Summer school on scintillation, dosimetric and phosphor materials
7-8 September 2018, Prague, Czech Republic

Scintillation and dosimetric materials in military applications

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LumDeTr '18 Prague

Nowadays concept of operation and equipment

- Limited possibility of usage NUC weapon;
- Mass scale accident → isolated incident;
- Basic counters (ionizing chamber, proportional counters, GM tubes) → more sophisticated detectors (NaI(Tl), LaBr(Ce), CZT, HPGe, LSA) with spectrometric response;
- High dose/dose rate measurement → low dose/dose rate measurement with high precision and low deviation;
- Informal measurement → forensic level;
- Only military operation → all possible operation (peace keeping, enforcing, military aid, etc.);

Components of Radiation Monitoring

Operations Support Department

- CBRN Reachback
- Modelling & Simulation
- Ops Planning Support

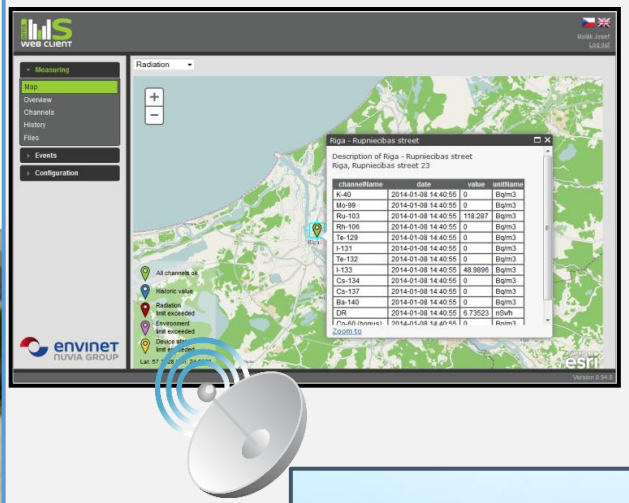
Monitoring networks
Portal detectors

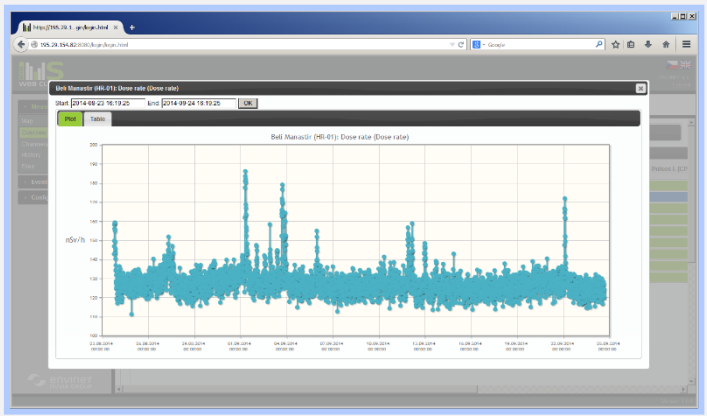
Radiometric station

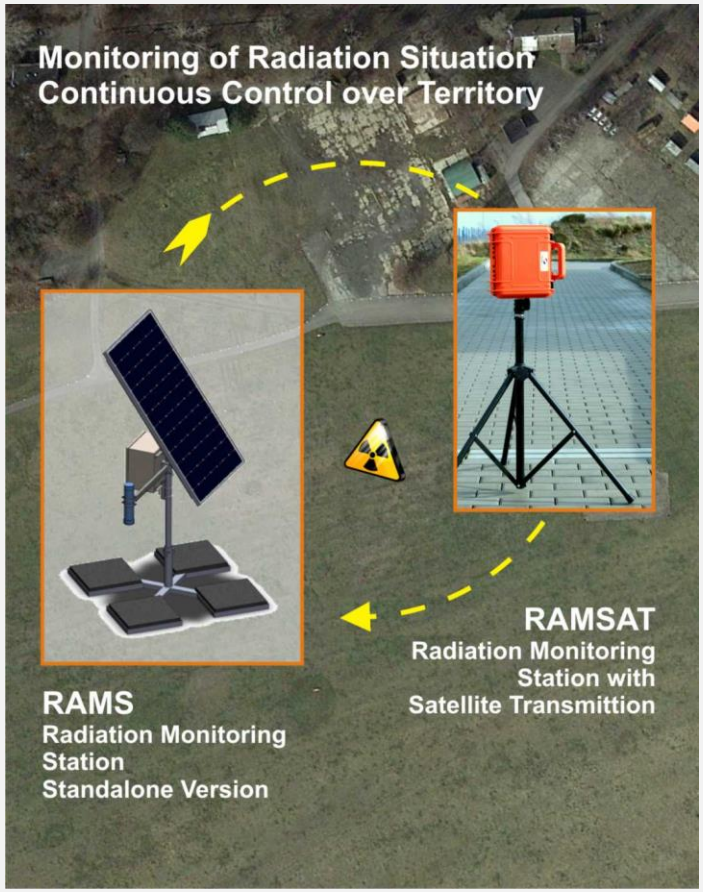
- Equipped with intelligent GM tube
- Optionally with NaI(Tl) detector and meteorological station
- Data transferred via GSM or special military network
- Can be equipped with solar panel and batteries
- Multiple stations serve as a monitoring network

Portable dose rate monitoring stations

- Dose rate measurement in the field
- Measurement of radioactive pollution
- Satellite transmission of the data
- GM tubes


web client
Measuring
Map
Overview
Channels
History
Files
Events
Configuration
Radiation
Riga - Rupniecibas street
Description of Riga - Rupniecibas street
Riga, Rupniecibas street 23
channelName | date | value | unitName
K-40 | 2014-01-08 14:40:55 | 0 | Bq/m3
Mo-99 | 2014-01-08 14:40:55 | 0 | Bq/m3
Ru-103 | 2014-01-08 14:40:55 | 118.287 | Bq/m3
Rh-106 | 2014-01-08 14:40:55 | 0 | Bq/m3
Te-129 | 2014-01-08 14:40:55 | 0 | Bq/m3
I-131 | 2014-01-08 14:40:55 | 0 | Bq/m3
Te-132 | 2014-01-08 14:40:55 | 0 | Bq/m3
I-133 | 2014-01-08 14:40:55 | 48.9896 | Bq/m3
Cs-134 | 2014-01-08 14:40:55 | 0 | Bq/m3
Cs-137 | 2014-01-08 14:40:55 | 0 | Bq/m3
Ba-140 | 2014-01-08 14:40:55 | 0 | Bq/m3
DR | 2014-01-08 14:40:55 | 6.73523 | nSv/h
Zoom to
envinet
NUVIA GROUP
esri


Beli Manastir (HR-01): Dose rate (Dose rate)
Start: 2014-09-23 16:19:25
End: 2014-09-24 16:19:25
OK
Plot
Table
Beli Manastir (HR-01): Dose rate (Dose rate)
nSv/h


Monitoring of Radiation Situation
Continuous Control over Territory
RAMS
Radiation Monitoring
Station
Standalone Version
RAMSAT
Radiation Monitoring
Station with
Satellite Transmittion

Portal monitoring

- Portal monitoring provides ultimate sensitivity for both vehicles and personnel scanning in key sites or applications.
- Large plastic/NaI(Tl) scintillation detectors or HPGe detectors for gamma radiation detection
- Recognition sensor of the objects presence with optionally speed alarm triggering.
- Audible alarm indication via acoustic alarm and alarm lights.
- Data transfer via Ethernet/WiFi from the detector array to the operator's room.
- Database with results, data replication
- Camera recording system

Modular Radiation Screening System

- Easily installable, collapsible and transportable mobile radiation screening system
- Light, stable, variable framework composed of lightweight material, ensuring sufficient support for the whole detection system
- Variable assembly for pedestrians, motorcars and trucks
- Detection unit: system is usually based on scintillation detectors
- Detection units are housed in water and dust-resistant boxes allowing easy decontamination.
- Optical sensors, semaphores, alarm signaling unit
- Detection unit s are connected with a cable to the control box which provides power supply and control interface.
- PC operated, printer
- Software package (SQL database, labels and protocol printing etc.)

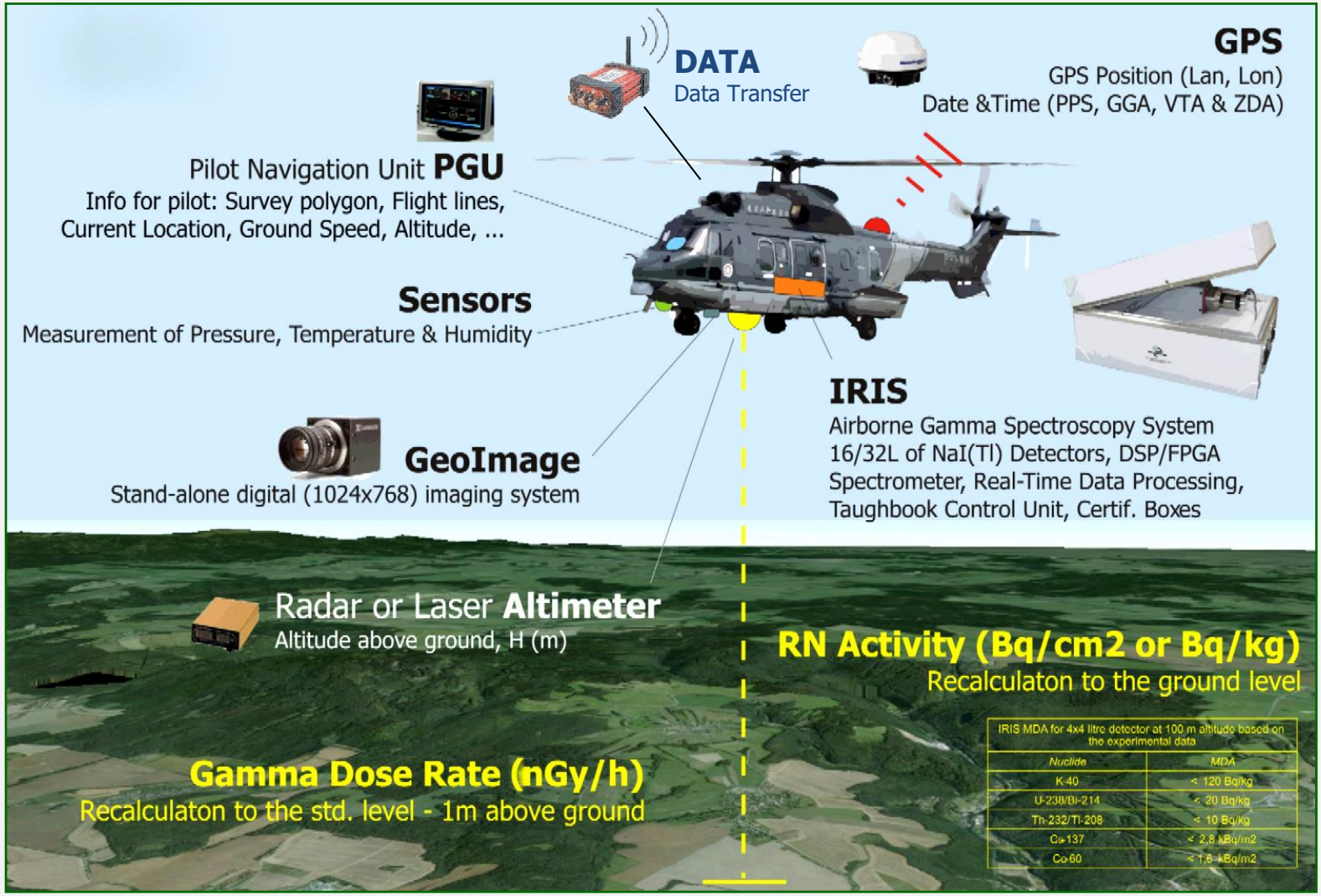
Airborne Monitoring

Aerial detection is one of the powerful tool for

- Quick estimation of dose rate, radionuclide composition in large scale environment.
- Search mode (lost or stolen source)
- Obtaining visual data of surroundings

Detectors

- Scintillation – plastic or NaI(Tl)
- Semiconductor – HPGe

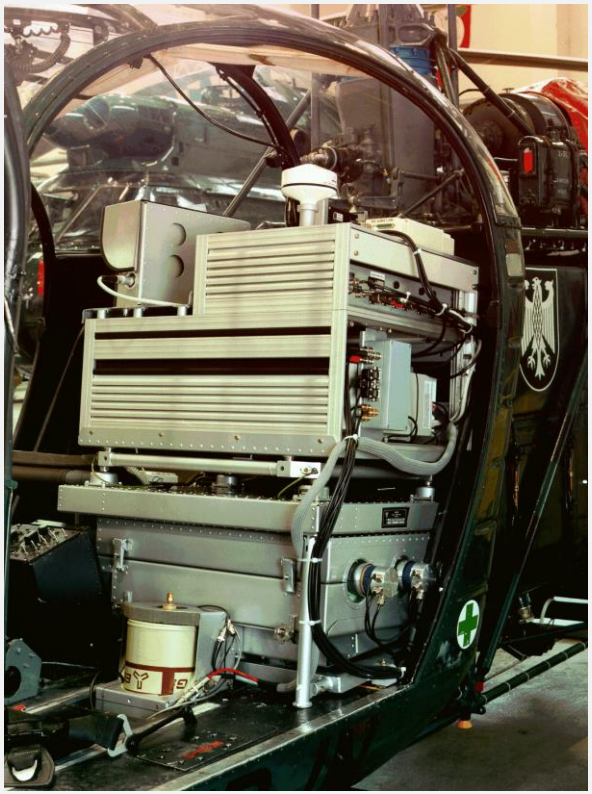

DATA
Data Transfer
GPS
GPS Position (Lan, Lon)
Date &Time (PPS, GGA, VTA & ZDA)
Pilot Navigation Unit PGU
Info for pilot: Survey polygon, Flight lines,
Current Location, Ground Speed, Altitude, ...
Sensors
Measurement of Pressure, Temperature & Humidity
IRIS
Airborne Gamma Spectroscopy System
16/32L of NaI(Tl) Detectors, DSP/FPGA
Spectrometer, Real-Time Data Processing,
Taughbook Control Unit, Certif. Boxes
GeoImage
Stand-alone digital (1024x768) imaging system
Radar or Laser Altimeter
Altitude above ground, H (m)
RN Activity (Bq/cm2 or Bq/kg)
Recalculaton to the ground level
Gamma Dose Rate (nGy/h)
Recalculaton to the std. level - 1m above ground
IRIS MDA for 4x4 litre detector at 100 m altitude based on the experimental data
Nuclide
MDA
K-40
< 120 Bq/kg
U-238/Bi-214
< 20 Bq/kg
Th-232/Tl-208
< 10 Bq/kg
Cs-137
< 2,8 kBq/m2
Co-60
< 1,6 kBq/m2

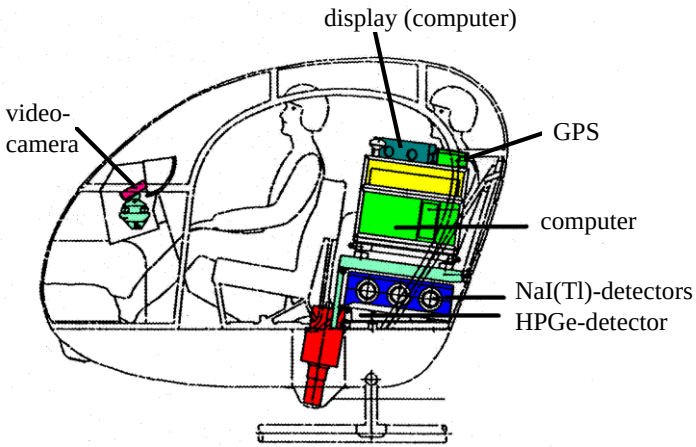
Example - IRIS

Detectors	4 x 4.2 Litre NaI(Tl); Energy Compensated GM tube
Electronics	Individual for each crystal; DSP / FPGA technologies; MCA - 8196
Channels	256/512/1024/2048
Resolution	< 8,5% FWHM @ 662 keV
Dose rate from	1 nGy/h to 1 Gy/h
Sampling rate	0.1 – 10 sec user defined
Spectra stabilization and energy calibration	Auto on natural radionuclides better than 0.5%

- ✓ Two detection units with 2 x 4 Litre scintillation detector each
- ✓ Data synchronized with GPS, altitude, and ancillary sensors
- ✓ Local dose measurement for crew safety
- ✓ Operator can control surveillance navigation


BUNDES-
GRENZSCHUTZ



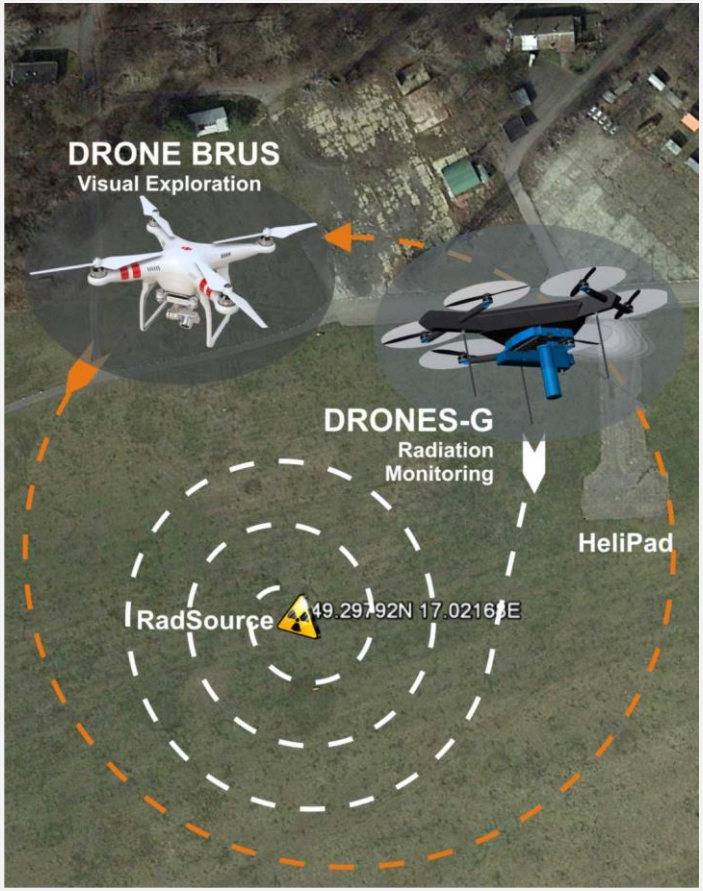

display (computer)
video-
camera
GPS
computer
NaI(Tl)-detectors
HPGe-detector

UAV (Unmanned Aerial Vehicle) / Robot Monitoring Systems

- New aspect of radiation monitoring and measurement;
- Saves HR;
- Can withstand high level of dose rate /dose;
- High modularity – mission adjustment;
- Autonomic mode – search and locate on defined landscape;
- High level of transmission encryption;
- Real time data vs. post processing;

- Compton gamma camera based on medipix2 chips

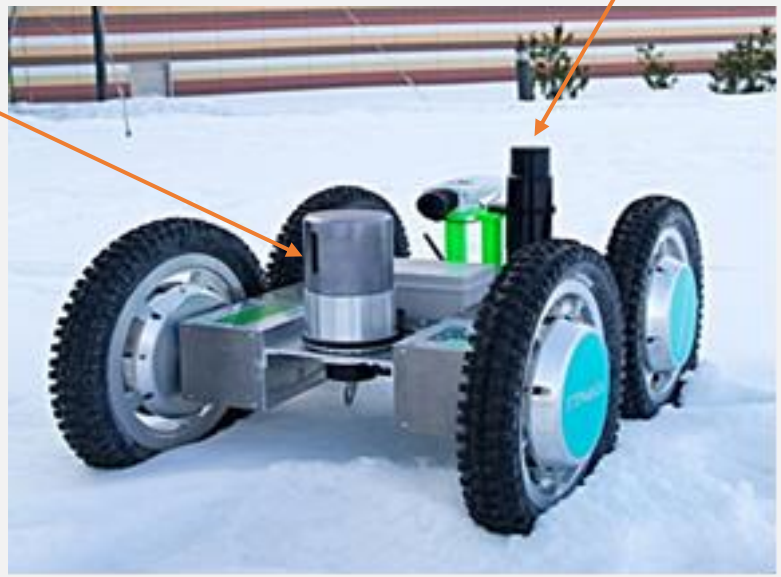
- „omnidirectional “ → measuring of dosimetric quantities



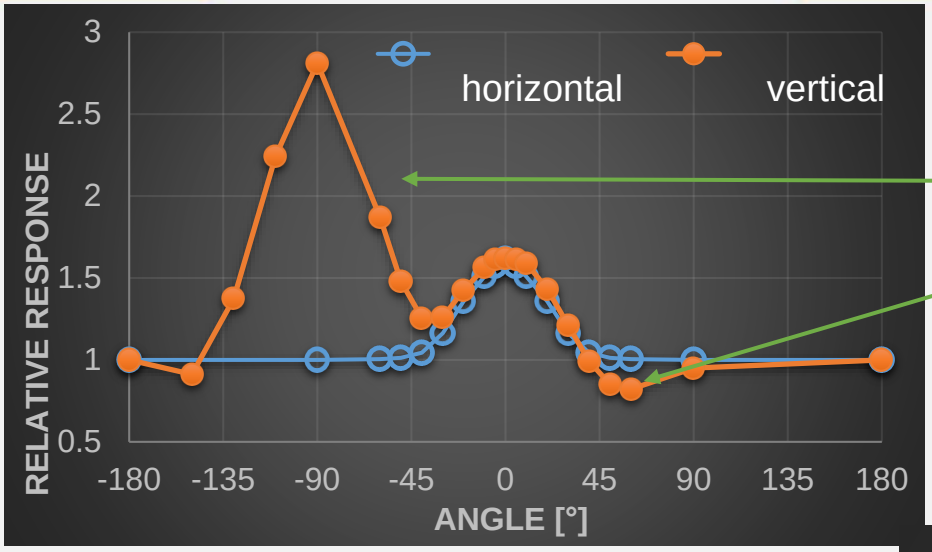
Survey of Selected Area & Radioactive Source Localization

New inteligent detection system

- 2 NaI(Tl) 2“x2“ detectors, 256 ch, 0,03–2 MeV
- „directional“ → rotating colimator → histogram of response in sectors (15°)
- „omnidirectional “ → measuring of dosimetric quantities



- Detection unit
  - ✓ Raspberry Pi2
  - ✓ Software
  - ✓ Communication
- Morpheus



Vertical dependency

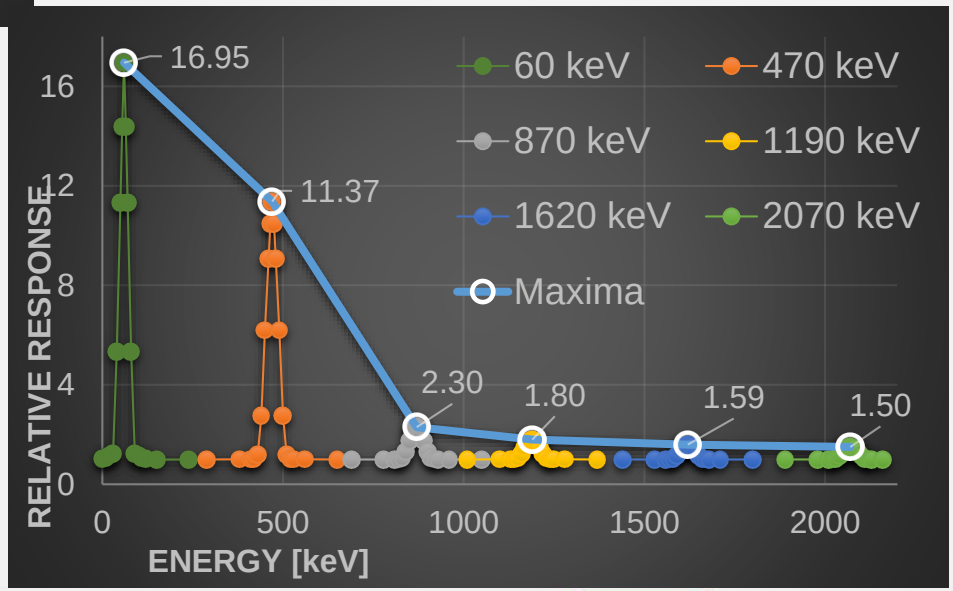
✓ influence of weak shielding

✓ values < 1→ longer diagonal path of photons.

Horizontal dependency as predicted

Angular dependency

Influence of the energy of the incident radiation



Mobile Monitoring

Mobile monitoring is used for:

- Monitoring of dose rate of selected roads or smaller areas
- Tracing stolen/lost sources according to obtained data from aerial monitoring
- Higher sensitivity, better selectivity in terms of resolution and nuclide identification
- Slower, more dangerous, smaller area
- Human interaction with victims/witness – precise information, background, motive, information extracting, etc.
- Real time data processing, post/processing

Example:

- Directional radiation recognition
- Neutron and ɣ sources detection
- Isotopes identification
- Real-time activity calculation for natural and man-made isotopes
- Customizable notifications and crew safety alarms.

PGIS-2

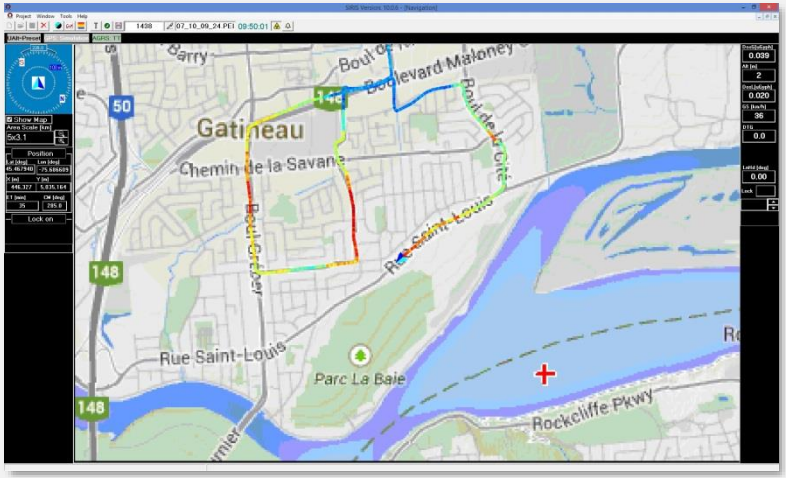
- Detector Volume 0.347 L, NaI(Tl) (or BGO optional)
- Integrated GPS (external GPS receiver connection possible)
- Wireless Data Logger – Android based smart phone

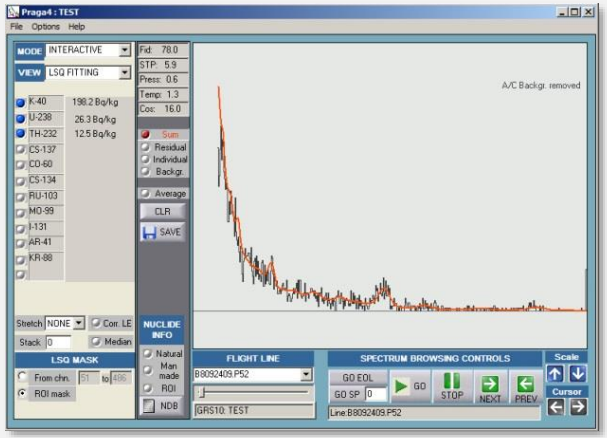
PGIS-2-1 (2)

- Detector Volume 1 (2) L, NaI(Tl)

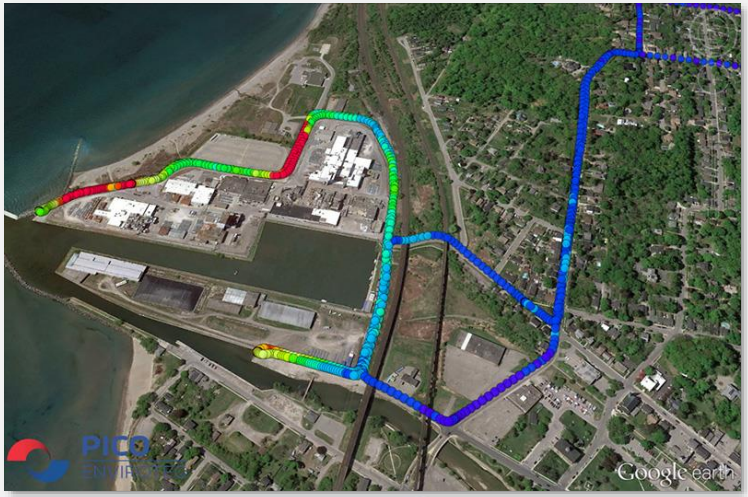
IRIS

- 2 x 2 Liter NaI(Tl); Energy adjusted GM tube (optional)
- 256/512/1024/2048 channels
- Dynamic throughput up to 250,000 cps per detector
- Resolution better than 8% FWHM @ 662 keV
- Energy range from 20 KeV to 3 MeV
- Dose rate interval: 20 nGy/h to 10 mGy/h
- Spectra stabilization and energy calibration: Auto on natural radionuclides better than 0.5%


Gatineau
Chemin de la Savane
Boulevard Maloney
Rue Saint-Louis
Parc La Baie
Rockcliffe Pkwy
50
148


Praga4 : TEST
File Options Help
MODE INTERACTIVE
VIEW LSQ FITTING
A/C Backgr. removed
FLIGHT LINE
SPECTRUM BROWSING CONTROLS
LSQ MASK
NUCLIDE INFO


IRIS
IRIS Mobile


Google earth


PGIS 2
PGIS-2-1 (2)

1. Double-wheel sampling system – two silicone-coated wheels for the automatic detection (whilst moving) of persistent warfare agents and hazardous adhering to the ground.
2. Standoff infrared detector capable of detecting volatile chemical substances in the air from a great distance.
3. «NBC tail» including the tube magazine for transporting samples, the marker trap, glove opening and tongs for manual sampling.
4. Mass spectrometer (behind the operator's position) for chemical analysis of samples collected.
5. Operator's position with the Rheinmetall software «NBC Inspector» – the heart of the NBC kit in the Fox reconnaissance vehicle.
6. Central computer system.
7. FLW 200 remotely controllable weapon station – operated from the armoured interior as a means of self-defence.


027 29-26

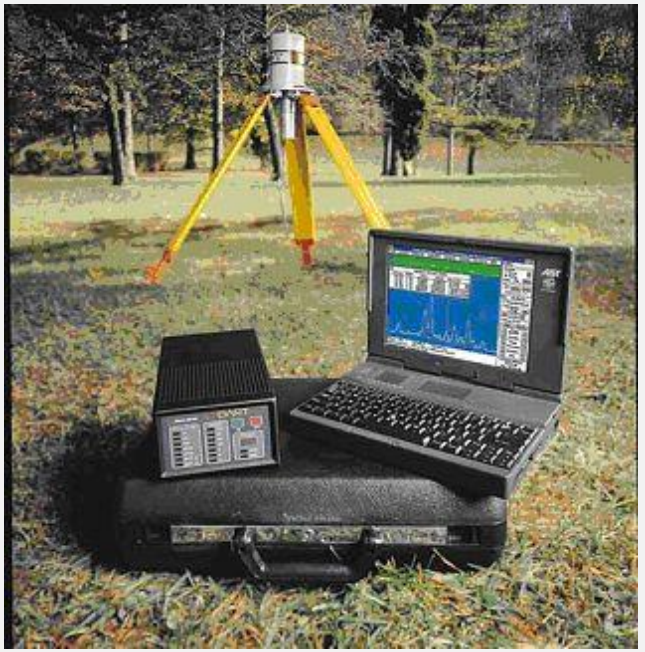
In-Situ measurement

- This method can be considered both a survey and a sampling technique, where radiation measurements are made in the field (*in situ*) and an assessment is made of the contaminant concentration at that location.

- Common systems include ground and aerial platforms, which use high-resolution and low-resolution detection systems.

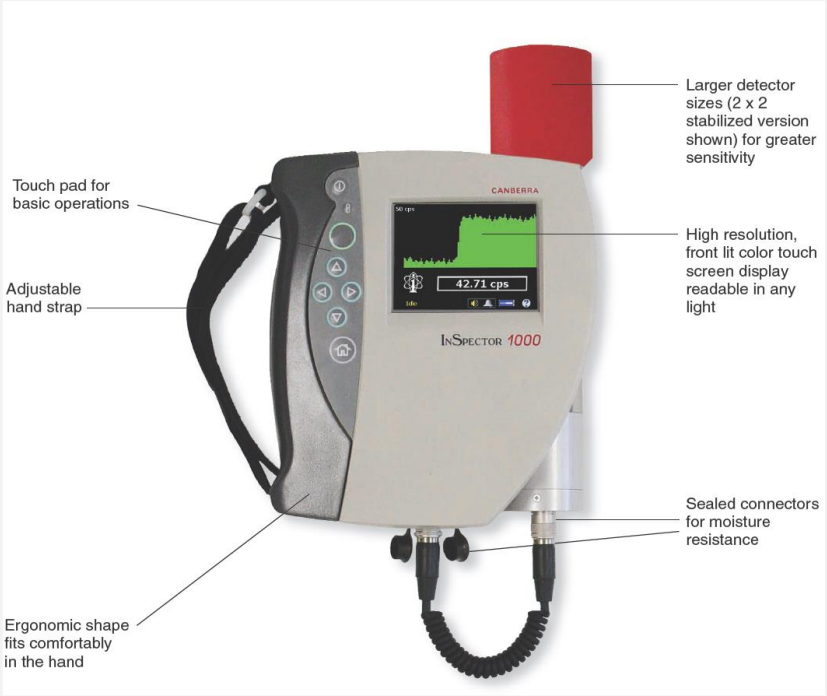
- Low-resolution gamma spectroscopy using a hand-held spectrometer with a sodium iodide or cadmium-zinc-telluride (CZT) detector is the simplest method available for prompt identification of gamma-emitting radioactive materials.

- State-of-the-art *in situ* systems consist of a portable intrinsic high-purity germanium detector (HPGe), associated electronics, and a personal computer for data reduction and logging.



InSpector™ 1000

- GM TUBE – Internal Geiger-Mueller tube for high dose/ count rate measurements.
- NaI PROBES – External NaI(Tl) detector with integrated preamplifier and programmable HVPS.
- IPRON-1: 1.5” x 1.5”; 6000 cps/mrem/h ±3.5%.
- IPROS-2: Stabilized 2” x 2” NaI probe*; 13 000 cps/mrem/h ±3.5%.



- IPROS-3: Stabilized 3” x 3”; 32 000 cps/mrem/h ±3.5%.
- IPROL-1: Stabilized 1.5” x 1.5” LaBr probe 8 000 cps/mrem/h ±3.5%.
- PULSE SHAPE – Tail pulse from detector preamplifier, positive or negative polarity.
- NEUTRON PROBE – External detector; moderated 3He tube (8 cm active length – 2 atm); intrinsic neutron sensitivity ≈1%, using an unmoderated 252Cf fast neutron source;

FLIR - identiFINDER R400


Hand-held g/n detector series:

- Detection media: NaI (<8%), LaBr (<4,5%), He-3, GM tubes (high count rate)
  - ✓ Gamma (Nal): 35 x 51 mm,
  - ✓ Gamma (NaI) Tungsten Shielded: 23 x 21 mm,
  - ✓ Gamma ($LaBr_3$): 30 x 30 mm,
  - ✓ Neutrons (He-3): 15 x 54 mm.
- Energy range/channels: 20 – 3000 keV / 1024
- Stabilization: LED
- Waterproof (up to 10 m), durable, EM proof, ANSI N42.34 nucl. identif.
- GPS, BlueTooth, webserver

FLIR - identiFINDER R500

Hand-held g/n detector series with large crystals:

- Detection media: NaI (<8%), LaBr (<3,5%), He-3, GM tubes (high count rate)
  - ✓ Gamma (Nal): 102 x 19 mm,
  - ✓ Gamma ($LaBr_3$): 38 x 38 mm,
  - ✓ Neutrons (He-3): 19 x 106 mm.
- Energy range/channels: 20 – 3000 keV / 1024
- Stabilization: LED
- Waterproof (up to 10 m), durable, EM proof, ANSI N42.34 nucl. identif.
- GPS, BlueTooth, webserver

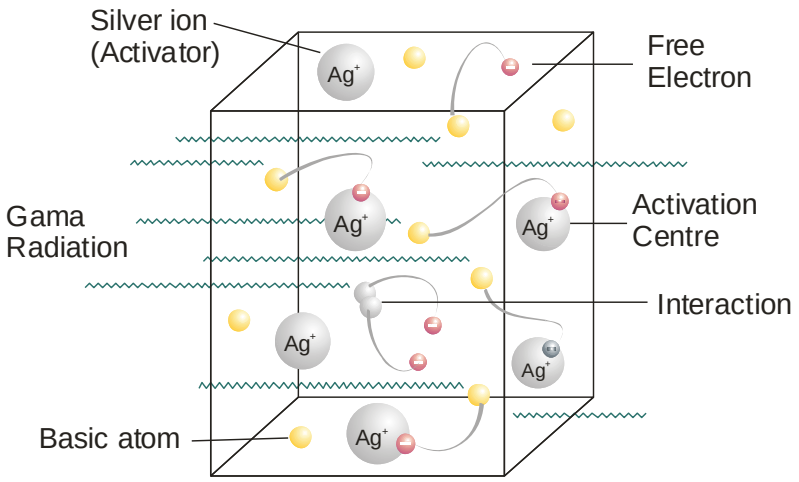
Personal dosimetry

- The personal dosimetry is conducted via two different approaches:
  - „Blind“ personal dosimeters: versatile detectors for common soldiers; no self-readable technolodgy, usually change in material structure such as TLD, OSL, etc. (DD-80).
  - Self-readable personal detectors: Personal Electronic Dosimeter (EPD MK2+).

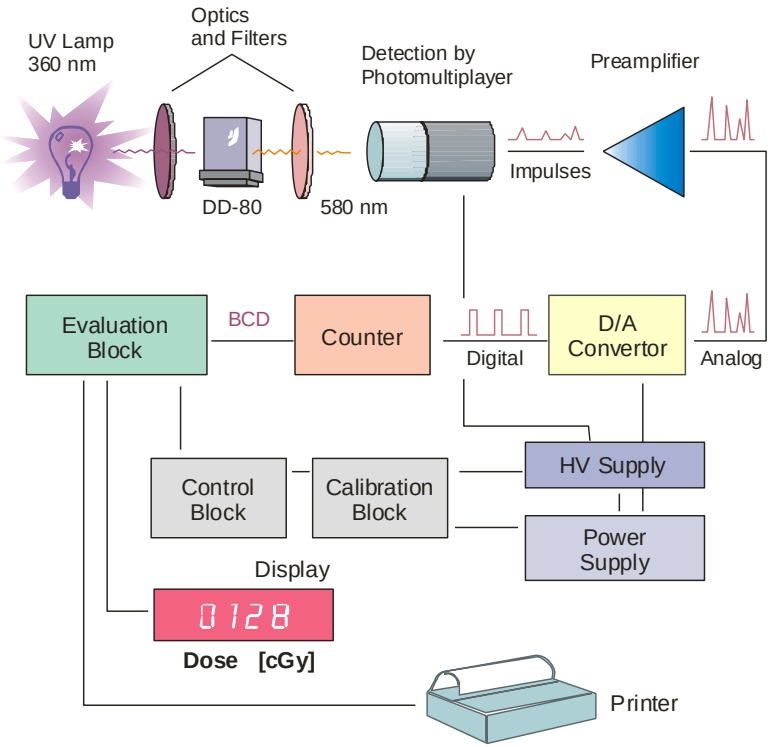
Diagnostic dosimeter DD-80

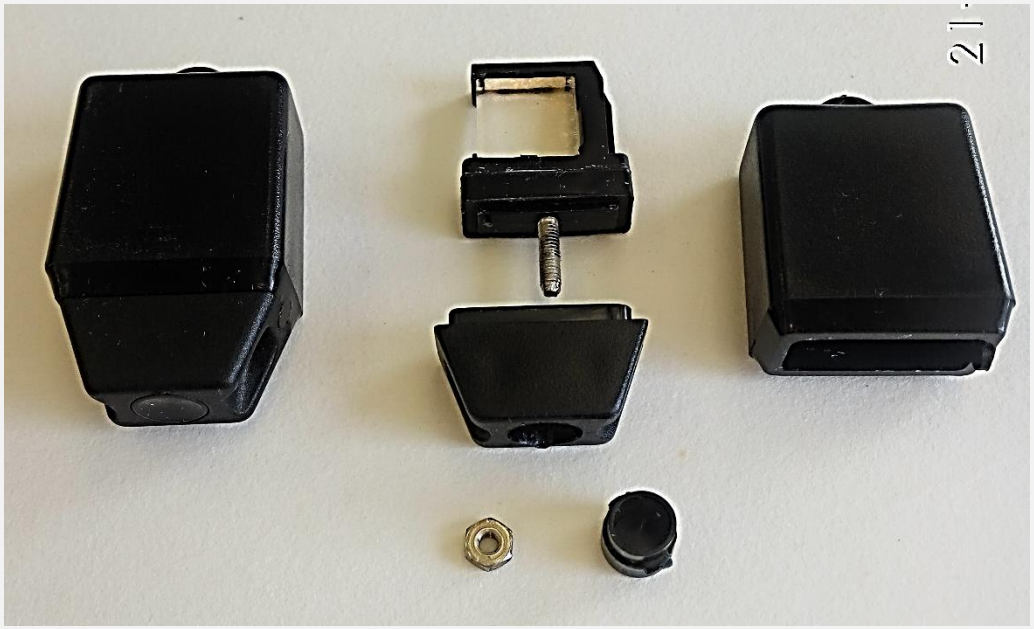
- Range of measurement 5 – 1500 cGy (0.05 – 15 Gy)
- Type of registered radiation: gamma, neutron
- Time of fading > 1 yr
- Dimensions: 44 x 25 x 15 mm
- Weight: 19 g
- Evaluated by dosimeter reader VDD-80

Phosphate glass activated by silver

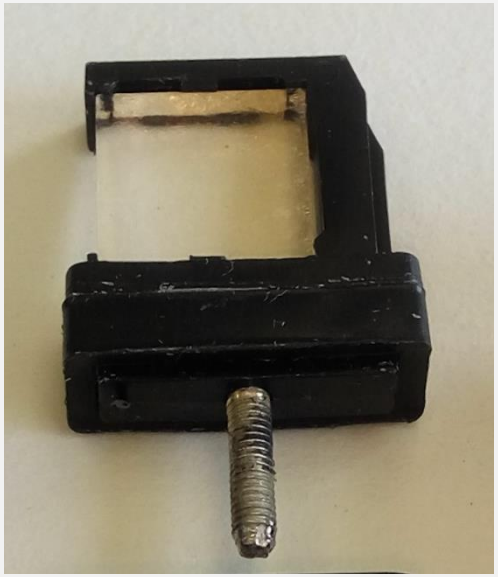


Principle of the Detection by DD-80





Diagnostic dosimeter DD-80; disassembled state

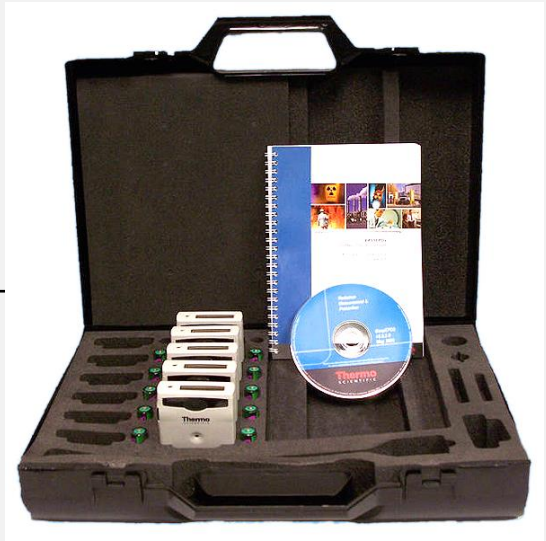


Detail of phosphate glass activated by silver.

EPD Electronic Personal Dosimeters MK2

Thermo Scientific™ EPD Electronic Personal Dosimeters monitor exposure to ionizing radiation in real time and emit both audible and visual alarms

Accuracy	Hp(10) 137Cs ±10%; Hp(0.07) 90Sr/90Y ±20%
Alarms	Dual Hp (10) dose and dose rate alarms, Hp (0.07) dose and dose rate alarms; typically 98 dB(A) at 20cm with multiple modes
Dose	0 to > 1600Rem/hr
Dose Range	0 to > 400Rem/hr
Advanced Radiological Performance	0.015 to 10MeV



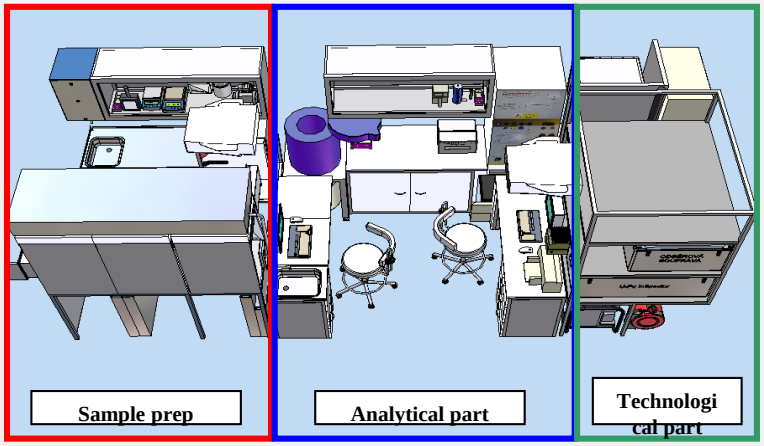
Mobile/Deployable Laboratories

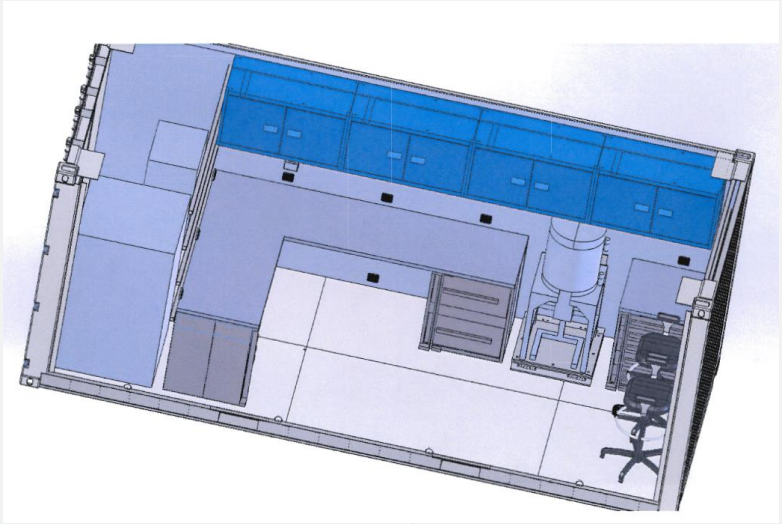
- Used for the rapid analysis of radioactively contaminated samples that **require little or no sample preparation** and can be measured using **instrumentation compatible with field conditions**. For example, swipes and air filters can be obtained from the field and immediately assessed for gross alpha and beta activity with no preparation.
- Samples or analytes **requiring radiochemical preparation** or complex radioanalytical instrumentation **are not suitable** for field analysis. Therefore, the clear advantage of field labs and *in situ* measurements is the **prompt validation** and quantification of R agents.
- Pre-screening samples - reducing the number of samples that require transport and analysis at fixed laboratories.
- Limited analysis capacity, because of their mobility, limited manpower and number of deployable instruments.
- Field labs may use smaller sample aliquots and shorter sample count times - increased limit of detection and measurement uncertainty.

- Due to environmental and operational factors - less precision and accuracy than fixed labs.

Capabilities for deployed laboratories

- Air filters and swipes for gross alpha/beta activity;
- Air filters (charcoal cartridges) for I-131;
- Water samples for gross alpha/beta activity;
- Swipes, water and urine samples for tritium activity;
- Soil, water, vegetation, air samples, and foodstuffs via gamma spectrometry;
- Screening in-vitro studies for gamma activity;
- In vitro gamma spectroscopy studies (using portable/hand-held spectrometers);
- In vivo whole body counts via in situ gamma spectroscopy;
- In vivo thyroid counts via thyroid uptake probe;
- Alpha energies from 3 to 6 MeV; beta energies from 0.2 to 2.5 MeV; gamma energies from 0.01 to 3 MeV (desirable up to 5 MeV), neutron energies from 0.025 eV to 10 MeV.





Stationary/fixed Laboratories

Capabilities for fixed laboratories

- All media requiring alpha spectrometry (e.g., americium, plutonium, thorium, and uranium);
- All media requiring nuclide-specific chemical preparation, (e.g., strontium and radium);
- All bioassay samples requiring estimates of intake for medico-legal reasons;
- All samples beyond the technical or physical capacity of deployed labs;
- Alpha energies from 3 to 8 MeV; beta energies from 0.1 to 2.5 MeV;
- Gamma energies from 0.01 to 5 MeV, neutron energies from 0.025 eV to 14 MeV.

Liquid scintillation counting/analysis

- Mixture of aromatic solvents and luminophores
- Quenching processes
- Harmful to human life and environment – problems with transportation, storage, using and discarding.

- Fine insoluble scintillation powder (YAP:Ce, YAG:Ce) with proper media (acidic, alkaline).
- Only optical quenching
- Re-usable, stable, inert under normal environment

Operations Support Department

CBRN Reachback

NATO CBRN Reachback Element (NATO CBRN RBE) - is a capability which provides timely and comprehensive scientific / technical and operational CBRN expertise, assessments and advice to NATO commanders, their staff and deployed forces during the planning and execution of operations.

As the core of the NATO CBRN RBE, the CBRN RBS is to provide CBRN information and related products in a timely and coherent manner in order to support NATO.

CBRN RBS TASKS

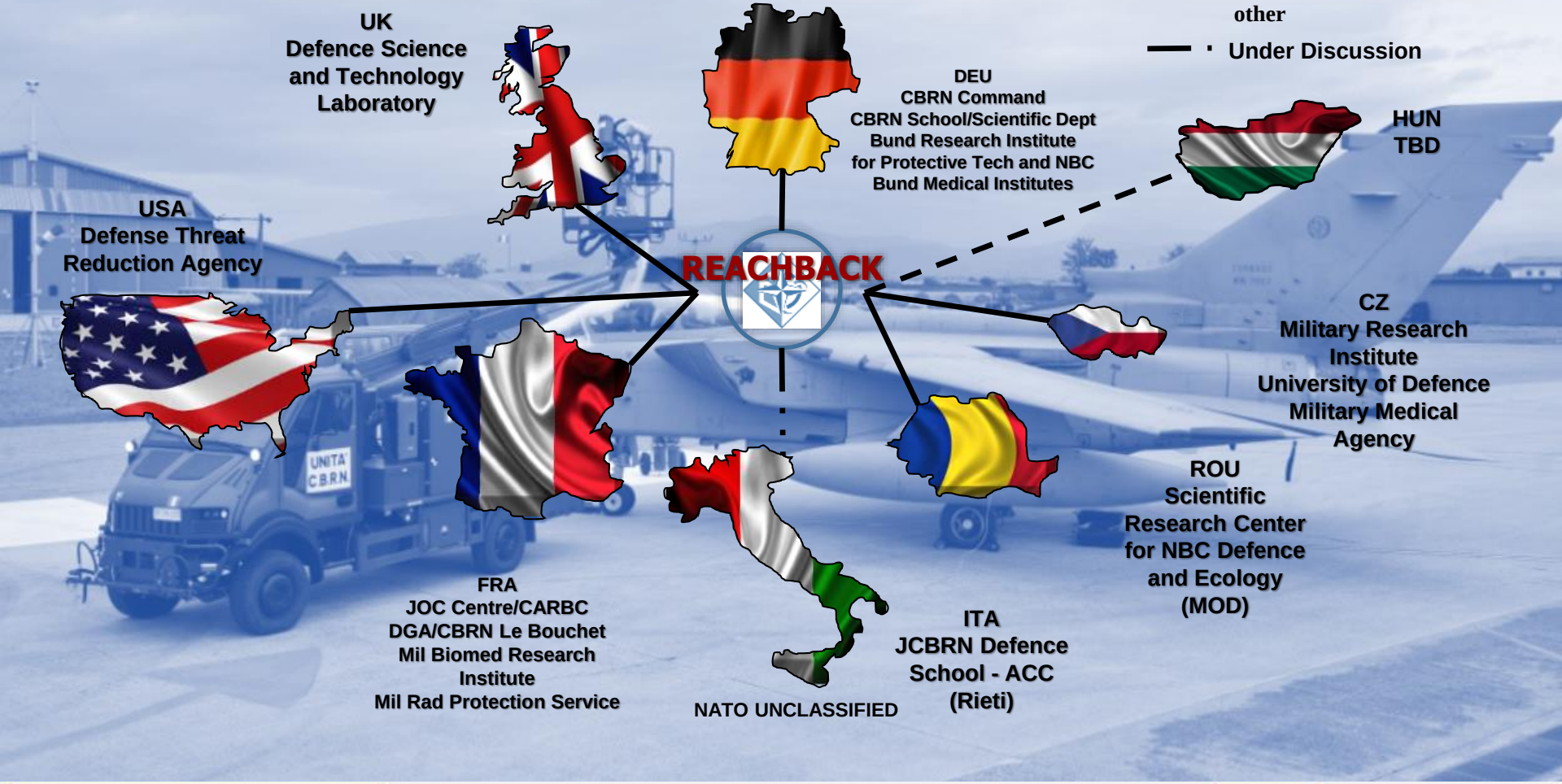
- ROUTINE TASKS
- MILITARY DECISION MAKING PROCESS SUPPORT TASKS
- OPERATIONS PLANNING SUPPORT TASKS
- ONGOING OPERATION SUPPORT TASKS

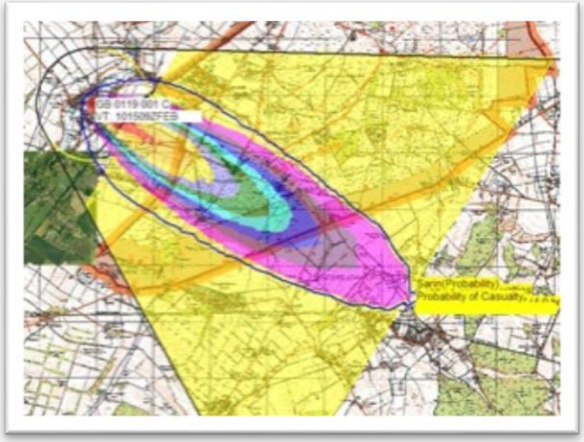
Reachback Secondary Network

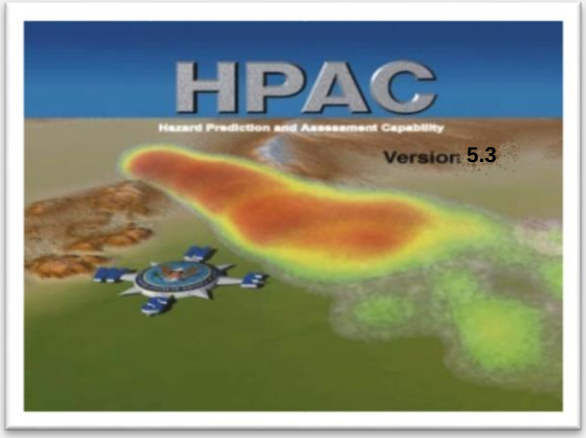
SIGNED TA/LoI/ other

DRAFT TA/LoI

Under Discussion



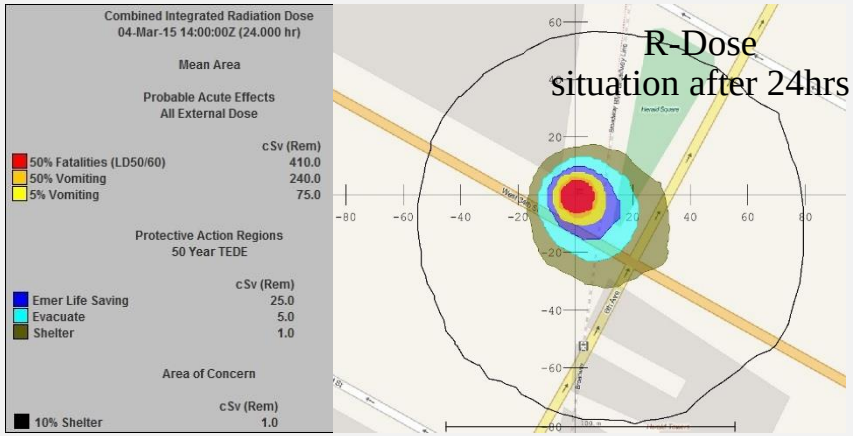




Modelling and Simulation

To support and assist in all relevant JCBRN Defence COE tasks in accordance with existing organizational structure, MOUs, JCBRN Defence COE's Concept and Program of Work.

R-Dose
situation after 4hrs



R-Dose
situation after 24hrs


merci
thank you
danke
gracias
obrigado
go raibh maith agat
спасибо
bedankt
arigatô
ありがとう
kia ora
barka
tau
grazzi
мерси
dakujem
ngiyabonga
dank je
terima kasih
mochchakkeram
sukriya
dhanyavad
shukriya
teşekkü ederim
gràcies
welalin
enkosi
gratias ago
misaotra
matondo
dhanyavadagalu
dziękuję
chokrane
sagolun
谢谢
takk
tapadh
krap
grazie
teşekkür ederim
mauruuru
taiku
leat
rahmet
kop khun krap
mercé
nandri
didi madloba
mahalo
hvala
köszönöm
хвала
blagodaram
trugarez
kam sah hamnida
nanni
paldies
faafetai lava
kop khun
najis tuke
mamnun
তোমাকে ধন্যবাদ
asante
Баярлалаа
vinaka
ευχαριστώ
xièxie
dankie
kiitos
sobodi
dankon
manana
tenki
murakoze
akun
ačiū
tack
sulpáy
bayarlalaa
dëkuji
rahmat
tanemirt
mersi
diolch
spas
djiere dieuf
chnorakaloutioun
grâcies
tapadh
mèsi
gràçie