# Whatever happened to drugs detection? Advances (and retreats) in technology since 2001

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## Abstract

Since the terrorist attacks on September 11th 2001 much of the resources devoted by US and other governments to researching the detection of illicit drugs have been redirected into counter terrorism. The last major conference on counter-drugs technology sponsored by the US Office of National Drugs Control Policy was in 2001 while the last Gordon Research Conference devoted exclusively to drugs was in 2002. There has, however been progress in many areas, particularly where counter-terrorism R&D has produced technologies with a secondary use in drugs detection, and where techniques have arisen in medical research. Some techniques which seemed promising in 2001 have, however, been largely abandoned.

This poster presentation, based on a review of the literature and on conversations with researchers in the field, reviews progress since 2001 in a wide range of detection technologies with counter-drugs applications, including vapour and trace detection, X-ray imaging, neutron techniques, millimetre wave and terahertz imaging and spectroscopy and immunoassay. It compares the state of Commercial Off-The-Shelf (COTS) techniques and those in the R&D phase in 2001 and today, and indicates which appear to be still advancing, which have stayed the same and which have fallen into disuse

## Explanation

The table below gives an assessment of 44 technologies, all of which were being actively promoted ten years ago for the detection and identification of illicit drugs. The technologies are grouped into classes depending on their application. These classes are based on subjective definitions and there will inevitably be some overlap and ambiguity.

To determine the state of the art in 2001, the main source of reference was the proceedings of two conferences, in 1999 and 2001, organised by the US Office of National Drug Control Policy Counterdrugs Technology Assessment Centre (ONDCP CTAC). The 2001 event was the last. There were also some technologies which were so well established in 2001 that they no longer featured in conference discussions, and these have been included.

The assessment of the current state of the art is largely based on a review of technologies done by XDtec in 2010 for the UK Home Office (whose support is gratefully acknowledged), which was based on a great many literature sources and personal communications. For this poster, references to current products or projects have been re-checked. Some of the techniques reviewed were not known to the counter-drugs community in 2001 but they are included here.

The assessment of progress, indicated by an icon at the end of each line, is a purely personal one and only meant as a general guide to which techniques appear to have significantly improved or to have declined in popularity – for the present, at least. It is not intended as a comment on how effective the technologies are.

## Key to Progress Rating

- Technology has moved from concept to active R&D or from R&D to COTS implementation
- Technology has improved in incremental steps
- No significant change
- R&D or use has declined

## Selected References

1. ONDCP International Technology Symposium 1999: Symposium Papers (CD ROM)
2. ONDCP International Technology Symposium 2001: Symposium Papers and Presentations (CD ROM)

A great number of sources were consulted in producing the Home Office review but the following were particularly useful:

3. Understanding X-Ray Cargo Imaging, Gongyin Chen, Nuclear Instruments and Methods in Physics Research B, 2005
4. Drugs of Abuse: Body Fluid Testing, Raphael Wong, Harvey Tse, Humana Press, 2005
5. Contraband detection with fast neutrons, Andy Buffler, Radiation Physics and Chemistry, 2004
6. Comparison of neutron and high-energy X-ray dual-beam radiography for air cargo inspection, Y. Liu, B.D. Sowerby and J.R.Tickner, Applied Radiation and Isotopes, 2008

| Application | Technique | Brief Description | State of the Art in 2001 | State of the Art in 2011 | Example COTS Products | Example R&D Projects | Progress Rating |
|---|---|---|---|---|---|---|---|
| **Detecting Drug Use** | Ion Selective Electrodes | Electrochemical technique for detecting drugs in solution – was applied to body fluids. | The US Naval Research Laboratory reported in 2001 on applying the technique to detecting cocaine in saliva | Abandoned because of low sensitivity and likely cost compared with immunoassay kits | | | ↓ |
| | Lateral Flow Immunoassay (oral fluid and sweat) | Detects drugs and metabolites using antibodies immobilised and chemically tagged to give a colour change. | COTS availability, but with a limited range of drugs detected | Much research, mostly in application to DUI screening. A wider range of drugs can be detected (though selectivity for some types of drug is limited), devices are widely available. Poor quantitation may be an issue in some countries, though sampling systems are improving | American Bio Medica Corporation (ABMC), Oralstat | | ↗ |
| | Lateral Flow Immunoassay (urine) | As for oral fluid and sweat but combined with a sampling device designed for urine. | COTS availability but not discussed at ONDCP in 1999 or 2001 | Wider range of drugs now detected with improvement in sampling devices and quantitation | | | ↗ |
| | Surface Enhanced Raman Spectroscopy | Raman spectroscopy made more sensitive by bringing the analyte into intimate contact with a microscopically textured metal surface. | Was proposed by the UK Home Office as a technique for detecting drugs in saliva, to be used at the roadside | No COTS product has been produced yet, partly because producing SERS substrates is difficult to do consistently. R&D continues. | | SpectraFluidics, Free-surface Microfluidic SERS<br>Real-Time Analyzers, Saliva SERS Drug Detector | ↗ |
| **Detecting Vapours And Traces** | Acoustic Mass Sensors | Sensors based on vibrating crystals with a selective coating. Adsorption of analyte or loss of reagent cause a change in vibrational frequency. Includes Quartz Crystal Microbalances and Surface Acoustic Wave detectors. | Used in COTS biosensors and GC-SAW devices. | Form the basis of a number of R&D projects but as far as off-the-shelf systems are concerned there is little change since 2001 | Biosensor Applications Sweden, BIOSENS 300/600 | Zen Sensing, Vapour Phase SAW Immunosensors | → |
| | Animal Olfaction | Uses natural olfactory ability of mammals such as dogs or insects such as bees. | Dogs had already been in use for many years. Automated systems based on both free-flying and constrained bees were being researched. | Dogs - little change.<br>Insects - further development has taken place but so far no COTS availability. | Many commercial dog trainers/service providers | Inscentinel, VASOR™ (honeybees) | ↗ |
| | Biosensors | Electronic sensors based on detecting enzyme or antibody reactions with the target drug. | At least one COTS implementation available | While there have been incremental improvements the technique is not widely used. Drawbacks include speed and limited selectivity for some types of drug | Biosensor Applications Sweden, BIOSENS 300/600 | Zen Sensing, Vapour Phase SAW Immunosensors | ↗ |
| | Biosensors (Body Fluid Sampling) | Electronic sensors based on detecting enzyme or antibody reactions with the target drug. Systems made for trace detection have also been used for saliva. | One COTS system in production | One COTS supplier, now with a range of products. Other R&D projects | Biosensor Applications Sweden, BIOSENS Dynamic/DrugScanner | McDevitt Labs, TasteChip | ↗ |
| | DMS/FAIMS | Differential Mobility Spectrometry or (high) Field Asymmetric Ion Mobility Spectrometry is a variation of IMS usually used with gas chromatography. Analysers are small and detect positive and negative ions simultaneously | Not discussed at ONDCP in 1999 or 2001 | Is used in the Thermo Scientific EGIS Defender explosive trace detector and the prototype SEDET ACES system but has not been fielded for drugs detection yet | | | ↑ |
| | Gas Chromatography | Separation technique used in combination with various detectors. | Main COTS implementations were GC-SAW and GC-IMS. Use of GC systems in portable devices had declined with increasing use of IMS. ONDCP paper in 2001 reported detection of ecgonidine methyl ester, a volatile decomposition product of cocaine, using lab GCMS | There are still some GC devices around, some of them developed in the last few years. Most originate in Canada. | Scintrex Trace, N2000<br>Quantitech, Teknoscan TSI 3000 Analyser (GC-IMS) | | ↗ |
| | Ion Mobility Spectrometry | Separates and detects ionised substances in the vapour phase by how fast they move through a gas under the influence of an electric field. | Most popular electronic trace detection technique, widely deployed | Improvements include more compact and rugged systems and dual-tube systems for simultaneous positive and negative ion detection. Development has been largely driven by counter-terrorism requirements. | Smiths Detection, Ionscan 500DT<br>Teknoscan, TSI 3000 (GC-IMS) | | ↗ |
| | Lateral Flow Immunoassay (Trace Testing) | As for oral fluid and sweat testing, but optimised for drugs rather than metabolites. | Widespread COTS availability of test devices, with one container- screening application discussed in 2001 - using air sampling. | No great change since 2001 except in detection range | Securetec Detektions-Systeme, DrugWipe & Drug Read<br>MMC International BV, Forensic Narcotic Tests | | ↗ |
| | Mass Spectrometry | Separates and detects ionised substances in the vapour phase by how they move through a vacuum under the influence of electric or magnetic fields. | Semi portable MS and GCMS systems already available but little used for drugs work. No ONDCP papers on field use | Lots of compact MS devices have been produced, mainly aimed at counter-terrorist and environmental applications. A COTS benchtop drugs detector was introduced then withdrawn, and an MS based person-sampling portal is now available | Mass Spec Analytical, Scentinel<br>Syagen Technology, Narcotics Trace Portal | Microsaic Systems, Miniature Quadrupole MS<br>SEDET, ACES (DMA-MS, currently explosives only) | ↗ |
| | Microcantilever Sensors | Sensors based on very small silicon strips (like springboards) coated with a selectively adsorbing or reacting coating. Adsorption of analyte or loss of reagent causes bending or changes the vibrational frequency of the strips. | One ONDCP paper, proposing the technique for detecting a taggant vapour | R&D continues but no COTS availability | | Triton Systems, MEMS Sensors | ↗ |
| | Molecularly Imprinted Polymers | Adsorbing materials engineered to selectively adsorb the target analyte. Used either with an acoustic mass sensor or to produce a visible colour change. | Was discussed in 1999 and 2000 as the basis for a sensor. Adsorption of the analyte was to be signalled by an optical method | No electronic sensors are availablein COTS form but an MIP-based "wet wipe" system was released for explosives. It signals detection by a colour change. There is an Australian project currently underway on drugs detection using MIPS | Raptor Detection, SAFE-T MIPs (explosives only) | University of Newcastle, Australia, R&D project | ↑ |
| | Surface Enhanced Resonance Raman Spectroscopy | A variation of Surface Enhanced Raman where the analyte is first turned into a coloured compound to enhance its absorption of light. | Was mentioned briefly in 1999 | Has been largely abandoned as it is very difficult to do consistently for a range of materials | | | ↓ |
| **Detecting Bulk Drugs (small)** | Dielectrometry | Uses radio or microwaves to measure the electrical properties of the target. Especially effective in discriminating between substances with different water contents, e.g. cocaine solution from pure water, drugs hidden in food | Application to drugs not discussed at ONDCP 1999 or 2001 but technique was being used in early 1990s | Many COTS devices now exist, mostly aimed at detecting explosives and flammable liquids in bottles but equally suitable for drugs | Emit Technologies, HTD660 Anomaly Detector<br>EMISENS, Emili 1+ | Emit Technologies, Dielectric People Portal II | ↗ |
| | Gamma and Neutron Backscatter Detectors | Hand-held non-imaging devices that use gamma rays to detect low-atomic-number materials. | A well established technique, not discussed at ONDCP in 1999 or 2001 | Only significant change is introduction of position sensing which allows a 2D graphical map of the instrument's response to be created, simplifying interpretation | SDS Group, Falcon Searcher Mk 6<br>Sas R&D Services, Buster K910B Contraband Detector | | ↗ |
| | Millimetre wave/terahertz imaging | Uses naturally emitted or electronically generated radiation to form an image of the body and objects hidden under clothing. | Technique existed but was not discussed at all for counter-drugs use | Many COTS devices, mainly aimed at counter-terrorist applications but some have been tried for detection of "body packers". Use for CT purposes has been controversial, however | Smiths Detection, eqo<br>Thruvision Systems,T4000 | Millivision, Portal System 350<br>Jet Propulsion Laboratory, Terahertz Imaging Radar | ↑ |
| | Nuclear Magnetic Resonance | Uses radio waves to identify substances by measuring the way the spin axes of atomic nuclei precess in a magnetic field. Used in medicine to produce images of soft tissues in the body. | US Customs in 1999 reported experimenting with the use of medical Magnetic Resonance Imaging scanners for detecting internal concealments - instead of using medical X-ray | During the decade efforts have been made to apply NMR to screening bottles of liquid for explosives. If such devices become common they may be applied to drugs but information is scarce | | | ↗ |
| | Nuclear Quadrupole Resonance | Uses radio waves to identify substances by measuring the way some asymmetric nuclei (such as nitrogen) are affected by the electric field of the surrounding electron cloud. | Detection of cocaine was discussed in 1999 and 2001 and there were two COTS baggage scanners for explosive detection on the market around that time. In the UK detection of drugs on people was being investigated. | Baggage systems are no longer available, partly because their use for explosives detection did not catch on. The Australian Commonwealth Science and Industrial Research Organisation (CSIRO) is testing a hand-held NQR "wand" for people screening. | | CSIRO Minerals , Handheld NQR Wand | ↗ |
| | Terahertz Spectroscopy | Terahertz radiation can pass through clothing and can be used to identify some substances by their distinctive reflection or emission spectra | Was unheard of in the counter-drugs/counter-terror community in 2001 | Despite excitement early the projected benefits have proved very difficult to realise in practical applications. Some work on illicit drugs has been carried out in China. | | RIKEN Advanced Science Institute (Japan), Mail Inspection System | ↑ |
| | X-Ray Backscatter Radiography: Baggage and Package Screening | Images scattered X-radiation to produce an image of inside baggage. Produces a natural-looking image which shows organic materials well. A transmission image is also produced | A well established technique, not discussed at ONDCP events. Used by US Customs though take-up globally was patchy | No major changes except that COTS systems now typically incorporate dual-energy transmission imaging | AS&E, Gemini series | | ↗ |
| | X-Ray Backscatter Radiography: People Screening | Images scattered X-radiation to produce an image of the body and objects under clothing. | COTS products well established and being tested operationally by US Customs in 2001 | Use for aviation security has raised awareness of the technology but also caused controversy about privacy and safety. There are regulatory problems in some countries | American Science and Engineering, SmartCheck<br>Rapiscan, Secure 1000 | | ↗ |
| | X-Ray Diffraction Imaging | Identifies substances, by their Bragg scattering patterns. Conventional method using a monochromatic source and measuring scattering angles, and an alternative measures energy spectrum at a fixed angle (Low Angle Scatter) | A baggage screening system using the conventional method was in an advanced stage of R&D. Work on low angle scatter for explosives detection had also begun | The conventional technique is now available commercially, the Low Angle Scatter technique is still at the R&D stage | Morpho Detection, XRD 3500 | UK Home Office/University College London, DILAX | ↑ |
| | X-Ray Tomography/Laminography | Uses multiple X-ray transmission images to build up a 3D model of a suitcase or cargo pallet and identify substances by their X-ray absorption properties. | Computed tomography for detecting explosives in baggage was an established technique in 2001 but not widely deployed. ONDCP papers were presented on the use of CT for drugs detection in baggage and packages | Although CT baggage scanners have improved considerably since 2001, they have not found much application in drugs detection yet. Drugs are harder to detect than explosives because they are often less dense and therefore harder to recognise | Reveal Imaging/SAIC, CT-80DR/CT80<br>Rapiscan Systems, RTT | | ↗ |
| | X-Ray Transmission Radiography: People Screening | Shows objects inside the body as well as in clothing | Not discussed at ONDCP 1999 or 2001 events but technique was already available commercially | There are now several COTS systems and increased interest in their use along with other body scanning techniques | Adani, ConPass<br>FISCAN, CMEX-70200 | | ↗ |
| | X-Ray Transmission Radiography: Baggage and Package Screening | Produces the familiar 2D shadow image of objects. By comparing images captured using different X-ray energies some discrimination between materials can be achieved. | A well established technique but not discussed at ONDCP in 1999 or 2001 | Main change has been automated detection, often based on multiple views, but this is harder to apply to drugs than to explosives, because drugs are less dense. Non-imaging systems using energy-discriminating detectors available for screening bottles of liquids | Reveal Imaging Technologies Inc, ArrayCT<br>Kromek, Bottle Scanner | | ↗ |
| **Detecting Bulk Drugs (large)** | Associated Particle Imaging (Tagged Neutrons) | Type of neutron activation analysis which provides a low-resolution image of the distribution of certain target elements. | New R&D subject with one ONDCP paper | A major R&D project took place in Europe during the decade and at least two companies now offer COTS devices for scanning cargo and baggage. Much of the R&D activity has been based on Russian technology. The technique is intrinsically slow, however. | Raytheon, neu-VISION Vehicle Inspection System<br>EADS-Sodern, ULIS | Euritrack/Eritr@c Consortium, EURITRACK/Eritr@c | ↑ |
| | Coded Aperture Fast Neutron Analysis | A lensless imaging technique applied to fast neutrons | Drugs application was being researched at MIT | Aside from its applications in medicine, coded aperture neutron imaging appears to be seen now largely as a method of locating radioactive sources | | | ↓ |
| | Neutron radiography | Uses a neutron beam to produce transmission images which preferentially show low-Z materials | Was known but not discussed in 1999 or 2001 | A combined neutron/X-ray system for air cargo was developed by the Australian Commonwealth Science and Industrial Research Organisation (CSIRO) during the decade, tested at Brisbane airport and commercialised by the Chinese company Nuctech | Nuctech, AC6015XN | | ↑ |
| | Potassium 40 Gamma Detection | Use of conventional radiation detectors to detect the radiation given off by vegetable matter such as cannabis, due to its high potassium content. | This technique was being researched by Canadian and US Customs for screening vehicles and cargo for large quantities of cannabis. | Abandoned when effort was switched to counter-terrorism | | | ↓ |
| | Pulsed Fast Neutron Activation | Uses a pulsed, directed beam of neutrons to trigger the emission of characteristic gamma rays from target elements and create a 3D image of elemental distribution. | A major operational trial of PFNA for cargo screening was being set up in 2001 at El Paso on the US/Mexican border | Systems were operationally deployed at El Paso (road freight) and at several airports (air cargo) but these projects have now ended and there has been no further take up | | | ↓ |
| | Pulsed Fast Neutron Transmission Spectroscopy and Fast Neutron Resonance Radiography | Two different methods of detecting target elements by their resonant capture of neutrons of a characteristic energy. | A paper on R&D in FNRR for contraband detection was presented in 2001 | Like most other big static neutron-based techniques this appears to have been abandoned, possibly because it has not been adopted for explosives detection | | | ↓ |
| | Pulsed Fast/Thermal Neutron Analysis | Uses pulses of fast neutrons which are thermalised in the target giving the benefits of both fast neutron and thermal neutron activation. | Two systems were in the R&D stage, Western Kentucky University's NELIS for cargo and SAIC's PELAN for searching buildings and ships | This technique seems to have been abandoned | | | ↓ |
| | Photon Activation Analysis | Uses gamma rays to induce radioactivity in various elements and identifies them by the shape of their decay curves. | Application to drugs not discussed at ONDCP 1999 or 2001 but technique was being investigated for explosives detection in late 1980s | One known project, aimed at explosives and drugs detection | | Valley Forge Composite Technologies, Thor LVX | ↗ |
| | Thermal Neutron Activation | Simplest neutron activation technique. Uses slow neutrons from an isotopic source to trigger the production of characteristic gamma rays from target elements, particularly nitrogen and chlorine. Has no imaging capability. | A vehicle screening system (VEDS) and a man-transportable ship-search system (SeaVEDS) were described in 1999 and 2001 respectively. | VEDS was commercially available and a system for screening small bags (SPEDS) was introduced during the decade. Neither were widely used, however, and they are no longer made | | | ↓ |
| | X-Ray Backscatter Radiography: Vehicle and Cargo Screening | Images scattered X-radiation to produce an image of inside vehicles. Produces a natural-looking image which shows organic materials well. | Mobile vehicle screening systems, which also had a transmission imaging-capability, were commonly deployed for customs use as were pallet-screening systems. | Change has mostly been in the addition of a separate high-energy transmission imaging system - in one system this is combined with three backscatter systems. Backscatter on its own is used in van-based and trailer-based systems, mostly for counter terrorist uses. | American Science and Engineering, Z Backscatter Van (ZBV), OmniView Gantry | | ↗ |
| | X-Ray Transmission Radiography: Vehicle and Cargo Screening | Produces 2D shadow image of objects. Comparing images captured using different X-ray energies in the 3-6 MeV region gives some discrimination between materials. Used in static, transportable and fully-mobile forms | A big area of interest in 2001; US Customs were investing heavily in it, and COTS products were becoming commonplace. Maximum X-ray energies were typically 2.5 MeV less but at least 1 6MeV system was under test. 1 MeV gamma systems were also popular. | Most systems now have 3-6 MeV maximum energy. Materials discrimination now available. Portal systems are a new development - used in a drive-through mode. Many systems used for detecting general contraband and detecting radiological and nuclear materials. | Many products from Smiths Detection, SAIC, Rapiscan, L3, Adani, Nuctech and others. | | ↗ |
| **Identifying Visible Quantities** | Colorimetric test kits | Use a range of chemical reactions to produce a visible colour change. Some will detect sub-milligram traces while others require larger amounts | Some tests (such as the Marquis test) were well established but none were discussed at ONDCP events 1999 or 2001 | A wide range of test are now available in a variety of forms - multi-reagent kits, wipes, sprays. Colorimetric kits can identify a wider range of drugs than immunoassay tests but typically specific only one drug at a time | IDenta Corp, IDenta range<br>Mistral Group, Cannabispray | | ↗ |
| | Fluorescence Spectroscopy | Detects or identifies drugs by their fluorescent properties | Not discussed at 1999 or 2001 ONDCP conferences though clearly a known technique | Two COTS devices available, one a hand-held device which detects traces of methamphetamine by their fluorescence and one which analyses solutions of drugs | CDEX, ID2 Meth Scanner,<br>NarTest, NTX2000 | | ↑ |
| | Infrared Spectroscopy | Identifies materials by their IR spectrum in transmission (vapours) or reflection (solids and liquids) | One ONDCP paper in 1999 on detection of drug-associated volatiles in air. | Portable IR spectrometers available for identification of liquids and solids. Standoff vapour detection is is largely in the R&D phase but air sampling IR detectors for volatiles are available. Developed for counter-terrorism and other uses but with potential for drugs use. | Smiths Detection, TravelIR II<br>Thermo Scientific, TrueDefender | | ↗ |
| | Raman Spectroscopy | Identifies compounds by illuminating them with light of a fixed wavelength and looking for characteristic spectral peaks in the scattered light. | Portable Raman spectrometers were just being introduced for identifying solids and liquids. Standoff detection was discussed in 1999. | Now a well-established off-the-shelf technique for identification of visible quantities. Standoff Raman is still in the advanced R&D stage and is aimed mainly at counter-terrorist applications | Thermo Scientific, FirstDefender<br>Morpho Detection, StreetLab Mobile | | ↑ |



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