State of the Art of Explosive Detection Equipments

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THREATS / TECHNICAL SOLUTIONS

Different threats require different technical solutions

- **Public transportation**
- **Monitoring of contents in container**
- **Protection of infrastructure transportation**
- **Check-point**
- **Suicide attack**
- **Road side bomb**

DETECTION PRINCIPLES

- **Trace detection**
  - **Needs trace amounts of explosive in gas phase or in the form of explosives particles**

- **Bulk detection**
  - **Look for the explosive itself in the explosive device and requires large amount of explosive**

MAIN TRACE DETECTION TECHNOLOGIES IN USE

Trace detection Technologies

Ion Mobility Spectrometry (IMS)

- **Used by both people and carry-on luggage at airports**
- **4 sub-components :**
  - **radioactive ion source region;**
  - **ion gate;**
  - **drift region**
  - **detector**
- **limit of detection : ppb in vapour phase ; ng for trace**
- **Speed : few seconds**
- **Selectivity : good**
- **Large range of explosives can be detected**

Trace detection Technologies

- **Ion Mobility Spectrometry (IMS)**

Portable detector

Vapour and trace

Semi-portable detector

Trace

Fixed detector

Trace

Trace detection Technologies

Chemiluminescence (CL)

- **Most explosive compounds contain either nitro (NO2) or nitrate (NO3) groups.**
- **CL detectors take advantage of this common property of most explosives by detecting infrared light that is emitted from electronically excited NO2 molecules**
- **CL detectors are not capable of identifying what type of explosive molecule is present**
- **CL detectors are not used alone but are fitted with a front-end gas chromatograph (GC)**

Portable detectors

Trace detection Technologies

Amplifying Fluorescent Polymers (AFPs)

- **AFPs consist of fluorescing chromophores linked together in polymer chains**
- **Binding of a single molecule of explosive quenches the brightness of the fluorescence of many chromophores ⟶ resulting in an amplification of the quenching effect**

Portable detectors

Vapour and trace for solid exlosive

Vapour for peroxide (TATP; H2O2;…)

Trace detection Technologies

Energetic materials detection (EMD)

- **All explosive materials decompose exothermically after being supplied with sufficient activation energy**
- **The subsequent decomposition process produces a localized, sharp increase in temperature followed by a sharp decrease in temperature after the energetic material is consumed**
- **limit of detection : ng for trace**
- **Speed : few seconds**
- **Selectivity : good**
- **Large range of explosives can be detected**

Semi-portable detector

Trace detection Technologies

Quartz microbalance (QCM)

- QCM is a surface acoustic wave (SAW) sensor with a thin layer of selective polymer
- The microbalance is a tool enabling a mass variation to be converted into a frequency variation, and subsequently into an electrical signal
- Detection is mainly gravimetric
- QCM detector needs several sensors to cover a large range of explosives
- The mass variations detected are of the order of a few nanograms.

Semi-portable detectors

Portable detectors (prototypes)

BULK DETECTION TECHNOLOGIES IN USE

Bulk detection Technologies

X-RAYS

- X-ray machines can detect explosives by looking at the density and (or) atomic weight (Zeff) of the items being examined.

- Some of these machines use Computed axial tomography based systems that are enhanced with dedicated software, containing an explosives threat library and false - color coding, to assist operators with their dedicated threat resolution protocols.

- X-ray detection is also used to detect related components such as detonators, weapons,…

Bulk detection Technologies

X-RAYS

- **Computed tomography (CT)**
  It's an imaging method employing tomography created by computer processing.
  Digital geometry processing is used to generate a 3D image of the inside of an object. Explosives are defined by the atomic weight (Zeff) and the density.

- **Multi view and multi energy generators X-ray**
  Produce several independant images and data results. Explosives are defined by the atomic weight (Zeff) and the density.

- **Backscatter X-ray**
  Produce an image of the present different organic objects
  But no access to the chemical composition
  Penetration less than **CT** or **Multi Energy**

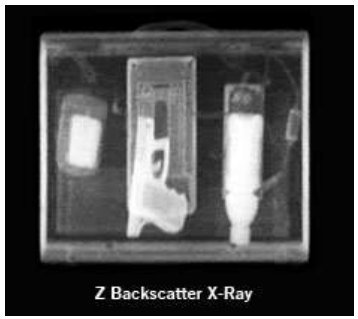
Bulk detection Technologies

X-RAYS

Computed tomography (CT)

Multi energy generators

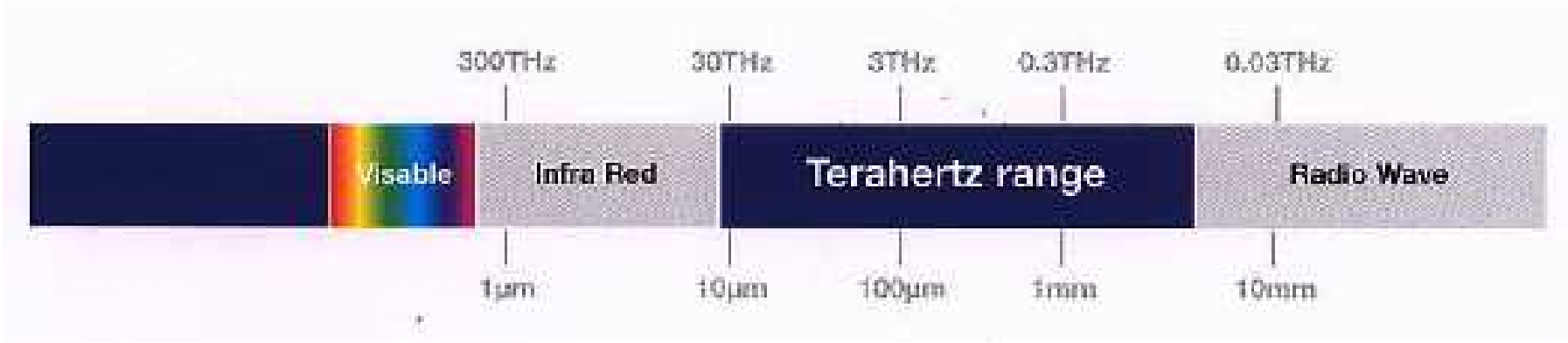
Backscatter X-ray



Bulk detection Technologies

Millimeter wave imaging and THZ spectroscopy

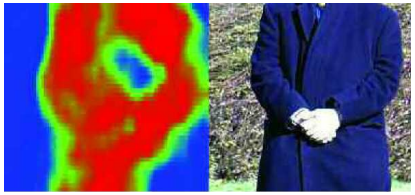
- **Clothes and many materials (except metals) become nearly transparent for wavelenght longer 300 microns (1THZ)**

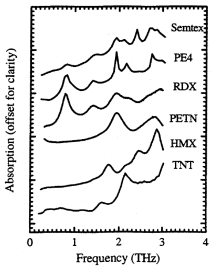


Bulk detection Technologies

Millimeter wave imaging and THZ spectroscopy

- **Detects THz emission through screens (clothes or other)**
- **Suitable technology to detect suicide bombers**
- **Suitable for stand-off detection**
- **Possible integration in a large variety of vehicles and check-point**





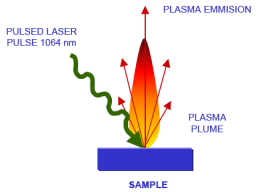
Bulk detection Technologies

Evolving technologies

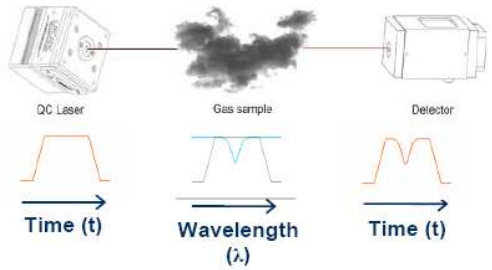
- Neutron activation

- NQR (Nuclear Quadripole Resonance)

- LIBS (Laser Induced Breakdown Spectroscopy)



- Quantum Cascade Laser mid Infra (QCL MIR spectroscopy)



Explosive Detection Technologies

CONCLUSION

The most commonly used techniques based :

- **on X-ray for bulk detection**
- **and IMS for trace detection**