Final Report

ITRAP

ILLICIT TRAFFICKING RADIATION DETECTION ASSESSMENT PROGRAM

Pilotstudie zur praktischen Erprobung von Grenzmonitorsystemen gegen Nuklearkriminalität

By Order of

Bundesministerium für Wirtschaft und Arbeit (Co-ordinator)

Bundesministerium für auswärtige Angelegenheiten

Bundesministerium für Inneres

Bundesministerium für Finanzen

Bundesministerium für Verkehr, Infrastruktur und Technologie

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AUSTRIAN RESEARCH CENTERS
SEIBERSDORF

INHALT

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The whole ITRAP team thanks to all border officers of the border site Nickelsdorf and Vienna Airport for their patience and kindly assistance, interest in our work and the outstanding co-operation during the ITRAP field exercise test program.

2. Zusammenfassung (Summary in German)

Die Thematik Illicit Trafficking in Nuclear Materials (Nuklearkriminalität) wird, bedingt durch die hohe Anzahl in Umlauf befindlicher radioaktiver Stoffe und die große Menge von spaltbarem Material, sowie insbesondere durch die Veränderungen der organisatorischen Infrastruktur zur Kontrolle dieser Materialflüsse in den Nachfolgestaaten der ehemaligen Sowjetunion zusehends mehr zu einem Problem. Die Datenbank der IAEA erfaßt derzeit mehr als 300 verifizierte Vorfälle. Das dadurch verursachte Gefährdungspotential erstreckt sich von möglichen Gesundheitsgefahren für die Bevölkerung über terroristische Aktivitäten bis zur Herstellung von Kernwaffen. Neben den primär kriminellen Ursachen zeigt sich die illegale Entsorgung radioaktiver Strahlenquellen als Altmaterial, Schrott und dergleichen als ein weiteres Problem, was in der Vergangenheit bereits zu schwerwiegenden Unfällen mit Todesfolgen geführt hat (z.B. Goiana, Mexiko). Wie die vorliegende Studie ITRAP (Illicit Trafficking Radiation Assessment Program) bestätigen konnte, mehren sich auch in Österreich die Fälle teilweise erheblich kontaminierter Schrotttransporte aus Nachbarländern. Verschiedentlich wurden bereits in einzelnen Staaten isolierte Gegenmaßnahmen gesetzt (z.B. Grenzschutzmonitoring an der finnisch - russischen und deutsch – polnischen Grenze, Grenzschutzmonitoring in Italien).

Die internationale Atomenergiebehörde (IAEO) hat durch die Schaffung eines neuen Programmes zur Bekämpfung der Nuklearkriminalität auf diese aktuelle Problematik reagiert und die Durchführung einer Pilotstudie zur praktischen Erprobung von Grenzmonitorsystemen angeregt. Koordiniert durch das Bundesministerium für Wirtschaft und Arbeit, finanzierte ein Konsortium aus fünf verschiedenen Ministerien:

- *Bundesministerium für Wirtschaft und Arbeit (BMWA)*
- *Bundesministerium für Inneres (BMI)*
- *Bundesministerium für Finanzen (BMF)*
- *Bundesministerium für auswärtige Angelegenheiten (BMAA) und*
- *Bundesministerium für Verkehr, Infrastruktur und Technologie (BMVIT)*

die Erstellung der Pilotstudie ITRAP (Illicit Trafficking Radiation Detection Assessment Program) durch die Austrian Research Centers Seibersdorf (ARCS).

Ziel der ITRAP - Studie war es die technischen Voraussetzung und die Machbarkeit für ein sinnvolles Überwachungssystem an Grenzübergängen zu erarbeiten. Die Ergebnisse sollen von der IAEO als internationale Empfehlungen für derartige Überwachungssysteme den Mitgliedsstaaten angeboten werden.

Die ITRAP - Studie wurde von September 1997 bis September 2000 durchgeführt. Nach einer Vorauswahl der Geräte und umfassenden Laboruntersuchungen im Forschungszentrum Seibersdorf wurden die ausgewählten Systeme an der Grenzstelle in Nickelsdorf, sowie am Flughafen Wien installiert. Die praktische Erprobung der Geräte bestätigte, dass die Grenzkontrolle von nuklearem und anderem radioaktiven Material mit vertretbarem Aufwand zuverlässig möglich ist. Jedes Gerät war online mit dem Forschungszentrum Seibersdorf verbunden und konnte so permanent durch Experten überwacht werden. Durch ein entsprechendes Trainingsprogramm wurde das Grenzpersonal mit den Messgeräten vertraut gemacht. Die ständige Ruferreichbarkeit von Seibersdorf stellte sicher, dass selbst bei unvorhergesehenen Vorkommnissen ausreichende Fachunterstützung zur Seite stand. Neben dieser praktischen Eignungsprüfung der Geräte durch die Anwender war die Erarbeitung eines einheitlichen Verfahrensablaufes ein wesentliches Ergebnis.

3. Summary

Illicit trafficking in nuclear materials (nuclear criminality) has become more and more a problem, due to the circulation of the a high number of radioactive sources and the big amount of nuclear material, particularly, caused by the changes of the organisational infrastructures to supervise these material within the successor states of the former Soviet Union. The IAEA data base counts at present more than 300 verified cases. The endangering cased thereby ranges from possible health defect for the publication to terrorists activities and production of nuclear weapons. In addition to the primary criminal reasons the illegal deposal of radioactive sources as salvage, scrap and others show a further problem, which has lead to severe accidents and lethal effects in the past (e.g. Goiana, Mexiko). As the study ITRAP (Illicit Trafficking Radiation Assessment Program) can show, also in Austria the cases of partly considerable contaminated scrap transports from neighbouring countries exists. Some countries have already under taken countermeasures (e.g. Monitoring at the Finnish-Russian and German-Polish border, border monitoring in Italy).

The International Atomic Energy Agency (IAEA) has reacted on this actual problem by setting up a new program to fight against nuclear criminality and has suggested a pilot study for the practical test of border monitoring systems.

Co-ordinated by the *Bundesministerium für Wirtschaft und Arbeit* a consortium of five different Austrian ministries:

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- *Bundesministerium für Verkehr, Infrastruktur und Technologie (BMVIT)*

financed the pilot study ITRAP carried out by the Austrian Research Centers Seibersdorf (ARCS).

Aim of the study was to work out the technical requirements and the practicability of an useful monitoring system at border crossings. The results of the study will be offered by the IAEA to the member states as international recommendations for border monitoring systems.

The ITRAP study was carried out from September 1997 to September 2000. After a pre-selection of equipment and comprehensive lab tests at the Austrian Research Centers Seibersdorf the selected systems were installed at the border site Nickelsdorf and at the Vienna Airport. The practical tests of the instruments showed, that the border monitoring of nuclear and other radioactive material, is possible with acceptable expense, according the worked out minimum requirements for such systems. Each system was online remote linked with the Austrian Research Centers Seibersdorf and could therefore be permanently checked. Border guards have been acquaint with the instruments by recurrent, appropriate training. The permanent call-stand-by of the Austrian Research Centers Seibersdorf assured that even in unforeseen cases sufficient expert support was available. In addition to the practical tests of the instruments by the users the workout of a standardised course of the inspection procedure was an important result.

4. Introduction

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The ITRAP study is an international laboratory and field test site exercise for gamma and neutron radiation detection instruments and monitoring systems at border crossings. The ITRAP study is not an intercomparison study. Participating companies were invited to exchange experience and worked together within working groups on requirements for appropriate equipment for border monitoring.

Co-operating partners of ITRAP was also a team of IAEA experts. Further more the Illicit trafficking program was supported by WCO and INTERPOL.

International suppliers and manufacturers of nine different countries as *Austria, Belarus, Canada, France, Germany, Russia, Sweden, UK, USA* participated initially the ITRAP study:

23 Companies

AEA Technology
ASPECT
Barringer
Berthold
BICRON RMP
BITT
Constellation Techn.
ESM
EURISYS MESURES
Exploranium
GBS Elektronik
Hörmann
Klimonitors
MGP instruments
NE-Technology
NOVELEC
OXFORD- NUCSAFE
RNI - Comtrade
SAPHYMO
Sensor Technology
TSA
POLIMASTER
Quantrad

5. ITRAP Project Tasks

The ITRAP study was carried out during five working tasks.

1. Design of the study
2. Pre selection of equipment
3. Laboratory tests at Seibersdorf
4. Field exercise at border test sites
5. Assessment summary report

5.1 Design of the Study

Together with IAEA experts the definition of equipment and performance requirements have been worked out. For further investigations and tests the following categories of instruments have been defined:

1. Fix-installed monitoring instruments
2. Pocket type instruments
3. Hand held instruments
   - searching instruments
   - dose rate survey meters
   - isotope identification instruments

The fix-installed monitoring systems should detect gamma as well as neutrons. Pocket type instruments have not to be sensitive for neutrons. Hand held instruments are desirable with the capability of neutron detection but not necessarily in one unit. A hand held instrument has not to have all mentioned properties in one unit.

Concerning the test scenarios lab tests for the qualifications to further practical field tests at border crossing have been agreed by the experts. For the lab tests an outside, controlled area at the Austrian Research Center Seibersdorf have been defined. The concerning control units of the fix-installed monitoring systems have to be in a dry area. For the ITRAP field test site the Austrian-Hungarian border and the Vienna Airport have been selected. Reason for the Austrian-Hungarian border was due to the high frequency of border crossing by different types of vehicles: truck, car, bus. Vienna Airport has been selected because of the very high number of passengers.

For the testing of the selected equipment minimum requirements have been worked out by an IAEA expert group assisted by suppliers supported working groups (see appendix).

5.2 Pre-Selection

After a presentation of available instruments at the Austrian Research Centers Seibersdorf in November 1997 by the suppliers an official invitation to participate the ITRAP study with the defined instruments has been sent to the all IAEA member states as well as to several suppliers. The pre-selection of equipment, based on supplier's product information, a standardised equipment data sheet (see appendix), additional information and literature was carried out end of February 1998.

Pre-selected Systems and Instruments

Instrument Type	Instrument Name	Manufacturer / Supplier	Country
Fix-installed	Yantar-1U	ASPECT	Russia
Fix-installed	Yantar-2U	ASPECT	Russia
Fix-installed	APM Automobile & Personnel Monitor	BICRON-NE	USA
Fix-installed	BPM Border Monitor	BICRON-NE	USA
Fix-installed	RGM	BITT	Austria
Fix-installed	FHT 1388	ESM - Eberline	Germany
Fix-installed	SYREN 510 N	EURISYS MESURES	France
Fix-installed	GR-526/4400 (Gammascan 300)	EXPLORANIUM	Canada
Fix-installed	GR-606/1100 (Gammascan 200)	EXPLORANIUM	Canada
Fix-installed	CGV	MGP instruments	France
Fix-installed	PUMA-TM (Neutron Glass)	NUCSAFE	USA
Fix-installed	PM5000 (VM-250 GN)	POLIMASTER / TSA	Belarus / USA
Fix-installed	CDM-001	SAPHYMO	France
Fix-installed	TSA 700	TSA	USA
Fix-installed	TSA 702	TSA	USA
Hand Held	N92 Neutron Scanning Instrument	AEA Technology	UK
Hand Held	Neutron Survey Meter LB 6414	Berthold	Germany
Hand Held	MicroSievert	BICRON-NE	USA
Hand Held	FH 40 G-L Radiameter System with gamma and neutron probes (FHZ 502 P+FHT752SH)	ESM – Eberline	Germany
Hand Held	Syrena	EURISYS MESURES	France
Hand Held	Neutron Rem Counter	NE Technology	England
Hand Held	DG5A	Novelec	France
Hand Held	PM1402+BD01+BD04+BD02	POLIMASTER	Belarus
Hand Held	PM1710	POLIMASTER	Belarus
Hand Held	RNI 10/SR+Bicronsonde	RNI AB	Sweden
Hand Held	6150 AD Ratemeter	SAPHYMO	France
Hand Held	PRM-470P	TSA	USA
Hand Held / Isotope Identification	Universal Radiometer-Spectrometer MKS-A02	ASPECT	Russia
Hand Held / Isotope Identification	FieldSPEC	Bicron	Germany
Hand Held / Isotope Identification	MiniSPEC	EXPLORANIUM	Canada
Hand Held / Isotope Identification	MCA 166	GBS Elektronik	Germany
Hand Held / Isotope Identification	Nanospec 2	OXFORD-INSTR.	USA
Hand Held / Isotope Identification	Ranger / Ranger – Plus	QUANTRAD SENSOR	USA
Pocket	RIC-11	Constellation	USA
Pocket	PM 1401	POLIMASTER	Belarus
Pocket	PM 1703	POLIMASTER	Belarus
Pocket	Radiation Pager	Sensor Technology	USA

5.3 Laboratory Tests

The ITRAP lab test was designed to work as a very strict benchmark to qualify border monitoring systems with very low false alarm rates for further field tests at the border sites. In addition the minimum sensitivity to give an alarm has been defined for fix-installed systems, pocket type and hand held instruments (see annex: IAEA Minimum Requirements).

Lab test of fix-installed systems

In summary 14 fix-installed systems have been installed in a circular geometry to measure all instruments at the same time. In the centre the test source was located in an exact distance of 3 m to the reference point of the detector (Fig. 1). For two pillar monitoring systems each single pillar has to fulfil the IAEA minimum requirements.

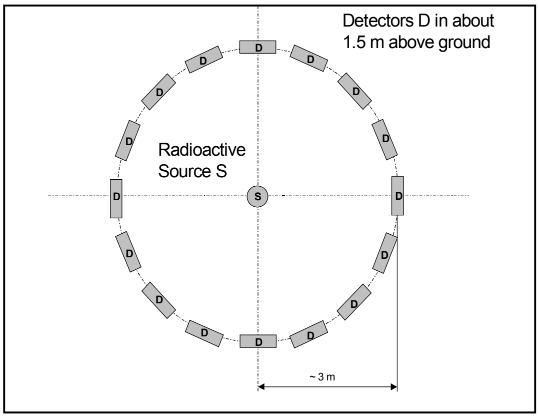

Fig. 1: All detector systems have been tested at the same time at a circular arrangement. The radius is 3 meters with the radioactive source in the centre.

The systems are in a fenced, outside area, unprotected against temperature changes, humidity, etc. installed (Fig. 2). The control units are in a protected location, close to the detectors (Fig. 3).

Fig. 2: View of several monitoring systems at the ITRAP lab test facility and the gamma test source.

Fig. 3: View of the control units of the detector systems and the ITRAP lab test control system.

For the sensitivity tests in the alarm case, a gamma source (^{137}Cs, ^{241}Am, ^{60}Co) as well as a neutron source (^{252}Cf) have been used to exposure the systems for time period of 1s, in the case of a gamma and 10 s, in the case of a neutron source, according the IAEA minimum requirements for these instruments. The increase of the dose equivalent rate is 0.1 µSv/h above a background of 0.2µSv/h for all used gamma sources. After the exposure the source stayed for a minute behind the shielding and starts afterwards the next test cycle. The facility is able to operate continuously for several weeks. The natural background is increased by an additional radiation source (^{137}Cs) in the centre according to the IAEA test requirements.

For the neutron tests a special prepared Californium source (^{252}Cf) was used to simulate the weapons plutonium according the IAEA minimum requirements. The source is shielded against gamma radiation, use a moderator and provides the required neutron rate of 20.000 n/s at 2 m distance.

To test the false alarm rate (rate of false positive) the same test facility, under the same background conditions, was used but without a radioactive test source.

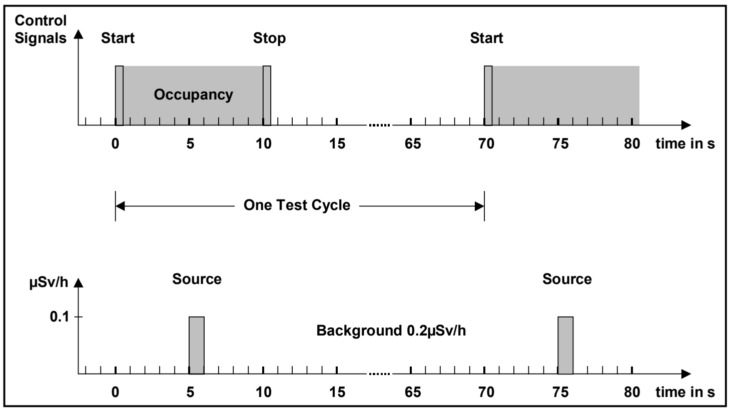

Fig. 4: Test cycle for the gamma alarm test for fix-installed monitors. The ITRAP control system provides all monitoring systems and instruments with a start and a stop signal to simulate the "occupancy" situation of a vehicle or pedestrian. The status of all systems was checked every 0.5 s by the ITRAP control system. During the waiting period the systems had time to recalibrate.

Summary of alarm and false alarm tests

Tab. 1 and Tab. 2 shows all lab tests with fix-installed and transportable systems (pocket type and hand held instruments). In summary we have done some 190,000 tests with fix-installed systems and 40.000 tests with transportable systems. The high number of tests guaranties a high statistical probability to qualify the systems concerning false alarms.

Tab. 1**:** Number of lab tests with fix-installed systems:

Test with	Number of Tests
gamma sources: ^{241}Am, ^{137}Cs, ^{60}Co	50.000
modified neutron source Cf-252	51.000
false alarm tests	86.000
SUMME	**187.000**

Tab. 2: Number of lab tests with transportable systems:

Test with	Number of Tests
gamma sources: ^{241}Am, ^{137}Cs, ^{60}Co	10.000
modified neutron source Cf-252	10.000
false alarm tests	20.000
SUMME	**40.000**

Further tests with Pocket sized and Hand Held instruments

According to the IAEA lab tests requirements for transportable systems the pocket type and hand held instruments have to passed the following tests according the IAEA minimum and test requirements (see appendix):

1. Battery life test under alarm and no-alarm conditions.
2. Test of the dose rate display for systems which give the display in dose unity (e.g. see Fig. 5)
3. Test of the sensitivity, alarm- and false alarm test.
4. Isotope - identification test (e.g. see Fig. 6)
5. Environmental test for a specified temperature and humidity range.

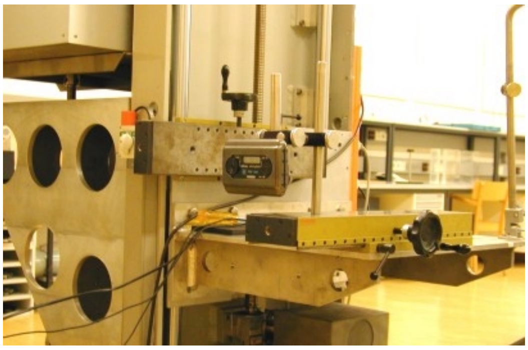

Fig. 5: ITRAP Test at the ARCS gamma calibration facility

Fig. 6: Isotope identification test with fertiliser.

ITRAP lab test conclusions

Fix-installed Monitoring Systems

The ITRAP lab tests for the fix-installed systems started at May 1998 and first results were given in September 1998. Conclusion: Only 2 of 14 fix-installed monitoring systems could fulfil the minimum requirement for neutron detection. The IAEA expert team decided to allow the suppliers improvement of their fix-installed systems for a period of 6 months. ARCS supported this improvements by the installation of a development workshop for interested suppliers using the ITRAP test facility. In May 1999 7 of 10 suppliers with 7 of 14 fix-installed monitoring systems (50%) passed the ITRAP lab test. Together with the suppliers and IAEA experts it was decided, that 9 fix-installed monitoring systems have been at the ITRAP field test sites Nickelsdorf and Vienna airport (2 supplier provides more systems of the same tested unit).

Pocket Type and Hand Held and Instruments

Concerning the tests of the transportable units 13 of 24 instruments or instrument combinations have passed the ITRAP lab tests for pocket type and hand held instruments. 7 systems clearly failed the tests and 4 systems could not be tested according the minimum requirements due to less instrument preparations by the suppliers. Concerning the Isotope identification no instrument has fulfil the minimum requirement particular concerning the shielding of radioactive material.

5.4 Field exercise at border test sites

The field exercise at border test sites at two different Austrian borders is the second important part of the ITRAP study to take into account the diverse procedures concerning road traffic and airport. Particularly in this phase of the study the co-operation with the concerning resorts, customs and border guard officers was a very important part.

The tests have been done at

1. Austrian – Hungarian Border Nickelsdorf
   - three fix-installed monitors at three car lanes (Fig. 7)
   - two fix-installed monitors at one bus lane
   - two fix-installed monitors at one truck lane
   - pocket sized systems and hand held instruments at each location
   - standardised response procedure carried out by the border guards
2. Vienna Airport
   - Two monitors at custom check point at green channel (Fig. 8) and blue channel
   - “quiet alarm” – no response procedure

The installation of the fix-installed monitors at the border site Nickelsdorf was done in June 1999. In the same month a special ITARP training program with border guards concerning basics in radiation protection, usage and searching of radioactive material and operation of the instruments has been carried out. Due to the unexpected delay of the official allowances for the tests at the border crossing Nickelsdorf the start was shifted from June 1999 to November 1999. Further training for the border guards have been organised for several days in early spring 2000. Border guards were also trained on a standardised response procedure in the case of an alarm at all fix-installed monitoring systems.

The official allowance for the tests at the airport was given beginning of the year 2000, so that the tests could start in March 2000. At the airport no response procedure by the border guards was carried out.

All devices have been checked weekly concerning the proper operation and were tested with a test source by an ARCS expert. The fix-installed monitoring systems were remote linked to ARSC to have data access and control at any time. In addition a permanent call standby hotline to ARCS experts was established.

Fig. 7: Installation of fix-installed monitors at the car lane at the ITRAP field test site Nickelsdorf.

Fig. 8: Installation of fix-installed monitors at the ITRAP field test site Vienna airport.

Results of the border tests

The official ITRAP field exercise tests at the Austrian – Hungarian border Nickelsdorf lasted from mid of November 1999 to end of June 2000. The control procedure by the border guards in the case of an alarm at Nickelsdorf was:

- Alarm at the fix-installed monitoring system.
- Verification of the alarm with a hand held equipment by the border guard.
- Recording of the event in the ITRAP journal book.
- Carrying out of the appropriate responds.

The fix-installed systems alarmed at approximately 15% background increasing at each monitoring location. Fig. 9 shows an alarm event distribution at the truck lane during a start period of about one month (mid of November to mid of December 1999). The alarm level is given in multiple of natural background at the monitoring location. Even during this first period of observation (Nov. 1999 to Dec. 1999) a wide range of different goods, which ring an alarm at the truck lane, could be observed (see table in Fig. 9).

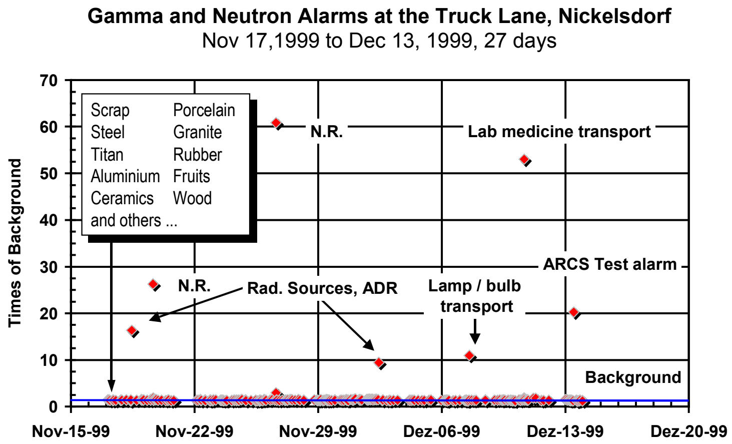

Fig. 9: Alarm event distribution at the truck lane during a start period of approximately one month: mid of November to mid of December 1999. The indication N.R. means that no record in the ITRAP journal book was made by the border guard.

The border guards have been trained on the instruments in June 1999 during the installation of the equipment at the border site. Due to the delay of the official allowances for the tests at the border crossing Nickelsdorf the start was shifted from June 1999 to November 1999. During this 6 month period a change of the border guard officers has taken place. Tab. 3 shows very instructively the effects of the training with border guard officers: The percentage of recorded alarms by the border guards during the test period April 2000 was almost 100% for the truck and the bus location, 57% at the car lane, in the case after a detail training in March 2000. Compared with the start period November / December 1999 is was about the half of theses results.

Nov/Dez 1999	**TRUCK**		**BUS**		**CAR-3**	
Number of Passages	25,338		729		98,000	
Number of Alarms	286	1%	3	0.4%	22	0.0%
Alarms per day	11		0.1		0.8	
Recordes Alarms	160	**56%**	2	**67%**	6	**27%**
April 2000						
Number of Passages	26,448		902		127,941	
Number of Alarms	465	2%	3	0%	7	0%
Alarms per day	15.5		0.1		0.2	
Recordes Alarms	430	**92%**	3	**100%**	4	**57%**

Tab. 3: Comparison of a test month during the start period with test month after detailed training.

An overview of a 6 months test period (January – June 2000) shows Tab. 4. The rate of alarms per day ranges from about 13 alarms per day at the truck lane, to 8 alarms per day at the airport and one alarm in 2 days at the car and bus lanes. The observed false alarm rate of the fix-installed instruments was quite low (< 0.01%) which demonstrates the effect of the strict qualification at ITRAP lab test. No neutron alarms were detected at the truck lane. The neutron alarms at the bus and car location have been either not recorded in the journal book or could not be verified by a further test with a hand held instrument. There are also strong indications, that some old, gas driven cars produced electronic interference which also could lead to a neutron alarm at the car or bus lane. Further analyses would be necessary to explain effects in greater detail. We observed also neutron alarms at the airport for which we have no verification by the officers up to now. possible explanations for the observed neutron alarms could come from nuclear material, statistical false positive alarms, unknown electromagnetic interference or interactions with neutron contribution from solar events. This explanation are very speculative and a further inspection procedure for such alarms by border officers is strongly recommended. During the continuously test alarm checks each monitor has detected the test sources. The maximum background increase have been observed at the truck lane with about 60, 15 at the bus lane, 3 at the car lane and 11 at the airport monitoring location. It has been analysed that 50 % of all observed alarms are coming from a radiation increase compared to the natural background of some 20% to 40% (see Tab. 4).

	Truck	Bus	Car-1	Car-2	Car-3	Airport
Days	181	181	181	181	181	106
Number of Passages	162958	5400	360000	300000	236690	260490
Number of Passages per day	900	30	1989	1657	1308	2457
False - Alarms	<0,01%	<0,01%	<0,01%	<0,01%	<0,01%	<0,01%
Gamma Alarms	2256	66	65	76	48	837
Neutron Alarms	0	5	11	12	11	5
Alarms per day (G + N)	12.5	0.4	0.4	0.5	0.3	7.9
Not detected Test Alarms	0	0	0	0	0	0
Max. BGR	68	15	3	3	3	11
50% of the Alarme from BGR	> 1,4	> 1,2	> 1,3	> 1,3	> 1,4	> 1,3

Tab. 4: Overview of the results in a test period of 6 month (January to June 2000) at the ITRAP field exercise test site Nickelsdorf.

No industrial radioactive source or smuggled nuclear material has been found during an observation period of November 1999 – June 2000. It is also very unlikely to find a smuggled radioactive source or nuclear material during such a study because the study was already internationally announced and very public. A smuggler would take an other route or an other border than Nickelsdorf. Nevertheless, it is important to mention, that one alarm per week was due to an iron, scarp or metal transport (see Tab. 5). It should be mentioned that at the border site Nickelsdorf there is no facility to unload or dump e.g. scrap. Such facility would be necessary to control a contaminated scarp loading on a truck. Alarms from agricultural products have been observed about one week. Some of this events have been analysed by the customs concerning radiation limits in food. Tab. 5 shows a summary of four different defined categories which caused an alarm at the truck lane in Nickelsdorf during the test observation period. In the last row of Tab. 5 the maximum radiation increase is given in multiple of natural background which were found in the concerning category, including the recorded event by the border guard. An increase of 60 is the maximum value what the instrument could show. Above this level the instrument gives an overload.

Tab. 5: Categories of goods which have been found during the alarm observation period of 6 months at the truck lane Nickelsdorf.

Alarms	Reason	Max. observed multiple of BKG / Example
10 per day	**Industrial Products and Raw Material** e.g. ceramics, fertiliser, lamps, TV, etc	60 / some events with e.g. ceramics
1 per week	**Agricultural Products** e.g. fruits, vegetable, wood, etc.	60 / e.g. one event with a chicken transport
1 per week	**Iron and Metal Transports** e.g. Scrap, etc.	60 / e.g. metal plates
1 per week	**ADR (legal) Transport** e.g. radio pharmaceutical transports and industrial sources, etc.	60 / almost all transports

5.5 Results of the ITRAP Study

1. First results of the ITRAP lab test have shown that initially almost all (85%) tested, fix-installed monitoring systems did not fulfil the IAEA minimum requirements concerning neutron detection! And more than 70% did not fulfil the requirements concerning gamma - and false alarms requirements.
2. After instrument improvements 50% of all tested equipment passed the ITRAP lab and field tests according the IAEA minimum requirements.
3. The ITRAP lab tests concerning isotope identification systems have shown that no instrument could fulfil all IAEA minimum requirements concerning isotope identification, particularly the requirements concerning identification of shielded isotopes. Further improvements of isotope identification systems (hard- and software) and advanced requirements for field tests are strongly recommended.
4. The ITRAP field tests have shown, that improvements of fix-installed systems concerning the neutron detection and further advanced minimum requirements for neutrons are recommended for future developments.
5. During the field tests at the Vienna airport neutron alarms have been observed. A procedure of further verification and check by customs and border officers are strongly recommended.
6. All ITRAP qualified systems showed good performance concerning false alarms and reliability at the border exercise field tests.
7. The ITRAP lab and field test showed that instrument standards and harmonised regulations concerning border monitoring and control procedures are urgently required!
8. Concerning the practicability of fix-installed monitoring systems the instruments should give a more clear and permanent visible indication of the maximum observed increase of radiation during the measurement procedure (e.g. increase of back ground in cps or in multiple of back ground or several alarm levels).
9. In general it has been observed that several of the tested hand held equipment was to complicated for the practical usage by border guards. Instruments which needs a continuous training are not recommended for the usage at the border. A “three button mode” (soft- or hardware solution) is recommended: Searching mode, dose rate mode and isotope identification.
10. During the practical tests with the hand held instruments it has been observed, that detailed searching measurements with hand held instruments at large vehicles, particularly trucks are not practicable. For detailed measurements of huge vehicles a more sophisticated fix-installed system (one per border crossing) at a different location than the first check radiation is recommended.
11. The maintenance and servicing of mature instruments is after a start period absolutely possible. Some prototype kind systems showed continuously difficulties during the tests, but which have been solved in time by the suppliers.

12. Almost all fix-installed monitoring instruments were successfully linked by a mobile phone remote connection to ARCS during the whole test period. Only two systems were not able to work with the GSM standard used during these tests.
13. A training of border guard officers concerning radioactive material at borders is strongly required (e.g. including into the basic training of officers).
14. It has been observed, that during the Hotline service (permanent call standby of ARCS experts) an increase of successful carried out response procedures could be observed. Officers told also at continuously interviews, that a link to experts was a great help and support!
15. The unbureaucratic connection of border officers and experts, using “new” communication facilities (mobile phone, comprehensive data link, etc.) is strongly recommended, particularly in cases of the identification of radioactive material.
16. At border crossings, at least one or two border officers trained in radiation basics should be continuously available.
17. The legal bases of border monitoring in Austria have been worked out to: § 177B Strafgesetzbuch in connection with §33 Sicherheitspolizeigesetz.
18. A standardised response procedure to check on vehicles concerning radioactive material has been worked out during this study together with border guards.
19. Four different categories of transported goods which cause alarms have been identified with a certain alarm rate per day and week.
20. About 10 alarms per day are coming from industrial products and raw material. Contaminated iron, metal or scarp as well as alarms from agricultural products have been observed once in a week. Legal transports lead to one alarm per week.
21. It has been observed and practically tested, that at a standard truck loading of about 10 metric tons the used monitoring system are easily able to work as an entrance check on food products concerning radioactive contamination. For instance at a loading of blackberries 30% of the maximum limits of radioactive contamination for food has been detected. This is particularly important in cases of an radioactive accident.
22. The protection of the population and border guards can be ensured by such control monitoring systems.
23. It can be concluded, due to the installation of such monitoring systems at border crossings the protection against illegal transports of nuclear and other radioactive or contaminated material is highly increased.

6. Appendix

6.1 Equipment Specification sheet:

Please **complete** separate sheet for each instrument submitted to ITRAP

Name of the Supplier:	
Address:	
FAX:	
e-mail:	
Purpose / Type of the equipment:	☐ Fixed installed ☐ Hand-held ☐ Pocket
Model:	
Number of equipment in use	
since when	

General:	
Temperature range:	
Humidity range:	
Dimensions / Weight:	
Power requirements / Battery Life:	
Non-interruptible power supply:	
Remote control / indication:	
Recording capabilities:	
Instrument Availability:	
Tamper protection:	

Gamma detection:	
Kind of the gamma detector:	
Dimensions of gamma detector:	
Minimum dose rate level at detector reference point in µSv/h to trigger an alarm:	
- for ^{241}Am:	
- for ^{60}Co:	
- for ^{137}Cs:	
- at Background level:	
- max. passing speed:	
Detection probability:	
Nuisance alarm frequency:	
Energy dependence	
Background compensation:	
Automatic nuclide identification:	☐ no ☐ yes number of nuclides:
Identification of K-40:	☐ no ☐ yes

Model:	

Neutron detection:	
Kind of neutron detector:	
Dimensions of neutron detector:	
Minimum mass of Weapons Pu to trigger an alarm at 2 m distance (gamma shielded):	
- at environmental background level of :	
- max. passing speed:	
Detection probability:	
Nuisance alarm frequency:	

6.2 IAEA Minimum Requirements for Fixed-installed Monitoring Systems at Border Crossings

Alarm level for gamma radiation:

Increase of the dose rate at the reference point of the detector from a background level of 0.2µS/h by a dose rate of 0.1µSv/h for a duration of 1 second. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system.

Alarm level for neutron radiation:

A neutron flux density of 20,000 n/s emitted from weapons Plutonium for a duration of 10 seconds at 2m distance from the reference point of the detector, gamma radiation shielded to less than 1%, should trigger alarm. (Tested with a modified, gamma shielded Cf-252 source).

Search region:

Geometrical region in which the minimum requirements for alarm level are fulfilled:

- Pedestrian monitor: vertical: 0 to 1.8m, horizontal: up to 1.5m.
- Vehicle monitor: vertical: 0 to 3m; horizontal: up to 4m.
- Train monitor: details to be defined

Detection probability:

Probability to detect radioactive material causing the dose rate specified under alarm level: 99.9% i.e. 1 failure in 1000. (Test: Not more than 10 failures in at least 10,000 tests).

False alarm rate:

Rate of alarms which are not caused by a radioactive source:

1 false alarm in 10,000. (Test: Not more than 4 false alarms in at least 40,000 tests).

Operational availability:

99%, i.e. less than 4 days out of operation per year.

Background level:

All tests are performed at a background level of at least 0.2µSv/h.

6.3 IAEA ITRAP Test requirements for pocket type and hand held instruments

1. Pocket Type

1.1. **Sensitivity Test:** Dose rate of 1.0 µSv/h (^{137}Cs) at the detector reference point, for a duration of 2 seconds should trigger alarm. This requirement has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system.).

[Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137].

1.2. **Alarm Threshold:** check validity of specified threshold level (one low and one high threshold only). [Test setup: Dosimetry lab, Circular exposure system with Cs-137].

1.3. **Dose Rate Indication:** check validity of indicated dose rate (one low and one high value only). [Test setup: Dosimetry lab, Circular exposure system with Cs-137 (± 30% uncertainty)].

1.4. **Detection probability:** Probability to detect radioactive material causing the dose rate specified under alarm level: 99% i.e. 1 failure in 100. (Test: Not more than 100 failures in at least 10,000 tests). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

1.5. **False Alarm Rate**: Rate of alarms which are not caused by a radioactive source: not more than 1 false alarm in 12 hours of operation. (Test: Not more than 10 false alarms in at least 120 hours). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

1.6. **Environmental Tests:**

Operate in temperature range: -15°C to + 45°C. [Test Setup: climatic chamber, instrument tested with source to give alarm at low and high temperature]

Operate at high humidity >95% rel. [Test Setup: instrument wrapped in plastics bag with moist tissue for 30 min, then tested with source Cs-137].

1.7. **Battery life:** > 800 hours for non rechargeable, > 12 hours for rechargeable units under no alarm conditions. More than 3h under alarm condition. [Test setup: under no alarm condition, current drawn from battery measured].

1.8. **Drop Test:** meet specification after 0.7 m drop on concrete (at the risk of the manufacturer !), three times in three different directions.

2. Hand held Instruments

1.9. **Gamma sensitivity test:** Dose rate increase of 0.2 µSv/h (^{137}Cs) at a background of 0.2 µSv/h at the detector, for a duration of 3 seconds should trigger alarm. This requirements has to be fulfilled in a continuous, incident gamma energy range from 60keV to 1.5 MeV (tested with ^{241}Am, ^{137}Cs and ^{60}Co). Reference point: Most sensitive location at the detector system.

1.10. **Neutron sensitivity test:** ITRAP test source (modified Cf-252 source) in 0.25 m distance for 10 seconds should trigger alarm.

1.11. **Detection probability:** Probability to detect radioactive material causing the dose rate specified under alarm level: 99% i.e. 1 failure in 100. (Test: Not more than 100 failures in at least 10,000 tests). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

1.12. **False Alarm Rate**: test only applicable if instrument provide alarm feature. At background level of 0.2 µSv/h and threshold above background: Requirement: not more than 1 false alarm per minute (Test: Not more than 100 failures in at least 100 minutes). [Test setup: ITRAP circular exposure system. Background 0.2µS/h Cs-137, alarm output line required].

1.13. **Dose Rate Indication:** check validity of indicated dose rate (one low and one high value only). [Test setup: Dosimetry lab, with Cs-137 (± 30% uncertainty)].

1.14. **Isotope Identification:** After calibration the following isotopes should be identified behind 3mm and 5mm steel shielding, dose rate at detector without shielding 0.5 µSv/h above background, duration of identification less than 3 min:

Unshielded: (less than 1 min) In-111, Tc-99M, Tl-201, Ga-67, Pd-103, Xe-133, I-125, I-131, Am-241.

Shielded behind a 3 mm steel shielding: U-235, U-238, U-233, Co-57, Ba-133.

Shielded behind a 5 mm steel shielding: Pu-239, K-40, Ra-226, Th-232, Cs-137, Co-60.

1.15. **Environmental Tests:**

Operate in temperature range: -15°C to + 45°C. [Test Setup: climatic chamber, instrument tested with source to give alarm at low and high temperature]

Operate at high humidity >95% rel. [Test Setup: instrument wrapped in plastics bag with moist tissue for 30 min, then tested with source Cs-137].

1.16. **Battery life:** > 12 hours under no alarm conditions, > 3h under alarm conditions. [Test setup: current drawn from battery measured].

1.17. **Searching Capability:** to be tested during field tests on border. Time required to find source in a vehicle should be as short as possible.

6.4 Passed monitoring systems and instruments

The instruments described in this annex have participated in the ITRAP laboratory and field tests and have met or exceeded the ITRAP minimum requirements as set forth in the IAEA Technical Manual on Detection of Radioactive Materials at Borders. It should be mentioned, that no isotope identification instrument passed the identification test. The concerning instruments are listed here because of the fact that they have passed the minimum requirements for detection and searching of radioactive material.

Instrument Type	Instrument Name	Manufacturer / Supplier	Country
Fix-installed	Yantar-1U	ASPECT	Russia
Fix-installed	Yantar-2U	ASPECT	Russia
Hand Held / Isotope Identification	Universal Radiometer-Spectrometer MKS-A02	ASPECT	Russia
Fix-installed	APM Automobile & Personnel Monitor	BICRON	USA
Hand Held / Isotope Identification	fieldSPEC	BICRON / TARGET	USA / Germany
Hand Held	Neutron Survey Meter LB6414	PerkinElmer/ Berthold	Germany
Hand Held	FH 40 G-L Radiameter System with gamma and neutron probes (FHZ 502 P+FHT752SH)	ESM – Eberline	Germany
Fix-installed	SYREN 510 N	EURISYS MESURES	France
Hand Held	Syrena	EURISYS MESURES	France
Hand Held / Isotope Identification	miniSPEC	EXPLORANIUM	Canada
Hand Held	DG5A	Novelec	France
Fix-installed	PUMA-TM (Neutron Glass)	NUCSAFE	USA
Hand Held	PM1710	POLIMASTER	Belarus
Hand Held	PM1402	POLIMASTER	Belarus
Pocket	PM 1401	POLIMASTER	Belarus
Pocket	PM 1703	POLIMASTER	Belarus
Fix-installed	PM5000 (VM-250 GN)	POLIMASTER/ TSA	Belarus/USA
Fix-installed	CDM-001	SAPHYMO	France

The specifications and data that follow have been provided by the respective equipment manufacturer. The sponsoring organization of ITRAP cannot assume any responsibility as to correctness and completeness of this information. Inquiries should be directed to the instrument manufacturers or, where available their importers, distributors or representatives.