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Centice Mobile Field Lab-3000 (MFL-3000)
Technical Evaluation Report

October 2013 *(Phase II testing, February 2014, noted on page 15)*

Project Information

Evaluation Type: Mobile Field Lab-3000 Portable Raman Spectrometer

Stakeholder: Centice Corporation

Product Serial Number: 2102000003 (Unit 03)   Manufactured: June 2013

Product Serial Number: 2102000079 (Unit 79)   Manufactured: March 2013

Stakeholder Information

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Evaluation Summary

The National Forensic Science Technology Center (NFSTC) conducted an evaluation of the Centice Mobile Field Lab-3000 (MFL-3000), a Raman device purported to quickly interrogate and identify illicit drugs, common diluents, drug mixtures, precursors and controlled pharmaceutical preparations. This portable device was designed for use by law enforcement professionals to obtain analytical data about suspected drug samples in field environments.

The test plan for this evaluation was developed in conjunction with Centice. The framework of the test plan includes modules addressing:

- Conformity/Specificity-Illicit Drugs, Precursors, and Cutting Agents
- Conformity/Specificity-Pharmaceutical Preparations
- Specificity Groups
- Mixture Analysis
- Environmental Challenge
- Real World Samples
- Reproducibility

Centice provided two MFL-3000 units for the evaluation: unit 03 and unit 079. Unit 079 was used only in the environmental challenge portion of the evaluation. It was decided to use a second device for the environmental challenge to facilitate the testing process.

All samples in the evaluation were run in triplicate. Between runs, the samples were removed from the sampling surface, shaken (if appropriate), and replaced back on the sampling surface. Bulk powder samples were analyzed in plastic bags as well as powder emptied from capsules. Pharmaceutical preparations other than capsules were analyzed directly on the sampling surface (no baggie) per the manufacturer's request. Refer to Appendix A for the entire MFL-3000 test plan.

The results for each sample analyzed in this evaluation are summarized in data tables. It should be noted that polyethylene was detected and reported as a component in some of the samples. The baggies used in sample analysis are made of polyethylene. Attempts to optimize placement of the sample on the sampling surface were made in order to eliminate the polyethylene from the results without much success.

Conformity of Illicit Drugs, Precursors, and Cuts

Thirty pure bulk standard compounds were interrogated by the MFL-3000 in this section of the evaluation. The majority of the compounds produced accurate results that were reproducible in each trial. Codeine sulfate generated a result of morphine sulfate each time it was analyzed. Morphine sulfate successfully produced the correct result in two out of three trials. The third trial produced a "no result" response. The evaluation team has previously observed that codeine and morphine are not always correctly identified by Raman spectroscopy. This is not surprising given the similarity of the chemical structures.

Dextrose was the only other compound not accurately identified by the MFL-3000. "No result" was produced in each trial even though dextrose is in the Illicit Library.

Two cathinones, mephedrone HCl and MDPV HCl were successfully identified in triplicate by the MFL-3000. This is of particular significance since the illicit use of cathinones, also known as bath salts, has created the need for reliable field tests.

Conformity of Pharmaceutical Preparations

Illicit prescription drug abuse is a significant area of concern for law enforcement. Until now, pills were unsuccessfully analyzed by Raman spectroscopy devices due the small amount of active compound found in the pill, or due to interference by the binders, fillers and coatings. Online databases are used to presumptively identify prescription drugs in the field by their markings. Without completely intact, easily read markings even that method is difficult. Centice has addressed this concern with the MFL-3000. Unlike other Raman instrumentation currently available, the MFL-3000 features a prescription pill identification database that allows the user to enter pill markings, color or shape to identify an unknown prescription pill. This feature is used to further aid in the identification of prescription drugs when utilizing the "measure Rx & analyze" function. It is also used as a standalone "Visual Search" feature, which allows the user to presumptively identify pills in the field, which in turn allows them to enter case details, save and print the result. The prescription pill library contains 3,600 entries for comparison to samples encountered by law enforcement. The scope of this evaluation included the analysis of 24 pharmaceutical preparations, but did not include the analysis of partial pills or pills with the markings removed.

In most cases, the MFL-3000 accurately and reproducibly identified the pharmaceutical preparations interrogated. Of particular note is that alprazolam, a very popular tranquilizer frequently diverted for illicit use, was identified at 2mg, 0.5mg, and 0.25mg dosages.

Chlordiazepoxide yielded one "no result." A 50mg/25mg meperidine/promethazine sample produced three "no results." promethazine is in the library, but meperidine or a mixture of the two compounds is not. A tablet containing only promethazine was identified correctly. A 0.5mg lorazepam tablet gave a "no result" in each trial. The 5mg oxycodone tablet yielded one alprazolam result and two doxazosin results. The lorazepam and oxycodone data may be due to the low concentrations of the target compounds. The library contains both substances.

A 20mg Oxycontin was accurately identified as Oxycontin. It is recommended that the entry in the library be named the drug name of oxycodone instead of the trade name of Oxycontin. This naming convention is suggested for all entries in the prescription library.

Specificity Groups

The MFL-3000 handled the specificity groups well. Three different groups contained compounds of the same family and/or containing common structural characteristics. The objective was to ensure that the MFL-3000 could distinguish between them. The amine group and the cocaine group were 100% accurate and reproducible. Codeine again came up as morphine. As discussed before, this is probably due to the similar structural characteristics.

Mixture Analysis

Mixture analysis can be a challenge for any spectroscopy technique. As concentration of the target analyte decreases, the probability of the laser "seeing" it decreases as well. The laser interacts only with a very small section of the entire sample. To counteract this issue and to generate the most accurate results possible, operators should be trained to run a sample multiple times, to mix the sample between runs, and to optimize placement of the sample on the sampling surface.

The samples presented to the MFL-3000 in this section were prepared from pharmaceutical standards. The cocaine HCl:caffeine 50:50wt/wt and the methamphetamine HCl:dimethylsulfone 50:50wt/wt mixtures reported both components in triplicate. The 50:50 wt/wt mixture of cocaine base and caffeine generated two results reflecting both components, and one trial producing only caffeine for a result.

The 20:80 wt/wt cocaine base and caffeine was the only mixture at this concentration that the MFL-3000 reported both components in all three trials. The MFL-3000 saw only caffeine in the 20:80 wt/wt cocaine base and caffeine mixture in triplicate. Methamphetamine and DMS were reported in two of the three trials by the MFL-3000 at this lower concentration. The third trial reported only DMS.

Real World Samples

Analysis of real world samples using Raman spectroscopy is not only impacted by the limitations of mixture analysis mentioned above, but also by fluorescence. Real world samples can be complex mixtures containing compounds that emit significant fluorescence which compromises Raman analysis. Real world samples may also have a color or pigment that compromises Raman analysis. These limitations of the technology were evident in the results of this section.

The MFL-3000 only identified the target analyte in 50% of the real world samples. The cocaine base and methamphetamine samples were correctly identified for each trial. Cocaine HCl did not produce a result for all three trials and MDMA reported as baking soda twice and no result for the third trial.

Environmental Challenge

The MFL-3000 is contained in a ruggedized Pelican® case which complies with US Military, NATO, IEC and ATA standards for waterproofing, stacking, impact and durability. The MFL-3000 was subjected to two environmental challenges. Unit 03 was placed in a laboratory refrigerator for two weeks at a consistent 2°C, while Unit 79 was placed in the trunk of a car for the same length of time at temperatures that varied from 21°-35°C. The results from the instrument that was placed in the

refrigerator was 100% accurate and reproducible. The instrument from the car was accurate and reproducible for all samples except for the three trials of cocaine base. All three of these trials generated a "no result" outcome.

Inter-day Reproducibility

Inter-day reproducibility was assessed by running a caffeine standard daily for five days. The results from the five days were 100% accurate.

Summary

The MFL-3000 is a Raman detection system capable of identifying bulk amounts of illicit drugs, prescription drugs, precursors, and cutting agents. The device software is uncomplicated to use, and provides a rapid response and a printable report. Identification of pills is further enhanced by allowing the user to enter the pill markings. The MFL-3000 is portable and compatible with a variety of locations and circumstances. Training to operate the MFL-3000 is straightforward. Operator competency is quickly attained. Overall, it is a promising tool for the detection of illicit and prescription drugs.

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Data Centice Mobile Field Lab-3000 (MFL-3000) Evaluation Phase II Report

Table 1. Conformity of Ilicit Drugs, Precursors, Cuts

#	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	Acetaminophen	Acetaminophen	Acetaminophen	Acetaminophen	Sigma Aldrich, #:A7085, Lot: 111K0253
2	Acetic Anhydride	Acetic Anhydride	Acetic Anhydride	Acetic Anhydride	Fisher Scientific A10-100 Lot: 092K1175
3	Acetylsalicylic Acid (Aspirin)	Aspirin	Aspirin	Aspirin	Sigma Aldrich S-6271 Lot:11K0194
4	Amphetamine Sulfate	Amphetamine	Amphetamine	Amphetamine	Sigma Aldrich: A5880 Lot: 71K1581
5	Baking Soda	Baking Soda	Baking Soda	Baking Soda	Arm and Hammer Lot:9062
6	Benzocaine	Benzocaine	Benzocaine	Benzocaine	Sigma Aldrich: E1501 Lot: 092K1175
7	Benzylpiperazine (BZP)	BZP	BZP	BZP	Lipomed: PPZ-1070-HC Lot: 1070.1B1.2
8	Caffeine	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187
9	Carisoprodol	Carisoprodol	Carisoprodol	Carisoprodol	Sigma Aldrich C8759 Lot:39H0704
10	Cocaine HCl	Cocaine HCl	Cocaine HCl	Cocaine HCL	Sigma Aldrich C5776 Lot:059K1139
11	Cocaine Base (Secondary Standard)	Cocaine Free Base	Cocaine Free Base	Cocaine Free Base	TS-003 Supplier: DEA Lot: N/A
12	Codeine Sulfate	Morphine Sulfate	Morphine Sulfate	Morphine Sulfate	Sigma Aldrich: C122 Lot: 79H1482
13	Dextrose	No Result	No Result	No Result	Supplier: Beer and Winemaker's Pantry, Pinellas Park, FL Lot: N/A
14	Dimethyl Sulfone	Dimethyl Sulfone	Dimethyl Sulfone	Dimethyl Sulfone	Gaylord Chemical :GCC3 Lot: 09-028-02
15	Hydromorphone	Hydromorphone HCl	Hydromorphone HCl	Hydromorphone HCl	Sigma Aldrich: H5136 Lot: 072K0851
16	Inositol	Myo-inositol	Myo-inositol	Myo-inositol	Aldrich: I-665-2 Lot: 03031AQ
17	Ketamine	Ketamine	Ketamine	Ketamine	Sigma Aldrich: K2753 Lot: 110K1108
18	Lactose	Lactose	Lactose	Lactose	Fisher Scientific:L5-500 Lot: 082281
19	Lidocaine	Procaine	Procaine	Procaine	Sigma Aldrich: L-7757 Lot: 101K0120
20	Mephedrone HCl	Mephedrone	Mephedrone	Mephedrone	Cerilliant: NMID937 Lot: 09-D-28

#	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
21	Methamphetamine HCl	Methamphetamine	Methamphetamine	Methamphetamine	Sigma Aldrich: M8750 Lot: 098K0693
22	Methylenedioxy Pyrovalerone HCl (MDPV)	Polyethylene MDPV	Polyethylene MDPV	Polyethylene MDPV	Cayman Chemical:10684 Lot: 0424943-27
23	Methylenedioxy-N-Ethylamphetamine (MDEA)	MDEA	MDEA	MDEA	Sigma Aldrich: M1796 Lot: 96H4002
24	Methylenedioxymetham-phetamine (MDMA)	MDMA	MDMA	MDMA	Sigma Aldrich: M6403 Lot:070M4053
25	Morphine Sulfate	No Result	Morphine Sulfate Polyethylene	Morphine Sulfate	Sigma Aldrich M8777 Lot:040M1228
26	Nicotinamide	Nicotinamide	Nicotinamide	Nicotinamide	Sigma Aldrich: N-3376 Lot:111K0026
27	Oxycodone HCl	Oxycodone	Oxycodone	Oxycodone	Sigma Aldrich:O1378 Lot: 442K1709
28	Phencyclidine HCl	Phencyclidine	Phencyclidine	Phencyclidine	Cerilliant P-007 Lot: RE081511-04
29	Procaine	Procaine	Procaine	Procaine	Acros Organic 207311000 Lot:A020146801
30	Quinine	Quinine	Quinine	Quinine	Sigma: Q1878 Lot: 31K2533

Table 2. Conformity of Pharmaceutical Preparations

#	Drug	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	Acetaminophen	Acetaminophen	Acetaminophen	Acetaminophen	NDC:56062-484-85 Oblong, white L484
2	Alprazolam, 0.25mg	Alprazolam	Alprazolam	Alprazolam	No NDC, round, off-white G3719
3	Alprazolam, 0.50 mg	Alprazolam	Alprazolam	Alprazolam	NDC: 0378-4003-01 Round, pink/peach Mylan A3
4	Alprazolam, 2.0 mg	Alprazolam	Alprazolam	Alprazolam	No NDC#, rectangle, GG 2 4 9
5	Aspirin	Aspirin	Aspirin	Aspirin	NDC:41163-416-78 Round, white Aspirin-L
6	Carisoprodol	Carisoprodol	Carisoprodol	Carisoprodol	NDC:53265-266-10 Round A 266
7	Chlordiazepoxide HCl	No Result	Chlordiazepoxide HCl	Chlordiazepoxide HCl	NDC:0555-0033-02 Capsule: black/green BARR 033
8	Ciproflaxin	Ciproflaxin	Ciproflaxin	Ciproflaxin	No NDC: oblong, white, R/127
9	Clonazepam	Clonazepam	Clonazepam	Clonazepam	NDC:57664-273-08 round, yellow .5/273
10	Diazepam, 5mg	Diazepam	Diazepam	Diazepam	NDC: 0378-0345-01 Round Orange Mylan 345
11	Hydromorphone, 8mg	Hydromorphone HCl	Hydromorphone HCl	Hydromorphone HCl	No NDC: triangle, white, 8
12	Hydrocodone: Acetaminophen	Hydrocodone/APAP	Hydrocodone/APAP	Hydrocodone/APAP	No NDC Oval, white M357

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#	Drug	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
	5:500mg				
13	Hydrocodone: Acetaminophen 7.5:350mg	Hydrocodone/APAP	Hydrocodone/APAP	Hydrocodone/APAP	No NDC: Oblong, white, M366
14	Hydrocodone: Acetaminophen 10:650	Hydrocodone/APAP	Hydrocodone/APAP	Hydrocodone/APAP	No NDC: Oblong, blue V/35 97
15	Lorazepam, 0.50 mg	No Result	No Result	No Result	NDC:0378-0321-01 Round, white M/321 * Ran 5x's in various positions due to extreme small size of pill
16	Meperidine/Prometha-zine 50mg:25mg	No Result	No Result	No Result	No NDC: Capsule, red, Ethex 027
17	Methadone	Methadone	Methadone	Methadone	NDC-0406-3454-34 Round, white, methadose 10
18	Naproxen	Naproxen Sodium	Naproxen Sodium	Naproxen Sodium	No NDC: diamond, blue Aleve
19	Oxycodone 5mg	Doxazosin	Alprazolam	Doxazosin	NDC:52152-165-02 Round A 5
20	Oxycontin 20mg	Oxycontin	Oxycontin	Oxycontin	NDC:59011-103-25 Round, pink OC/20
21	Promethazine HCl	Promethazine	Promethazine	Promethazine	No NDC: Round, white, gg 225
22	Propoxyphene	Propoxyphene	Propoxyphene	Propoxyphene	NDC:0378-0129-01 capsule, pink, Mylan 129
23	Temazepam	Temazepam	Temazepam	Temazepam	NDC:0378-4010-01 Capsule, orange, Mylan 4010
24	Tramadol, 50mg	Tramadol	Tramadol	Tramadol	No NDC: Round, white, 319

Table 3. Specificity Groups

Grp #	Sample	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	Amphetamine	Amphetamine Sulfate	Amphetamine Sulfate	Amphetamine Sulfate	Sigma Aldrich: A5880 Lot: 71K1581
	Methamphetamine	Methamphetamine polyethylene	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693
	MDMA	MDMA	MDMA	MDMA	Sigma Aldrich: M6403 Lot:070M4053
	MDEA	MDEA	MDEA	MDEA	Sigma Aldrich: M1796 Lot: 96H4002
2	Morphine	Morphine Sulfate	Morphine Sulfate	Not Found	Sigma Aldrich M8777 Lot:040M1228
	Codeine	Morphine Sulfate	Morphine Sulfate	Morphine Sulfate	Sigma Aldrich: C122 Lot: 79H1482
3	Cocaine	Cocaine HCl	Cocaine HCl	Cocaine HCl	Sigma Aldrich: C5776 Lot:
	Benzocaine	Benzocaine	Benzocaine	Benzocaine	Sigma Aldrich: E1501 Lot: 092K1175
	Lidocaine	Lidocaine	Lidocaine	Lidocaine	Sigma Aldrich: L-7757 Lot:

Grp #	Sample	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
					101K0120
	Procaine	Procaine	Procaine	Procaine	Acros Organic 207311000 Lot:A020146801

Table 4. Mixture Analysis

#	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	**Cocaine HCl: Caffeine HCl 50:50**	Polyethylene Cocaine HCl Caffeine	Cocaine HCl Caffeine Polyethylene	Caffeine Cocaine HCl Polyethylene	Sigma Aldrich: C5776 Lot:059K1139 / Sigma Aldrich: C-0750 Lot: 71K187
2	**Cocaine HCl: Caffeine HCl 20:80**	Caffeine Polyethylene Cocaine HCl	Caffeine Polyethylene Cocaine HCl	Caffeine Polyethylene Cocaine HCl	Sigma Aldrich: C5776 Lot:059K1139 / Sigma Aldrich: C-0750 Lot: 71K187
3	**Cocaine Base: Caffeine HCl 50:50**	Caffeine Cocaine Base Magnesium Stearate	Caffeine	Caffeine Cocaine Base Magnesium Stearate	Secondary Standard TS-003 (DEA) / Sigma Aldrich: C-0750 Lot: 71K187
4	**Cocaine Base: Caffeine HCl 20:80**	Caffeine	Caffeine	Polyethylene Caffeine	Secondary Standard TS-003 (DEA) / Sigma Aldrich: C-0750 Lot: 71K187
5	**Methamphetamine: Dimethyl Sulfone 50:50**	Methamphetamine Polyethylene Dimethyl Sulfone	Dimethyl Sulfone Methamphetamine Polyethylene	Dimethyl Sulfone Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693/ Gaylord Chemical :GCC3 Lot: 09-028-02
6	**Methamphetamine: Dimethyl Sulfone 20:80**	Dimethyl Sulfone Polyethylene	Dimethyl Sulfone Polyethylene Methamphetamine	Dimethyl Sulfone Polyethylene Methamphetamine	Sigma Aldrich: M8750 Lot: 098K0693/ Gaylord Chemical :GCC3 Lot: 09-028-02

Table 5. Real World Samples

#	Drug	Trial 1	Trial 2	Trial 3	Sample Source
1	**Cocaine HCl**	No Result	No Result	No Result	TS-002 DEA
2	**Cocaine Base**	Cocaine Free Base	Cocaine Free Base	Cocaine Free Base	TS-003 DEA
3	**Methamphetamine**	Methamphetamine	Methamphetamine	Methamphetamine	TS-005 DEA
4	**MDMA**	Baking Soda	Baking Soda	No Result	TS-046 DEA

Table 6 a. Environmental Challenge at 2° C (Unit 03)

#	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	**Cocaine HCl**	Cocaine HCl	Cocaine HCl	Cocaine HCl	Sigma Aldrich: C5776 Lot:059K1139
2	**Cocaine Base**	Cocaine Free Base 87%	Cocaine Free Base	Cocaine Free Base	Secondary Standard TS-003 (DEA)
3	**Methamphetamine HCl**	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693
4	**Alprazolam .5mg**	Alprazolam	Alprazolam	Alprazolam	NDC: 0378-4003-01 Round, pink/peach Mylan A3
5	**Hydrocodone/Acetaminophen 5:500**	Hydrocodone Acetaminophen	Hydrocodone Acetaminophen	Hydrocodone Acetaminophen	No NDC Oval, white M357

Table 6 b. Environmental Challenge in trunk of car with temperatures ranging from 21-35° C (Unit 79)

#	Drug Reported	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	**Cocaine HCl**	Cocaine HCl	Cocaine HCl	Cocaine HCl	Sigma Aldrich: C5776 Lot:059K1139
2	**Cocaine Base**	No Result	No Result	No Result	Secondary Standard TS-003 (DEA)
3	**Methamphetamine HCl**	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693
4	**Alprazolam .5mg**	Alprazolam	Alprazolam	Alprazolam	NDC: 0378-4003-01 Round, pink/peach Mylan A3
5	**Hydrocodone/APAP 5:500**	Hydrocodone Acetaminophen	Hydrocodone Acetaminophen	Hydrocodone Acetaminophen	No NDC Oval, white M357

Table 7. Reproducibility

Day #	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	**Caffeine**	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187
2	**Caffeine**	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187
3	**Caffeine**	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187
4	**Caffeine**	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187
5	**Caffeine**	Caffeine	Caffeine	Caffeine	Sigma Aldrich: C-0750 Lot: 71K187

Findings

Strengths

- The MFL-3000 operates in a Windows environment and the software is straightforward and easy to operate.
- The MFL-3000 performed with accuracy and reproducibility for most samples (See Executive Summary).
- The MFL-3000 can be used with powders, liquids and pills. This evaluation only addressed intact pills.
- The unique pill identification capability worked well and is a valuable tool for law enforcement.
- The MFL-3000 generates an easy to read report that includes the spectra, and when applicable, library photographs of suspected prescription drugs.
- The MFL-3000 has a searchable and customizable library.
- The MFL-3000 power source is a rechargeable Li-polymer battery pack.
- The battery lasted a minimum of 4 hours with consistent and intermittent use.
- The MFL-3000 device, battery source, and computer are housed in a ruggedized outer case.
- Operator training can be accomplished quickly.
- The MFL-3000 is a non-destructive test.
- Although Raman lasers are inherently dangerous, the MFL-3000 has safety measures built in, and the laser will not engage if either version of the sampling lid isn't properly seated.

Suggestions

- The ability to delete, rename, and edit scans would be a desirable feature. A system audit log should be able to track user changes which would protect the integrity of the reports generated.

- Forced calibration of the unit every half an hour is unnecessary. Emphasize to operators that this setting can be changed in accordance with agency protocol.

- The current sample window is fairly large, and sample must be specifically placed within a small region of the window for an optimal scan. This area is not clearly marked for the user, and at times multiple scans must be performed after moving the sample to produce acceptable data. A smaller, better defined sampling area would enable the user to more efficiently optimize sample analysis.

- Effective presentation of a sample to the laser should be emphasized in training. Operators lacking experience with analytical devices are sometimes not familiar with the correlation between effective sampling and adherence to a specific procedure to dependable results.

- The analysis area and lid configuration does not allow for sampling liquids in vials. Some samples may compromise the structure of a plastic bag. Vials are a less problematic sampling container choice.

- Colored bars indicating result/spectra strength were unreliable. Consistently, when a scan was accessed at a later time the yellow bar was green.

- When choosing which prescription pill is being identified the user must click on the box to make a check mark turn green and save the scan. It was noticed that when returning to the software to view results later the selection did not always save.

- Operators should be trained to compare the sample spectrum with the matched library spectrum to confirm results. This is important especially when court testimony is involved.
- MFL-3000 results should be coupled with the results of a second independent different analytical technique that agree with the MFL-3000 data before identification is reported.

Conclusion

The MFL-3000 is a Raman instrument that satisfactorily detects illicit drugs, prescription drugs and cutting agents, and precursors. Its portability, quickness, easy-to-use software, and its ability to identify pharmaceutical preparations renders it extremely valuable to law enforcement. Training should emphasize all limitations of Raman spectroscopy, so that any sample producing a negative, unexpected, or questionable result is submitted to a laboratory for a complete analysis.

Appendix A

Centice Corporation MFL-3000 Test Plan

Project Information

Evaluation Type: Mobile Field Lab-3000 Portable Raman Spectrometer

Stakeholder: Centice Corporation

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Procedure

General

The step-by-step process of presenting a sample for analysis, operating the device, and reading the results will follow the manufacturer's recommended guidelines and training. Each sample will be prepared and interrogated in clear plastic bags, provided by Centice, and will be analyzed in triplicate.

The MFL-3000 comes equipped with two libraries: the pharmaceutical library containing 3,600 pharmaceutical preparations; and the illicit substances library containing drugs of abuse, common cuts, and precursors. As the evaluation is performed, each sample will be analyzed using the appropriate library.

Inter-day Reproducibility

- Caffeine will be run five (5) consecutive business days.

Conformity/Specificity – The following reference standards and pharmaceutical preparations will be presented to the MFL-3000 to examine the accuracy of the identifications. Some of the pharmaceutical preparations were purchased from a pharmaceutical company and some were obtained through local law enforcement (case samples). For those substances with multiple dosages for the same preparation, analysis will stop at the lowest dosage producing a positive result. Also, included in this section are groups of substances with structural similarity to assess specificity.

- **Illicit Drugs, Precursors, Cuts (30)**
  - Acetaminophen
  - Acetic anhydride
  - Acetylsalicylic acid (Aspirin)
  - Amphetamine Sulfate

- o Baking Soda
- o Benzocaine
- o Benzylpiperazine (BZP)
- o Caffeine
- o Carisoprodol
- o Cocaine HCl
- o Cocaine Base (Secondary Standard)
- o Codeine Sulfate
- o Dextrose
- o Dimethyl Sulfone
- o Hydromorphone HCl
- o Inositol
- o Ketamine
- o Lactose
- o Lidocaine
- o Mephedrone HCl
- o Methamphetamine HCl
- o Methylenedioxy Pyrovalerone HCl (MDPV)
- o Methylenedioxy-N-Ethylamphetamine HCl (MDEA)
- o Methylenedioxymethamphetamine (MDMA)
- o Morphine Sulfate
- o Nicatinamide
- o Oxycodone HCl
- o Phencyclidine HCl
- o Procaine
- o Quinine
- **Pharmaceutical Preparation Library (2)**
  - o Acetaminophen
  - o Alprazolam 0.25mg
  - o Alprazolam 0.5mg
  - o Alprazolam 2mg
  - o Aspirin
  - o Carisprodol
  - o Chlorodiazepoxide HCl
  - o Ciproflaxin
  - o Clonazepam
  - o Diazepam 5mg
  - o Hydromorphone 8mg
  - o Hydrocodone: Acetaminophen 5:500mg
  - o Hydrocodone: Acetaminophen 7.5:350mg
  - o Hydrocodone: Acetaminophen 10:650
  - o Lorazepam 0.5mg
  - o Meperidine/Promethazine 50mg/25mg
  - o Methadone
  - o Naproxen
  - o Oxycodone 5mg
  - o Oxycontin 20mg

- o Promethazine HCl
- o Propoxyphene
- o Temazepam
- o Tramadol 50mg
- **Specificity Groups**
  - o Amphetamine, methamphetamine, MDMA, MDEA
  - o Morphine, Codeine
  - o Cocaine, Benzocaine, Lidocaine, procaine

Mixture Analysis

The mixture analysis section defines an estimated weight percent range for which the MFL-3000 will detect the target compound. Homogeneous mixtures of 50%wt and 20%wt of the target compound will be prepared and presented to the MFL-3000 for analysis:

- Cocaine HCl: Caffeine
- Cocaine Base : Caffeine
- Methamphetamine HCl : Dimethyl Sulfone

Environmental Challenge

The MFL-3000 will be subjected to one of two different environmental conditions for two weeks (14 days): a trunk of a car with the temperature monitored; and a refrigerator at 2°C. A subset of samples tested in the Conformity/Selectivity section shall be analyzed and the results recorded.

- Cocaine HCl
- Cocaine Base
- Methamphetamine HCl
- Alprazolam (lowest dosage producing a positive result in Conformity/Selectivity)
- Hydrocodone/Acetaminophen (lowest dosage producing a positive result in Conformity/Selectivity)

Real-World Samples

Samples from adjudicated case samples will be subjected to MFL-3000 interrogation. At acquisition, each case was accompanied by a laboratory report identifying the drug(s) of abuse content. Cuts or diluents and quantitative data are not provided. The result of the MFL-3000 will be compared to the results of the laboratory report. Pharmaceutical preparations were not included in this section since they were interrogated in the Conformity/Selectivity section. Substances represented in the case samples would include:

- Cocaine HCl
- Cocaine Base
- Methamphetamine
- MDMA

Final Report

Once testing is completed, the data will be tabulated and presented in a final written report along with conclusions about the performance of the MFL-3000.

Centice Mobile Field Lab-3000 (MFL-3000)
Evaluation Phase II Report

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Project Information

Evaluation Type: Mobile Field Lab-3000 Portable Raman Spectrometer

Stakeholder: Centice Corporation

Stakeholder Information

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Evaluation Summary

In 2013, the National Forensic Science Technology Center (NFSTC) performed an evaluation to assess the performance of the Mobile Field Lab-3000 (MFL-3000). Since that initial evaluation, Centice has updated the MFL-3000 software from version 5.1 to version 5.4. To assess the efficacy of the modified software, NFSTC re-analyzed the samples in the Mixture Analysis and Real World Sample sections. It should ne noted that a different cocaine HCl real world sample was interrogated in Phase II of the the evaluation. The sample used in Phase I was consumed in other NFSTC projects. All other samples were the same.

Mixture Analysis

Mixture analysis can be a challenge for any spectroscopy technique. As concentration of the target analyte decreases, the probability of the laser "seeing" it decreases as well. The laser interacts only with a very small section of the entire sample. To counteract this issue and to generate the most accurate results possible, operators should be trained to run a sample multiple times, to mix the sample between runs, and to optimize placement of the sample on the sampling surface.

The samples presented to the MFL-3000 in this section were prepared from pharmaceutical grade standards. The cocaine HCl:caffeine mixtures at both concentrations and the methamphetamine HCl:dimethylsulfone mixtures at both concentrations reported both sample components in triplicate. This was consistent with the results from Phase I. In Phase II the 50:50 wt/wt mixture of cocaine base and caffeine generated three results reflecting both components, while in Phase I, one replicate registered only the caffeine.

The Phase II results for the 20:80 wt/wt cocaine base and caffeine sample were consistent with those in Phase I. The MFL-3000 reported only caffeine in all three trials.

Real World Samples

Analysis of real world samples using Raman spectroscopy is not only impacted by the limitations of mixture analysis mentioned above, but also by fluorescence. Real world samples can be complex mixtures containing compounds that emit significant fluorescence which compromises Raman analysis. Real world samples may also have a color or pigment that compromises Raman analysis.

In Phase II of the evaluation, the MFL-3000 showed improvement in the analysis of real world samples. The target analyte was identified in all the samples but MDMA.

Summary

Data from Phase II of the MFL-3000 evaluation indicates improved performance due to the upgrade in software. Re-analysis of the mixture and real world samples produced an increase in accurate results during Phase II.

Data

Table 1. Mixture Analysis

#	Drug Solution	Trial 1	Trial 2	Trial 3	Sample Manufacturer Information
1	**Cocaine HCl: Caffeine HCl 50:50**	Caffeine Cocaine HCl	Caffeine Cocaine HCl Polyethylene	Caffeine Cocaine HCl Polyethylene	Sigma Aldrich: C5776 Lot:059K1139 / Sigma Aldrich: C-0750 Lot: 71K187
2	**Cocaine HCl: Caffeine HCl 20:80**	Caffeine Cocaine HCl	Caffeine Cocaine HCl Magnesiam Stearate	Caffeine Polyethylene Cocaine HCl	Sigma Aldrich: C5776 Lot:059K1139 / Sigma Aldrich: C-0750 Lot: 71K187
3	**Cocaine Base: Caffeine HCl 50:50**	Caffeine Cocaine Free Base	Caffeine Cocaine Free Base	Caffeine Cocaine Free Base	Secondary Standard TS-003 (DEA) / Sigma Aldrich: C-0750 Lot: 71K187
4	**Cocaine Base: Caffeine HCl 20:80**	Caffeine	Caffeine	Caffeine	Secondary Standard TS-003 (DEA) / Sigma Aldrich: C-0750 Lot: 71K187
5	**Methamphetamine: Dimethyl Sulfone 50:50**	Dimethyl Sulfone Methamphetamine Polyethylene	Dimethyl Sulfone Methamphetamine Polyethylene	Dimethyl Sulfone Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693/ Gaylord Chemical :GCC3 Lot: 09-028-02
6	**Methamphetamine: Dimethyl Sulfone 20:80**	Dimethyl Sulfone Methamphetamine	Dimethyl Sulfone Methamphetamine Polyethylene	Dimethyl Sulfone Methamphetamine Polyethylene	Sigma Aldrich: M8750 Lot: 098K0693/ Gaylord Chemical :GCC3 Lot: 09-028-02

Table 2. Real World Samples

#	Drug	Trial 1	Trial 2	Trial 3	Sample Source
1	**Cocaine HCl**	Cocaine HCl	Caffeine Cocaine HCl	Cocaine HCl Caffeine	**TST-118 PCSO**
2	**Cocaine Base**	Cocaine Free Base	Cocaine Free Base	Cocaine Free Base	**TS-003 DEA**
3	**Methamphetamine**	Methamphetamine Polyethylene	Methamphetamine Polyethylene	Methamphetamine Polyethylene	**TS-005 DEA**
4	**MDMA**	Baking Soda	Baking Soda	Baking Soda	**TS-046 DEA**