation of terrorist act. Travel and transport belong to our life and to our culture; they are part of the globalisation. Migration is another phenomenon of globalisation; it is together with terrorist attacks perceived as a threat and induces the urge of protection. Politics reacts and enforces border controls. There are multiple technologies which are employed which use X-rays for search for men, search of men and luggage; they aim to discover weapons, explosives, drugs and contraband. The exposure to X-rays means radiation risk, imaging with X-rays means opening up privacy to inspection. Airports are examples, where these applications are employed. It is intended to describe which technologies are in use, today.

Internal security concerns the police and the secrete services.

Material and method

Observations and descriptions have been collected. The principles and the technologic realisations have been analysed and evaluated. Personal collections of the operators and images provided from the manufactures have been reviewed. This became possible on the occasion of radioprotection project; for the German government the exposure dose in non medical X-ray exposures of humans was measured (1, 2). Examples will be displayed to demonstrate that this technology can contribute to security controls (3).

Methods of clinical radiology like simple radiographs and computed tomography are employed, furthermore, two methods adapted for control purposes: transmission imaging (fluoroscopy) (Fig. 1) and backscatter imaging (Fig. 2) (4, 5).

These two methods are also employed to control vehicles of different size; this includes containers, and covers also railway wagons, tank trucks and helicopters.

X-ray control of borders

Search of persons

The control of a person concerns the interior of the human body, its surface with the clothing, and the luggage. One looks for weapons, explosives and drugs. At the airports in some countries, the control of the passengers includes transmission imaging (fluoroscopy) combined with backscatter imaging, furthermore, computed tomography for

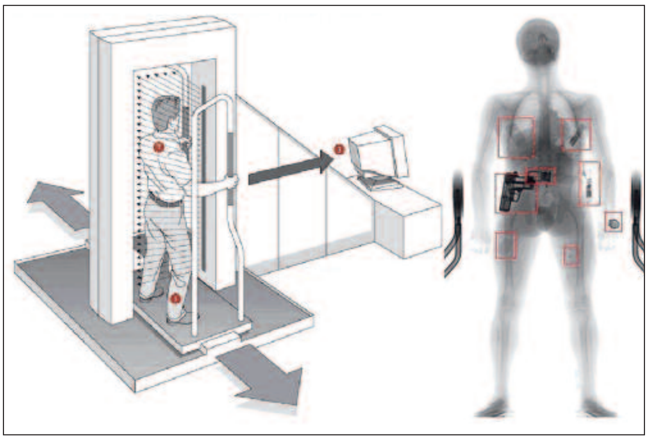

Fig. 1. — Transmission imaging (fluoroscopy). The image results of a scan: The person slides back and forth (1) for some seconds. A pencil beam (2) scans the person. This beam is adjusted to a line of detectors. The digitised image appears on a screen (3)*.

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accompanied and unaccompanied luggage. The manufacturers offer their equipment for controlling the access to commercial centres, national monuments (in the US: the Capitol and the Statue of Liberty), and the schools at risk of excesses of violence. The fear that a nuclear explosive device could enter the US hidden in a container has provoked the control of containers and of shipped palettes (5).

One consequence has been that by the control privacy is open to inspection by the controller (Fig. 3) and that societies have reacted thereupon.

However, the reason for control with X-rays remains the necessity to discover weapons, drugs and contraband (Fig. 4).

There are set ups which show persons practically naked; the image of a person can be displayed with a quality of a photo; this is especially valid for backscatter imaging equipment (Fig. 5).

However, embarrassing details may also be visualised with transmission imaging (Fig. 6).

Technical solutions exist which separate the display of weapons, explosives, drugs, and contraband from the visualisation of the person. Special software suppresses the person's traits and displays the recognised object. Furthermore, software has been developed which modifies the image of the human body and prevents the recognition of the controlled person (Fig. 5 and 7).

Luggage control

X-rays penetrate hand luggage, parcels and containers; they become transparent, dangerous objects

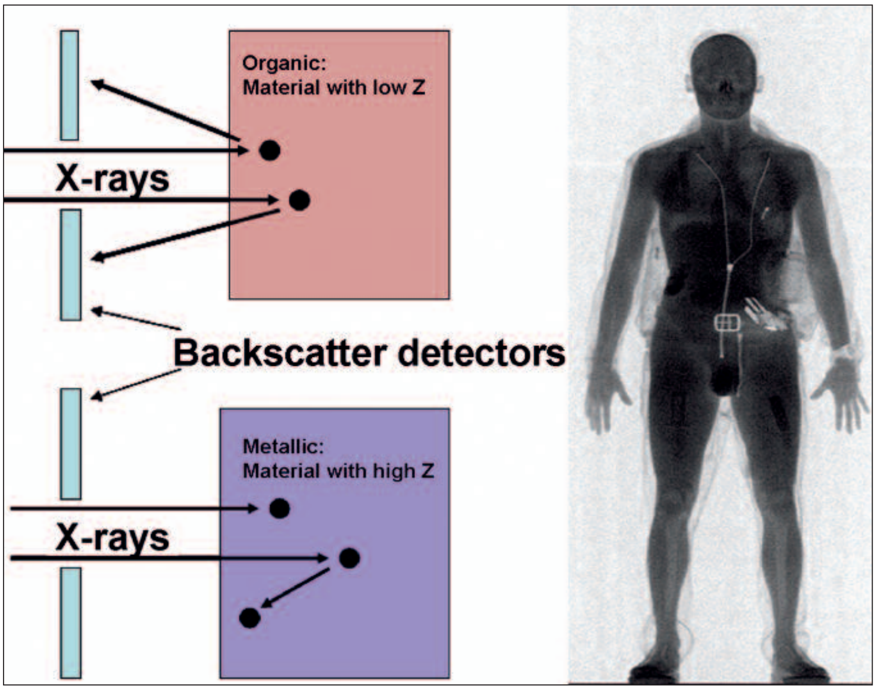


Fig. 2. — Backscatter imaging: The X-rays, which are scattered backwards are registered; they are employed to produce an image of the body's surface**.

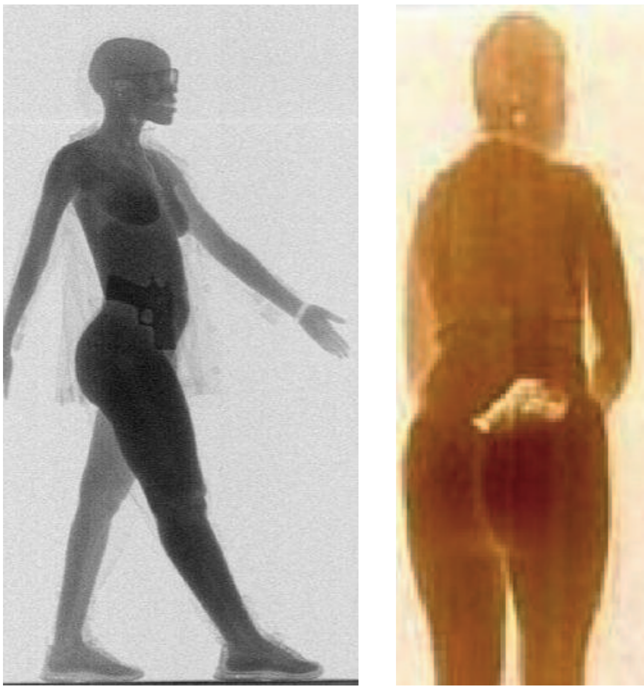


Fig. 3. — Backscatter images for demonstration: on the left a model with a pistol hidden under her clothing. On the right, a vice president with a pistol under her clothing – she was disappointed when she saw her image on the screen**.

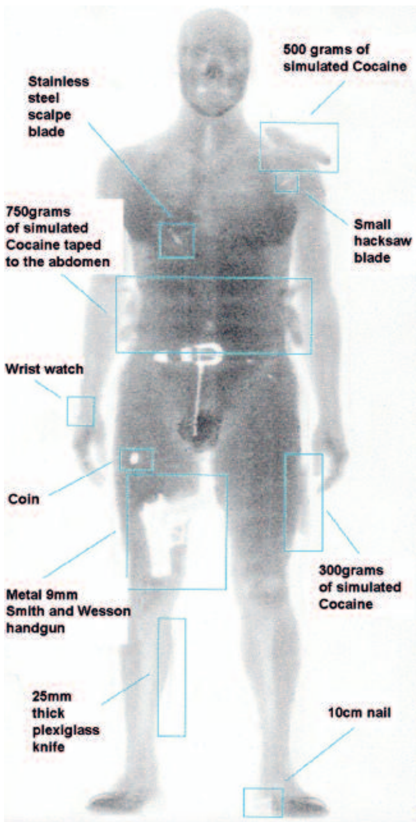


Fig. 4. — Weapons, explosives, and drugs visualised with X-rays. Backscatter image**.

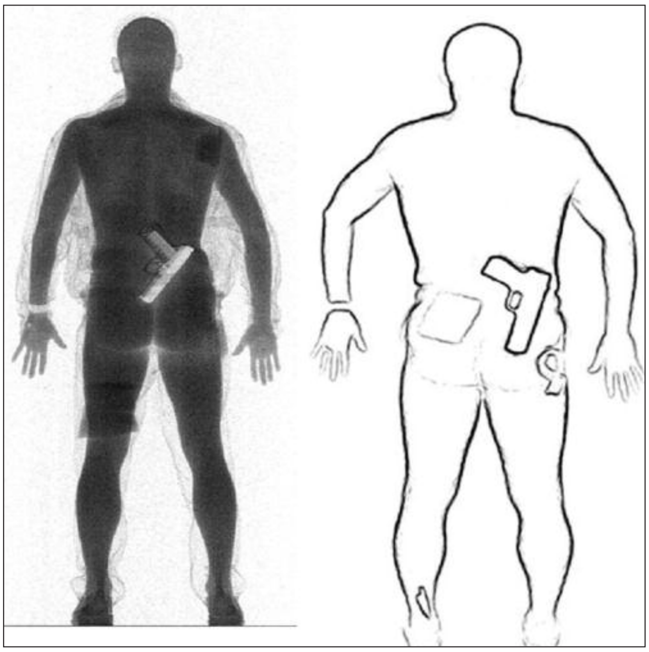


Fig. 5. — Pistol under the clothing. The displayed image shows the male-model practically naked. Backscatter imaging**.

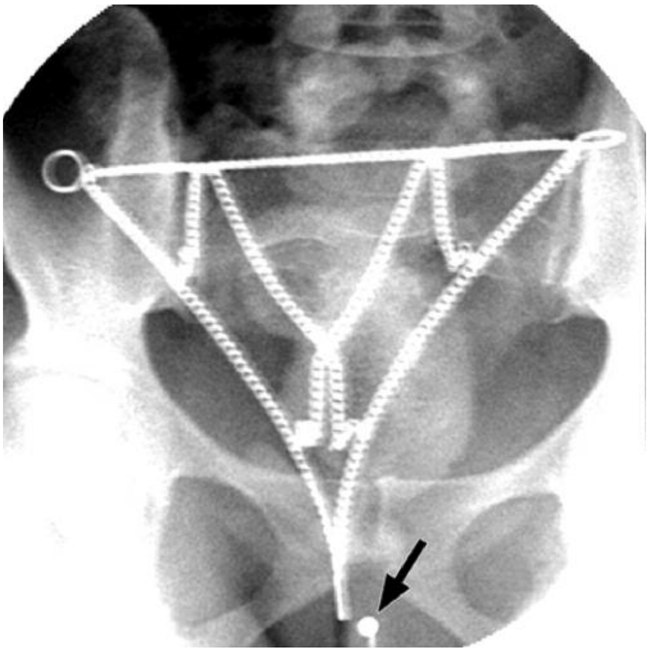


Fig. 6. — Pusher, drug parcel in the vagina. Sexy underwear and intim piercing (arrow). The drug courier intends deviating the controller's attention***.

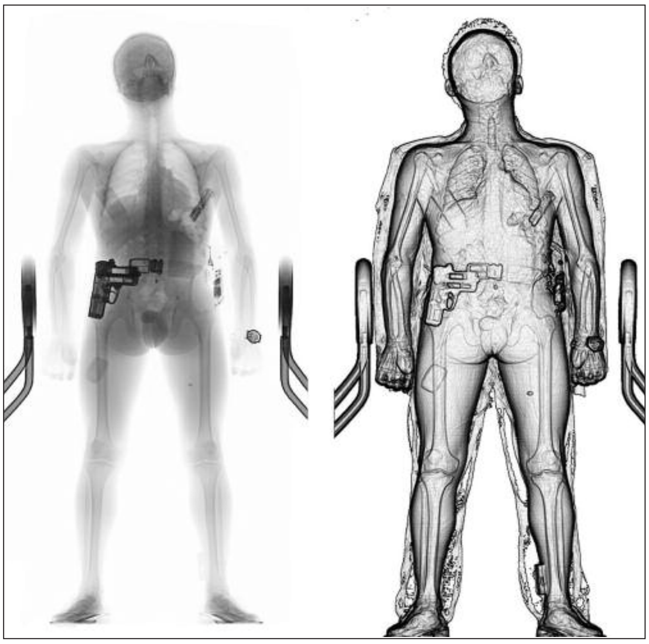


Fig. 7. — Alienation of the person's image combined with the recognition of a known object (pistol). Transmission imaging*.

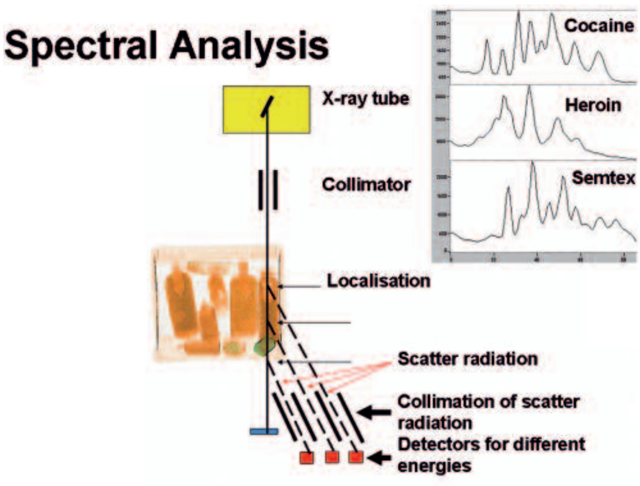


Fig. 8. — Combination of radio spectroscopy with localisation by another imaging method. The imaging shows and localises parcels in bottles. The registered spectrum is compared to those of a library for identification of the substance under suspicion.

become visible. The controller looks for weapons; he looks for an ignition device to identify explosives and bombs. The radiography shows details which may lead to the culprit. X-ray imaging allows inspecting the contents of suitcases, boxes, and containers without being noticed; without touching a person a firearm is recognised by its form, size and the density of its parts. Explosives and drugs are identified with double energy imaging and radio spectroscopy (Fig. 8) (6).

Employed methods are transmission imaging (fluoroscopy), backscatter imaging, double energy imaging, and computed tomography. Combination of different imaging methods exist (Fig. 9**) (4, 6).

Control of vehicles, containers and shipped goods

There are different technologies which are employed: Transmission images are obtained by using high

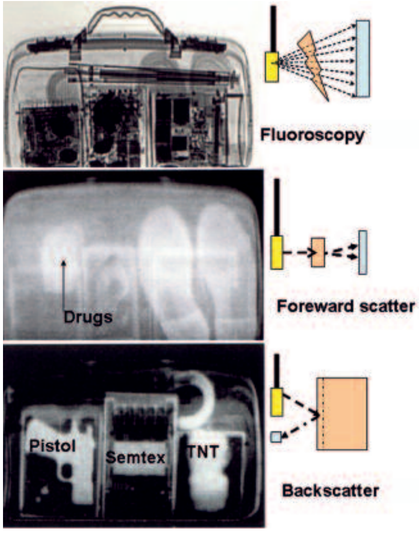


Fig. 9. — Same suitcase controlled with three different methods. The transmission image shows many details; however, superimposition limits the recognition of the essential.

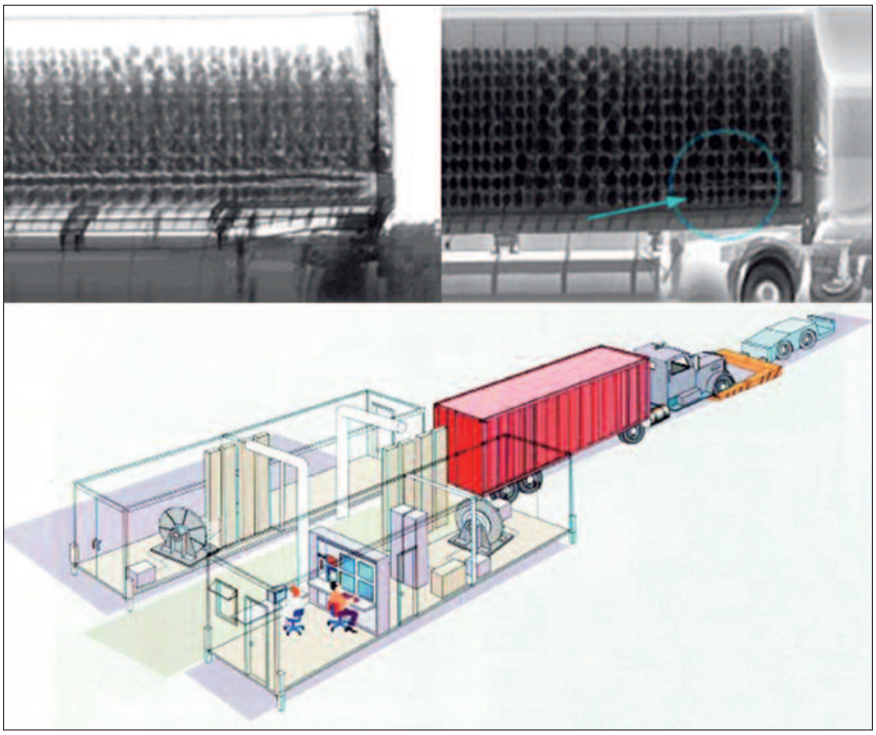


Fig. 10. — Truck control; combination of transmission imaging with backscatter imaging. Drugs (circle)**.

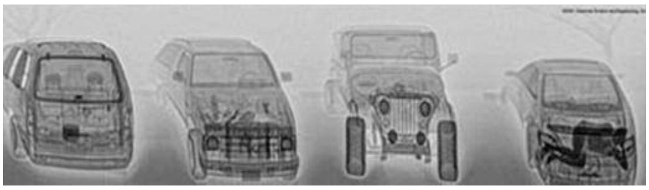


Fig. 11. — Person hidden in the trunk of a car. Backscatter imaging**.

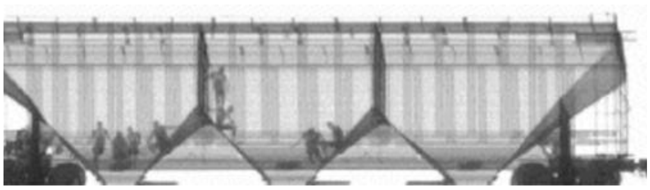


Fig. 12. — Economic refugees hidden in a railway coal wagon. Empty drive. Transmission imaging**.

energy ionising radiation produced with accelerators or liberated by radioactive substances like Cobalt-60 or Cesium-137; transmission imaging can be combined with backscatter imaging (Fig. 10) (5,7).

Illegal immigrants

Search for persons concerns autos (Fig. 11), trucks, containers and railway wagons (Fig. 12). Even helicopter control with backscatter imaging is possible (5, 8).

Secret services

In the former German Democratic Republic (GDR) the Ministry for State Security (Ministerium für Staatssicherheit, MfS, Stasi) was in charge of the internal security. At the border between the two German states, 17 out of 27 stations disposed of equipment for vehicle control with transmission imaging. Cesium-137 was used.

For pursuing suspected persons the Stasi employed different methods with application of a variety of radioactive substances applied in form of sprays, foils, and radiating needles. 50 to 70 operations were performed each year in the seventies and eighties of the former century. The marking of vehicles with Silver-110m may serve as example: A special projectile had been developed for an air gun; it contained a wire of Silver-110m; this projectile was placed into the tire of a vehicle with a shot; the design covered distances up to 25m.

After the fall of the wall in 1989, the Stasi destroyed the documents and the equipment; in consequence, our knowledge of the dimension of the use of radioactive material rests fragmentary. All the more, the Stasi, employed irradiating substances for marking passports, individuals, shoes, and clothing. The Stasi contaminated the floor to identify the participants of a meeting, and the pages of a manuscript of a dissident writer to identify the persons who transported it into the west. The Stasi had designed a special detection device for ionising radiation, which would be concealed under the clothing of the pursuing agent and which would indicate the radiation by vibration; a pursuit without intervisibility was possible (5, 9-11).

Discussion

Today, travellers are controlled with X-rays in Europe (Heathrow, and in 1998 at Charles de Gaulle), in Australia, and in North America at several airports. These controls mean exposure to X-rays and they have not to be confounded with controls employing millimetre waves being installed recently at Schiphol airport.

The control with ionising radiation allows visualising details, which are considered personal and, therefore, part of a person's privacy needing protection. A person's figure can be displayed practically naked on the control screen (3). Furthermore, radiographs displaying illegal immigrants hidden in trucks behind goods or in containers raise the question of human dignity. Public discussion and these observations pose the question of radiation exposure; frequently, this question indicates a feeling of discomfort more difficult to express. Our group has measured the exposure dose; it is lower than the additional dose received during a flight or during holidays in a country with a higher exposure dose due to radiation from natural sources like Finland (Table I) (1, 2).

The manufacturers have reacted; they have replaced the person's image by its silhouette (Fig. 5); furthermore, they have created the software able to identify suspicious objects. It seems realistic to expect that the visual control can be avoided in the future.

Scanning with X-rays offers the possibility to obtain biometric data, which can be compared to those contained in a library, in personal documents (passport), or in implanted chips. A plausibility check seems realistic; a cross dresser could be recognised. Height, sex, age could be deduced from a radiograph.

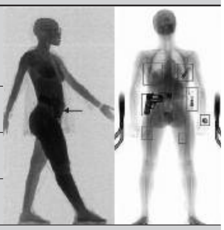
A combination of the person's control with that of its luggage is imaginable. Up till now, this has not been realised. It seems probable that such a possibility will be part of a discussion, if the analysis of a (future) terrorist attack leads to the conclusion that the attack could have been prevented by using such designs.

The control of persons and of goods has been initiated by terrorist attacks. Lockerbie, Richard Reid, and the World Trade Centre are landmarks. The attempt of Richard Reid, who tried to ignite explosive hidden in his shoes, induced shoe control; every passenger has to get out of his shoes to let them been X-rayed before being allowed boarding his flight to the US. The attack on the World Trade Centre induced luggage control with computed tomography. Today, politicians have reacted to the "Transatlantic Aircraft Plot" and prohibited carrying liquids in the hand luggage; in England, plans had been detected to compose liquid explosive out of different chemicals, which should be brought the airplane separated from each other (5).

It may be allowed predicting that future control will combine different methods. One may conclude that security technology has initiated a development, which is influenced and which influences politics and how society perceives a threat. It is apparent that the potential of radiology surpasses that realised in medicine.

It is probable that terrorist attacks with many victims would provoke the demand for this security technology. The border between privacy needing protection and the wish to be protected from terrorist attack will change in the future.

Table I. - Exposure dose, Hp(10), during flight, controls, and holidays (modified after 1 and 2)

	Hp(10) in µSv	
Backscatter imaging	***0,1***	
Transmission imaging	***6***	
Frankfurt - New York 7 hours	35	
Germany, external exposure natural sources	2100 µSv/year	40 µSv/week
Finland, external exposure natural sources	8000 µSv/year	150 µSv/week
Chest X-Ray	10-100	
CT 	8000-15000	

Conclusion

War against terrorism has created new conflicts. The individual feels threatened; airports and airplanes are sites where the threats may realise. In security control, several systems and technologies compete among each other. In the future, the number of security controls will increase. Time and costs will become a major issue. Automation will become an obligation. The control with X-rays has the inherent possibility to visualise a person's privacy, to show the person naked, and to inspect the interior of the human body. Even identification and authentification can be realised.

* Courtesy Compass Security, with permission
** Courtesy AS&E, with permission
*** Courtesy Algra PR – Medical Center Alkmaar, The Netherlands, with permission

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