An Improved Drug Driving Analytical Service.

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Abstract
The UK Government is targeting motorists suspected of driving whilst under the influence of drugs as part of its Road Safety Strategy and its Campaign Against Drugs. In response, the police service has adapted Standardised Field Sobriety Tests and Drug Recognition Examinations for use in the UK and introduced Field Impairment Testing (FIT).

The cost of the associated analytical work has hitherto been an obstacle to widespread adoption of FIT, but the Forensic Science Service has introduced a service that is structured to allow a graded response fitted to the requirements of each case. By using a modular structure, development was simplified and the service, which can process large numbers of samples quickly and cost effectively, can be easily extended.

Analysis of samples takes place in two stages, an initial enzyme immunoassay screen for a panel of common drugs of abuse followed by solid phase extraction, formation of a derivative and confirmation by gas chromatography/mass spectrometry. Much of the development work that was required was concerned with adapting these techniques for the analysis of blood samples using automated equipment.

For straightforward drug driving cases it is normal practice to confirm the presence of a single drug. When poly-drug use shows up there is a decision tree for selection of the drug to be confirmed. If required, the presence of the other drugs can also be confirmed. In a homicide all drugs detected are confirmed as a matter of course. A similar graded response is adopted for reporting the results.

The streamlined service was introduced in stages, starting on 1 January 2001. The new service has led to a substantial reduction in both cost and turn round time. Since it was introduced demand for the new service has also climbed steadily confirming that it met a need from the criminal justice system.

Introduction
Increased use and abuse of psychotropic drugs is seen as a potential cause of road traffic incidents. There is also evidence that a significant minority of drivers in the United Kingdom have drugs in their blood or urine and that this proportion is increasing. Between 1985 and 2000, for example, the proportion of road traffic fatalities with illicit drugs in their bodies increased from 3% to 18% (1). Furthermore, a survey of blood samples submitted for analysis for alcohol in 1995 found that 18% contained one or more drugs of abuse (2). In 2001 in a similar survey this proportion had increased to nearly 30% (3).
The proportion of drug users is much higher in specific segments of the population. For example, over 90% of a self-selected group of club goers reported that they had used drugs, 59% admitted to driving on drugs and 4.3% that they had been involved in a road traffic incident (4).

This research evidence supported a growing public perception that drug driving was contributing to death and injury on the road. As a consequence the UK Government has targeted motorists suspected of driving whilst under the influence of drugs as part of its Road Safety Strategy (5) and its Campaign Against Drugs (6).

As a response to the Government’s strategy the police service has adapted standardised field sobriety tests (SFST) and drug recognition examinations (DRE) for use in the UK. The result, Field Impairment Testing (FIT), was introduced in 2000 (7).

**Customer Requirement**
The UK has two specific drug driving offences (8):

- Driving whilst unfit through drink or drugs
- Causing death by driving whilst unfit through drink or drugs

In addition, of course, the presence of a psychotropic drug is an aggravating factor in motoring homicide. There are three essential ingredients to these offences - driving, impairment and the presence of a drug that could account for the impairment. Both the cost and time taken for this analysis have hitherto been major disincentives to increased enforcement activity by the police service. The Forensic Science Service (FSS) has now responded to these concerns by introducing a streamlined analytical procedure that allows it to process larger numbers of samples quickly and cost effectively. The analytical process is modular and capacity can be increased rapidly by adding additional modules when required. Reporting of results is structured in a way that also allows a graded response to the requirements of each case.

The past experience of the FSS indicated that 90% of positive samples from motorists contained one of a very limited group of drugs (9). In fact, cannabis and benzodiazepines (specifically temazepam and diazepam) accounted for 50% of the drugs detected in motorists’ blood samples. By concentrating on a standard panel of drugs, comprising amphetamines (including methylamphetamine and MDMA), benzodiazepines, cannabinoids, cocaine, methadone and opiates, the new system’s resources have been concentrated on the most important drug groups. If the arresting officer has reason to suspect that another drug is involved a more traditional screening process can be invoked.

For the least serious offence - driving whilst unfit - it is normal practice to confirm the presence of a single drug. When poly-drug use shows up at the screening stage there is a simple decision tree for selection of which drug to confirm. If required, the presence of the other drugs detected can also be confirmed. In a homicide all drugs detected are confirmed as a matter of course.

A similar graded response is adopted for reporting the results. In a straightforward case of impaired driving, an analytical report accompanied by a statement setting out the generic effects of the drugs is provided. When necessary this can be expanded to provide an interpretation of the analytical results in the specific context of the case. In a homicide this is done as a matter of course.
Analytical System
A two stage analytical process is used - screening to identify the drugs present in the blood sample followed by extraction, confirmation and quantitation of one (or more) of the drugs detected.

Screening
A competitive enzyme immunoassay (EIA) procedure is used for the screening. An enzyme labelled drug competes with free drug in the sample or standard for antibody sites that are fixed on a polystyrene plate. Excess enzyme is washed away, substrate is added and the absorbance of the well is measured. This is inversely proportional to the amount of free drug in the sample. The process uses a BioRad CODA™, which is an integrated immunoassay analyser intended for the automation of microplate-based assays. The drugs screened for, and their cut-off levels, are shown in Table 1. The instrument operates in a Windows 95 environment utilising icon-based commands.

Table 1

<table>
<thead>
<tr>
<th>Drug (Assay)</th>
<th>Cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine (Opiates)</td>
<td>25 ng/ml</td>
</tr>
<tr>
<td>Oxazepam (Benzodiazepines)</td>
<td>50 ng/ml</td>
</tr>
<tr>
<td>Specific Morphine</td>
<td>10 ng/ml</td>
</tr>
<tr>
<td>Benzoylecononine (Cocaine)</td>
<td>100 ng/ml</td>
</tr>
<tr>
<td>Methadone (Methadone)</td>
<td>25 ng/ml</td>
</tr>
<tr>
<td>Amphetamine (Amphetamines)</td>
<td>50 ng/ml</td>
</tr>
<tr>
<td>Methylamphetamine (Methylamphetamines)</td>
<td>50 ng/ml</td>
</tr>
<tr>
<td>Delta-9-THC (Cannabis)</td>
<td>10 ng/ml</td>
</tr>
</tbody>
</table>

Confirmation Decision Tree
A set of guidelines or “Decision Tree” is used to inform the choice of drug (or drugs) that will be confirmed following a positive response to more than one drug in the screening test. Decisions are based on a combination of information from three sources:

- Observations of the police officers involved
- The outcome of presumptive testing
- The effects of the drugs and their impact on driving skills

FIT training will equip police officers with some simple tools to enable them to determine whether or not a motorist is impaired and to classify the impairing substance. In general terms the symptoms can be classified as indicative of “sedation” or “stimulation”. As FIT becomes more widely used it should be possible to refine this classification. The target drugs can be assigned to one of these categories as shown in Table 2 although the “comedown” after stimulant use can give a broadly “sedation” picture. In addition specific symptoms may indicate a particular drug group.

Table 2

<table>
<thead>
<tr>
<th>Sedation</th>
<th>Stimulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine, codeine or dihydrocodeine</td>
<td>Amphetamine</td>
</tr>
<tr>
<td>Methadone</td>
<td>A ring-substituted amphetamine</td>
</tr>
<tr>
<td>Diazepam or temazepam</td>
<td>Cocaine</td>
</tr>
<tr>
<td>Cannabis</td>
<td></td>
</tr>
</tbody>
</table>
The immuno-assay results can be classified as "STRONG POSITIVE", "POSITIVE" or "INSIGNIFICANT/NEGATIVE". The limits for these classifications are shown in Table 3. In general a drug showing a strongly positive response to the immuno-assay screen will be confirmed in preference to one showing a weaker response.

**Table 3**

<table>
<thead>
<tr>
<th>DRUG CLASS</th>
<th>STRONG POSITIVE</th>
<th>POSITIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzodiazepines</td>
<td>&gt; 4000 ng/ml</td>
<td>50 to 4000 ng/ml</td>
</tr>
<tr>
<td>Free Morphine</td>
<td>&gt; 50 ng/ml</td>
<td>10 to 50 ng/ml</td>
</tr>
<tr>
<td>(Opiates)</td>
<td>(&gt; 500ng/ml)</td>
<td>(25 to 500 ng/ml)</td>
</tr>
<tr>
<td>Cocaine</td>
<td>&gt; 500 ng/ml</td>
<td>100 to 500 ng/ml</td>
</tr>
<tr>
<td>Methadone</td>
<td>&gt; 500 ng/ml</td>
<td>25 to 500 ng/ml</td>
</tr>
<tr>
<td>Amphetamine</td>
<td>&gt; 600 ng/ml</td>
<td>50 to 600 ng/ml</td>
</tr>
<tr>
<td>Methylamphetamine</td>
<td>&gt; 1000 ng/ml</td>
<td>50 to 1000 ng/ml</td>
</tr>
<tr>
<td>Cannabis</td>
<td>&gt; 175 ng/ml</td>
<td>10 to 175 ng/ml</td>
</tr>
</tbody>
</table>

**Confirmation**

The selected drug(s) are extracted from the blood sample using Solid Phase Extraction (SPE) on a Hamilton Microlab 4000 automated workstation. Positive pressure with nitrogen at up to 15psi is used to push liquids through the SPE cartridges. Duplicate samples of 0.5ml of blood and an aliquot of the appropriate deuterated internal standard are placed in glass tubes and the mixture made up to ~3ml with buffer solution. The solution is then vortexed and centrifuged and the supernatant liquid transferred to a Hamilton sample tube.

The SPE cartridges used are:

- 3ml ISOLUTE 130mg HCX for benzodiazepines, cocaine and methadone.
- 3ml ISOLUTE 100mg THC for THC-11-oic acid.
- NSYS SPEC PLUS 3ml MP1 30mg for opiates.

The opiates and THC-11-oic acid solutions undergo a hydrolysis step prior to extraction to hydrolyse any glucuronides. Amphetamines are not extracted by SPE methods, but by a simple liquid-liquid process. Calibration standards are made up for extraction using out-of-date human transfusion blood. Quality assurance (QA) standards and blank bloods also form part of the batch.

The SPE process then consists of a programmed series of actions by the robotic system:

- conditioning of the cartridges with methanol, water and buffer solution
- addition of the sample, forcing it through the cartridge and leaving the drug retained on the bed
- washing and drying the cartridge (aqueous/dry/solvent/dry)
- elution of the drug from the cartridge with a suitable solvent.

The extracts, with the exception of methadone, are converted to tertiary-butyldimethylsilyl (TBDM) derivatives prior to analysis by Gas Chromatography/Mass Spectroscopy.

Extracted samples are analysed in batches comprising a set of calibration standards, QA standards and case samples (in order of increasing EIA results). For calibration, a zero standard and five standards at concentrations varying between 10ng/ml and 2000ng/ml, are used, depending upon the drug being quantified. A minimum correlation coefficient of 0.99 is expected for the calibration graph.
A selective detector equipped with a positive ion source and quadrupole analyser is interfaced to an Agilent 6890 Series Gas Chromatograph with automatic sample injector. The system is controlled by Chemstation software and routinely operates in positive ion (EI) mode. A positive confirmation is only reported if the response for the compound is more than three times the background response in both the reagent blank and the solvent blank preceding the injection.

**Reporting Results**

The analytical results are reported in two stages. Initially, a simple factual report is issued setting out the results of both the screening tests and the subsequent confirmation of the presence of one or more of the drugs. The second report describes the effect of the relevant drug in general terms with specific reference to the effect that it might have on driving. Since drug induced impairment is an ingredient of the offence, this is necessary to demonstrate that there is a link between the impairment observed by the arresting officer and the drugs found.

Whilst in some cases a generic description of the effect of a drug on driving ability will suffice, in others the specific symptoms observed need to be related to the concentration of the drugs detected and the circumstances surrounding their consumption. In these cases the police can request a further report that deals with the specific facts of the case in question. At the same time the presence of other drugs detected during screening can be confirmed if this is necessary.

In cases of motoring homicide a full toxicologist’s report is provided as a matter of course.

**Discussion**

This new service was developed to enable modern automated analytical methods to be used on blood samples. The objective was to reduce both the cost of the service and the time taken to provide the police service and the criminal justice system with results. Using this approach, we have achieved a significant reduction in costs and timeliness has improved significantly, although there is still room for further improvement.

![Drug Driving Demand](image)

**Figure 1**

The extent to which we have met the needs of the police and criminal justice system can be judged by the demand for the new service. Since its introduction in January 2001 as a pilot with two police forces in the north of England, the new service has been made available to all
other police forces in stages, starting on 1 April 2001, and demand has increased steadily, as can be seen in figure 1.

Acknowledgements
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References