Final Report Date: **10/6/2009**

Forensic Technology Testing & Evaluation Project

Project Title:	**Projected Start Date:**
PHAZIR ™ handheld Near-Infrared Analyzer Evaluation	05/26/2009
Evaluation Type: (Instrument, kit, procedure, product-to-product comparison study, etc.)	**Projected End Date:**
Portable handheld instrumentation	09/01/2009
Evaluation Team Leader:	**Contact Telephone:**
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Evaluation Team:

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Manufacturer Information for product(s) being evaluated *(if applicable)*
Please provide information for each product. If more space is needed, attach a separate document.

Manufacturer	**Address**	**Contact Person**	**Phone**
Polychromix, Inc.	30 Upton Drive, Wilmington, MA 01887	Fredrick G. Haibach	(978) 284-6022

Evaluation Overview

Evaluation Summary:

The Forensic Services Chemistry section of the National Forensic Science Technology Center (NFSTC) performed an assessment on the handheld PHAZIR ™Near-Infrared spectral analyzer manufactured by Polychromix, Inc. This type of field portable Near Infrared (NIR) spectrometer is currently being utilized to conduct fast, non-destructive, qualitative or quantitative analysis on solids, powders as well as other materials in a variety of different industries. Some of those industries include pharmaceutical manufacturing, polymer recycling, agriculture, environmental monitoring, and petrochemical production. Given that NIR has been well established and proven successful in material identification for these industrial applications, this performance evaluation was conducted to determine whether the PHAZIR ™ would be suitable for the rapid identification of forensically relevant materials like controlled substances and explosives.

The PHAZIR™ is a handheld NIR-based spectrometer that has a semi-rugged, ergonomic, and light weight design. This instrument uses a safe Tungsten lamp as the excitation incident light source which is focused onto the unknown sample after the PHAZIR™ trigger has been activated by the user. When the sample is exposed to the electromagnetic radiation emitted from the light source, that radiation will be reflected, absorbed and/or transmitted. The interaction between this harmless radiation and the compound(s) contained within the sample cause molecular excitation as well as vibrational energy changes. These vibrational changes cause functional groups; especially O-H, C-H, C-O, C=O, C=C, S-H and N-H if they are present within the sample compound(s), to stretch and bend. During the analysis, the instrument collects digitized data of the corresponding overtones and combinations of vibrations that result in a spectra or unique chemical “fingerprint” of the material. This chemical “fingerprint” is graphically represented by plotting the spectral reflectance versus the wavelength. The PHAZIR™ model used in the evaluation was capable of scanning a wavelength range from 1600nm to 2400nm with an optical resolution of 11nm.

The evaluation objectives were as follows:

- Build a single chemometric model for controlled substances, cutting agents, and non-controlled substances.
- Objectively assess and determine the relevance of the PHAZIR™ analyzer for the analysis and identification of the aforementioned substances and explosives.
- Perform experiments to determine conformity, sensitivity, specificity, reproducibility, portability and the effects of environmental factors on performance.
- Provide user feedback to the forensic community, law enforcement and defense agencies as well as to the manufacturer regarding assessment findings.

Experimental Design:

To properly assess the application of the portable PHAZIR™ NIR analyzer for use in controlled substance and explosive identification, experiments were specifically designed to test the analyzers performance in traditional and non-traditional laboratories as well as a field-type environment. To accomplish these goals and maintain scientific objectivity, the evaluation was divided into the following parts:

Part I: Development of a Chemometrics Model for the Classification/Identification of Controlled Substances, Cutting Agents, and Non-Controlled Substances (OTC).

- Reference samples were placed into appropriately labeled 20mL disposable scintillation vials and capped (refer to Table 1).
- The reference samples of pure controlled substances, cutting agents, and non-controlled substances were analyzed as reference spectra.
- A background reference was automatically taken as needed using the white reference standard positioned within the instrument.
- A minimum of five spectra were collected for each reference standard.
- During the evaluator's training session, the PHAZIR™ Method Generator (MG) software and the previously ascertained spectra were used to build a chemometrics drug model with minimal assistance from the Polychromix instructor.
  **Note: When a chemometrics model is constructed properly, it will account for most of the molecular variability occurring within the collection of reference spectra for each of the compounds of interest; thus statistically reducing the occurrence of unknown sample misidentification errors.*
  ***Note: The manufacturer's explosive model was used during the assessment instead of developing a new user model for explosive identification. The Polychromix mathematically enhanced narcotics model was also evaluated.*

Part II: Determination of Conformity, Sensitivity, Specificity, Reproducibility, Portability, and Environmental Effects

- Conformity was ascertained using pure standards of controlled substances, cutting agents, and explosives with the appropriate chemometrics model selected on the PHAZIR ™ (see Table 4 for sample information).
- Specificity was assessed using control substance standards, cutting agents, non-controlled substances, explosives and NFSTC training samples (refer to Table 5). The "Controlled Substance ID", "Narcotics_MA_V1_0" and "Explosives_MA_V0.5" models were all used for this portion of the evaluation. A direct comparison was performed between the "Controlled Substance ID" model built at NFSTC and the "Narcotics_MA_V1_0" model; a modified version enhanced by a representative from Polychromix, Inc.
- Sensitivity was determined for each controlled substance using prepared standard mixtures of controlled substances with caffeine at varying weight to weight ratios ranging from 80:20 down to 5:95. Samples were placed into vials and analyzed in triplicate (see Table 6 for more information).
- To assess portability, the NIR analyzer was transported from the NFSTC laboratory to one of the NFSTC mobile laboratories. The instrument was removed from the transport Pelican™ case and allowed to warm-up for 5 minutes. A background reference spectrum was taken as needed. A small sample set comprised of explosives, controlled substances, non-controlled substances and cutting agents were analyzed in duplicate and the results recorded (refer to Table 7).
- Using a sample composed of a 50:50 ratio of cocaine HCl to caffeine, an intra-day as well as a ten-day inter-day reproducibility study was performed. The intra-day and inter-day studies were

conducted using the "Controlled Substance ID" model while obtaining spectra in triplicate from the same sample of cocaine HCl to caffeine ratio over a ten-day period (see Table 8).

- In order to test the performance of the PHAZIR™ under different environmental factors, the instrument was properly setup outdoors under the cover of shade with a temperature of 27.9°C and 64% humidity. Several test sample spectra were collected and the results recorded; while background spectra were collected as needed. The instrument was then moved to a controlled laboratory environment at 25.1°C and 47% humidity, and allowed to equilibrate. Following the equilibration period, spectra were obtained from the previously analyzed sample set for a direct comparison (Refer to Table 9).

Part III: Testing the PHAZIR analyzer on Real Case Samples

- The instrument was transported to the Manatee County Sheriff's Office in the foam-lined transport case provided with the device. Once there, the handheld analyzer was removed from its protective case, turned on, placed onto the laboratory countertop and allowed to warm up for approximately five minutes.
- Adjudicated forensic drug case samples were transferred to appropriately labeled 20mL scintillation vials, capped and then analyzed.
- The following information was recorded in an Excel spreadsheet for each of the case samples analyzed: sample number, laboratory results, lab methodology used for ID, as well as the PHAZIR results in triplicate (refer to table 10).

Standards, Controls and Samples Interrogated During Evaluation:

Table 1: Reference Standards for Chemometrics Model Build

Controlled Substances	**Controlled Substances**	**Explosives**
Alprazolam	Mescaline	TNT
Amitriptyline HCl	Methadone	C4
Amobarbital	d,l-Methamphetamine	PETN
d-Amphetamine Sulfate	Methaqualone	Ammonium Nitrate
d,l-Amphetamine Sulfate	p-Methoxyamphetamine (PMA)	Ammonium Perchlorate
Benzphetamine HCl	MDA	
Butalbital	MDEA	**Cutting Agents**
Carisoprodol	MDMA	Mannitol
Chloral Hydrate	Methylphenidate	Boric Acid
Chlordiazepoxide HCl	Morphine Sulfate	Caffeine
Clonazepam	Oxycodone	Procaine
Clorazepate	Phenobarbital	Benzocaine
Cocaine HCl and base	Phencyclidine	DMS
Codeine Sulfate	Phenobarbital	Niacinamide
Dextromethorphan HBr	Phetermine	Quinine
Diazepam	Piroxicam	
Ephedrine HCl	Pseudoephedrine HCl (OTC)	
S-Fenfluramine HCl	Psilocin	

Fentanyl Citrate Salt	Psilocybin	
Flunitrazepam	Secobarbital	
Gamma Hydroxybutyric Acid	Stanozolol	
Heroin	Temazepam	
Hydrocodone	Testosterone Acetate	
Hydromorphone	Testosterone Cypionate	
Imipramine HCl	Testosterone Decanoate	
Ketamine	Testosterone Enanthate	
Lorazepam	Testosterone Propionate	
Lysergic Acid Diethylamine	Triazolam	
Meperidine	Thebaine	

Table 2: Samples For Sensitivity Determination

Controlled Substance	Cutting Agent	Ratio(s)
Heroin	Caffeine	80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90, and 5:95
Methamphetamine		
Cocaine Base		
Cocaine HCl		

Table 3: Specificity Samples

Training Samples (Cases)	Explosives
Alprazolam 2mg, TS-015	TNT, C4, PETN
D,L Amphetamine, TS-001	Ammonium Nitrate
Clonazepam 5mg, TS-020	Ammonium Perchlorate
Cocaine HCl, TS-002	
Cocaine base, TS-003	**Non-Controlled Substances**
Diazepam 5mg, TS-020	Acetylsalicyclic Acid
MDMA/Methamphetamine, TS-006	Ibuprofen
Heroin, TS-004	Guafinosen
Methamphetamine, TS-005	Diphenhydramine
	Chlorpheniramine
Cutting Agents	Pseudoephedrine
Caffeine	
Procaine	**Controlled Substances**
Mannitol	Methylenedioxyamphetamine (MDA)
	Methylenedioxyethylamphetamine (MDEA)
	Morphine
	Codeine Sulfate

Projected Major Milestone Dates:
Please outline the procedure for your evaluation:

Date	Milestone Activity
05/26/2009	Building of Chemometrics Model

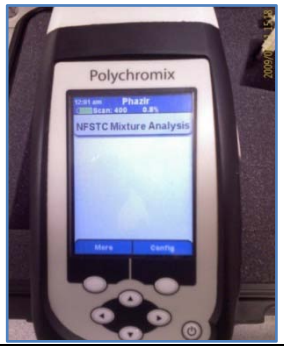
07/17/2009	Completion of Sensitivity, Specificity, and Reproducibility Studies
07/22/2009	Portability and Environmental Testing
07/28/2009	Adjudicated Forensic Drug Case Sample Testing

Product(s) Specifications:

Brief description of Product(s)/Technology/Procedure being evaluated:

Product Name(s)	**Model Number:**	**Serial/Lot Number:**	**Dimensions:**
PHAZIR™ NIR Analyzer	1624	1001	10in x 11.5in x 6in
	Cost:	**Weight:**	**Power Req.:**
	$38,000	**2.7 lbs**	**Battery**
Storage Conditions	**- 20 to +70°C**		
Operational Conditions:	**5 to 40°C**		
Associated costs: *(Consumables, maintenance, etc.)*	**Optional sampling vials.**		

Photo/Image of Product(s):



Evaluation

Instrumentation *(if applicable)*

Instrument Setup Performed by *(check one):*

____ Manufacturer
__x_ Manufacturer and Evaluator(s)
____ Evaluator(s) Only

Instrument Setup Comments:

The instrument was transported from Polychromix, Inc. to the NFSTC laboratory facility by a representative from the company. The following components were provided with the handheld NIR

instrument:

- Black foam-lined Pelican™ type case
- Wall plug adapter and battery charger
- Two lithium ion rechargeable batteries
- Scintillation vials w/caps
- Safety lanyard
- PC interface cable
- User manual
- PHAZIR MG software

The handheld NIR instrument was placed on a laboratory bench top and a lithium ion battery was inserted into the handle of the unit. The second lithium ion battery was placed into the table top battery charger, which was plugged into a 110 VAC outlet. After powering on the unit, it took approximately 30 seconds for the instrument to boot and reach operational readiness.

Level of Operator Knowledge as Set by Manufacturer:

_x__ Non-Scientist
____ Technician
____ Scientist

Results of Evaluation (Tables, Graphs)

Table 4: Conformity Data

Drug	Replicate #1 Confidence Level/ID	Replicate #2 Confidence Level/ID	Replicate #3 Confidence Level/ID	Model: Controlled Substance ID Comments
Cocaine HCl	High/Cocaine HCl, Scan # 686	High/Cocaine HCl, Scan # 687	High/Cocaine HCl, Scan # 688	
Cocaine Base (In Baggie)	High/Cocaine Base, Scan # 689	High/Cocaine Base, Scan # 690	High/Cocaine Base, Scan # 691	High/polyethylene for replicates #1,#2,#3
Methamphetamines	High/Methamphetamine, Scan # 692	High/Methamphetamine, Scan # 693	High/Methamphetamine, Scan # 694	
Heroin	High/Heroin, Scan # 695	High/Heroin, Scan # 696	High/Heroin, Scan # 697	
Cutting agents	**Replicate #1 Confidence Level/ID**	**Replicate #2 Confidence Level/ID**	**Replicate #3 Confidence Level/ID**	Model: Controlled Substance ID **Comments**
Mannitol	High/Mannitol, Scan # 698	High/Mannitol, Scan # 699	High/Mannitol, Scan # 700	
Niacinamide	High/Niacinamide, Scan # 701	High/Niacinamide, Scan # 702	High/Niacinamide, Scan # 703	
Boric Acid	High/Boric Acid, Scan # 704	High/Boric Acid, Scan # 705	High/Boric Acid, Scan # 706	
Benzocaine	High/Benzocaine, Scan # 707	High/Benzocaine, Scan # 709	High/Benzocaine, Scan # 710	708 scan-Failed due to movement of handheld during analysis
Lidocaine	High/Lidocaine, Scan # 711	High/Lidocaine, Scan # 712	High/Lidocaine, Scan # 713	
Caffeine	High/Caffeine, Scan # 714	High/Caffeine, Scan # 715	High/Caffeine, Scan # 716	
Procaine	High/Procaine, Scan # 717	High/Procaine, Scan # 718	High/Procaine, Scan # 719	
Inositol	High/Inositol, Scan # 720	High/Inositol, Scan # 721	High/Inositol, Scan # 722	
Tetracaine	High/Tetracaine, Scan # 723	High/Tetracaine, Scan # 724	High/Tetracaine, Scan # 725	
DMS	High/DMS, Scan # 726	High/DMS, Scan # 727	High/DMS, Scan # 728	

Explosives	Replicate #1 Confidence Level/ID	Replicate #2 Confidence Level/ID	Replicate #3 Confidence Level/ID	Model: Explosives MA V0.5 Comments
TNT	High/TNT, Scan # 730	High/TNT, Scan # 731	High/TNT, Scan # 732	
C4	High/C4, Scan # 733	High/C4, Scan # 734	High/C4, Scan # 735	
PETN	High/PETN, Scan # 736	High/PETN, Scan # 737	High/PETN, Scan # 738	
Ammonium Nitrate	High/Ammonium Nitrate, Scan # 739	High/ Ammonium Nitrate, Scan # 740	High/ Ammonium Nitrate, Scan # 741	
Ammonium Perchlorate	High/Ammonium Perchlorate, Scan # 742	High/Ammonium Perchlorate, Scan # 743	High/Ammonium Perchlorate, Scan # 744	

Table 5: Specificity Data

	Replicate #1	Replicate #2	Replicate #3	Comments
Training Samples (Cases)				Model: Controlled Substance ID
D,L Amphetamine, TS-001	High/Dimethylsulfone, Scan # 746	High/DMS, Scan # 748	High/ DMS, Scan # 750	High Confidence for DMS (~78% of spectrum), Amp std @ 9.7% conc. Scan747&749-Failed due to movement. Not identified
Cocaine HCl, TS-002	High/Cocaine HCl, Low PhenoBarbital, Scan # 759	High/Cocaine HCl, Low PhenoBarbital, Scan # 760	High/Cocaine HCl, Low Phenobartibal, Low Oxycodone, Scan # 761	High Confidence for Cocaine HCl but results are also showing low confidence for other drugs.
Cocaine base, TS-003	High/Cocaine base, Scan # 762	High/Cocaine base, Scan # 763	High/Cocaine base, Scan # 764	High Confidence for Cocaine Base (83-87% of spectrum). Cocaine Base std @83% conc.
MDMA/Methamphetamine, TS-006 (Pink color)	Unknown Material, Scan # 765	Unknown Material, Scan # 767	Unknown Material, Scan # 768	Scan 766 - Failed due to movement. No ID
Heroin HCl, TS-004	High/Herion, Low/H2O, Low Mescaline, Scan # 1038	High/Herion, Med/H2O, Low Mescaline, Scan # 1039	High/Herion, Low/H2O, Low Mescaline, Scan # 1038	Brown Heroin@86% conc. Heroin ~70-71% of the spectrum.
d,l Methamphetamine, TS-005	High/d,l-Methamphetamine, Scan # 1041 84%	High/d,l-Methamphetamine, Scan # 1042 79%	High/d,l-Methamphetamine, Scan # 1042 86%	Methamphetamine ~79-86% of the spectrum. d,l-methamphetamine @96% conc.
	Replicate#1	Replicate#2	Replicate#3	Comments
Training Samples (Cases)				Model:Narcotics_MA_V1_0
D,L Amphetamine, TS-001 (Powder)	High/MethylSulfone, Medium/LSD, Scan # 1018	High/MethylSulfone, Medium/LSD, Scan # 1019	High/MethylSulfone, Low/ LSD, Scan # 1020	High Confidence for MethylSulfone, Low to Med for LSD. Training

				sample @ 9.7% conc for amphetamine.
Cocaine HCl, TS-002 (Powder to slight chunky)	High/Cocaine HCl, Low/Borax, Scan # 1021	High/Cocaine HCl, Low/Borax, Low/Amitriptyline HCl, Scan # 1022	High/Cocaine HCl, Low/Borax, Scan # 1023	Cocaine HCl ~64% of the spectrum, while Borax was 8%
Cocaine base, TS-003 (Powder to semi-chunky)	High/Cocaine base, Scan # 1025	High/Cocaine base, Scan # 1026	High/Cocaine base, Scan # 1027	Cocaine Base ~83%-84% of the spectrum.
MDMA/Methamphetamine, TS-006 (Pink color powder)	Unknown Material, Scan # 1028	Unknown Material, Scan # 1029	Unknown Material, Scan # 1030	Not Identified
Heroin HCl, TS-004 (Brown Powder)	High/Heroin, Low/H2O, Scan # 1031	High/Heroin, Medium/H2O, Scan # 1032	High/Heroin, Medium/H2O, Scan # 1033	Brown Heroin@86% conc. Heroin ~69-70% of the spectrum.
d,l Methamphetamine, TS-005 (Powder to semi-chunky)	High/Methamphetamine, Scan # 1034	High/Methamphetamine, Scan # 1035	High/Methamphetamine, Scan # 1036	Methamphetamine ~82-85% of the spectrum. D,l-methamphetamine @96% conc.
	Replicate#1	**Replicate#2**	**Replicate#3**	**Comments**
Controlled Substances				Model:Controlled Substance ID
Methylenedioxyamphetamine (MDA) STD	High/Methylenedioxyamphetamine Scan # 1068	High/Methylenedioxyamphetamine Scan # 1069	High/Methylenedioxyamphetamine Scan # 1069	MDA~80% of the spectrum
Methylenedioxyethylamphetamine (MDEA) STD	High/Methylenedioxyethylamphetamine, Scan # 1064	High/Methylenedioxyethylamphetamine, Scan # 1065	High/Methylenedioxyethylamphetamine, Scan # 1067	MDEA~82% of the spectrum.
Morphine STD	High/Morphine Sulfate, Scan # 1052	High/Morphine Sulfate, Scan # 1053	High/Morphine Sulfate, Scan # 1054	Morphine Sulfate~87% of the spectrum
Codeine Sulfate STD	High/Codeine Sulfate, Scan # 1049	High/Codeine Sulfate, Scan # 1050	High/Codeine Sulfate, Scan # 1051	Codeine Sulfate ~80-84% of the spectrum.
	Replicate#1	**Replicate#2**	**Replicate#3**	**Comments**
Controlled Substances				Model:Narcotics_MA_V1_0
Methylenedioxyamphetamine (MDA) STD	High/Methylenedioxyamphetamine, Scan # 1072	High/Methylenedioxyamphetamine, Scan # 1073	High/Methylenedioxyamphetamine, Scan # 1074	MDA~78% of the spectrum
Methylenedioxyethylamphetamine (MDEA) STD	High/Methylenedioxyethylamphetamine, Scan # 1060	High/Methylenedioxyethylamphetamine, Scan # 1061	High/Methylenedioxyethylamphetamine, Scan # 1062	MDEA ~78% of the spectrum
Morphine STD	High/Morphine Sulfate, Scan # 1056	High/Morphine Sulfate, Scan # 1057	High/Morphine Sulfate, Scan # 1058	Morphine Sulfate~86% of the spectrum
Codeine Sulfate (Powder)	High/Codeine Sulfate, Scan # 1044	High/Codeine Sulfate, Scan # 1045	High/Codeine Sulfate, Scan # 1046	Codeine Sulfate ~87-88% of the spectrum.
	Replicate#1	**Replicate#2**	**Replicate#3**	**Comments**
Cutting Agents				Model:Controlled Substance ID
Caffeine	High/Caffeine, Scan # 769	High/Caffeine, Scan # 770	High/Caffeine, Scan # 771	High Confidence for Caffeine (90% of Spectrum)
Procaine	High/Procaine, Scan # 772	High/Procaine, Scan # 773	High/Procaine, Scan # 774	High Confidence for Procaine (90% of Spectrum)
Mannitol	High/Mannitol, Scan # 775	High/Mannitol, Scan # 776	High/Mannitol, Scan # 777	High Confidence for Mannitol (75% of Spectrum)
	Replicate#1	**Replicate#2**	**Replicate#3**	**Comments**

Cutting Agents				Model:Narcotics_MA_V1_0
Caffeine	High/Caffeine, Scan # 1075	High/Caffeine, Scan # 1076	High/Caffeine, Scan # 1077	Caffeine ~87% of the spectrum
Procaine	High/Procaine, Scan # 1078	High/Procaine, Scan # 1079	High/Procaine, Scan # 1080	Procaine ~87% of the spectrum
Mannitol	High/Mannitol, Scan # 1081	High/Mannitol, Scan # 1082	High/Mannitol, Scan # 1083	Mannitol~75% of the spectrum
SPECIFICITY	**Replicate#1**	**Replicate#2**	**Replicate#3**	**Comments**
Non-Controlled Substances				Model:Controlled Substance ID
Acetylsalicyclic Acid	High /Flunitrazepam, Low/ Lorazepam Low/DMS, Scan # 778	High/Flunitrazepam, Low /Lorazepam, Low/DMS, Scan # 779	High/Flunitrazepam, Low/ Lorazepam, Low/DMS, Scan # 782	Misidentification. FALSE POSITIVE (ASA Not in Model)
Ibuprofen	Unknown Material, Scan # 1098	Unknown Material, Scan # 1099	Unknown Material, Scan # 1100	No ID
Guafinosen	Unknown Material, Scan # 790	Unknown Material, Scan # 791	Unknown Material, Scan # 792	No ID
Diphenhydramine	Unknown Material, Scan # 793	Unknown Material, Scan # 794	Unknown Material, Scan # 795	No ID
Chlorpheniramine	High/Methadone, Low Methylsulfone, Low Triazolam, Low Ketamine, Scan # 1102 33%, 5%, 3%, 3%	High/Methadone, Low/DMS, Low Ketamine, Low Triazolam, Scan # 1103 32%,5%,4%,3%	High/Methadone, Low/Ketamine, Low Triazolam Scan # 1104 33%,4%,4%	Misidentification. FALSE POSITIVE (Chlorpheniraine Not in Model). Methadone ~33% of the spectrum, while the rest ranged from 3 to 5% of the spectrum
Pseudoephedrine	High/Pseudoephedrine, Scan # 1105	High/Pseudoephedrine, Scan # 1107	High/Pseudoephedrine, Scan # 1108	Pseudoephedrine (~93% of the spectrum)
	Replicate #1	**Replicate #2**	**Replicate #3**	**Comments**
Non-Controlled Substances				Model: Narcotics_MA_V1_0
Acetylsalicyclic Acid	High/ ASA, Scan # 784	High/ ASA, Scan # 785	High/ ASA, Scan # 786	Aspirin (79% of Spectrum)
Ibuprofen	Unknown Material, Scan # 1085	Unknown Material, Scan # 1086	Unknown Material, Scan # 1087	
Guafinosen	Unknown Material, Scan # 787	Unknown Material, Scan # 788	Unknown Material, Scan # 789	No ID
Diphenhydramine	Unknown Material, Scan # 1088	Unknown nownMaterial, Scan # 1089	Unknown Material, Scan # 1090	
Chlorpheniramine	Unknown Material, Scan # 1091	UnknownMaterial, Scan # 1092	Unknown Material, Scan # 1093	
Pseudoephedrine	High/Pseudoephedrine, Scan # 1094	High/Pseudoephedrine, Scan # 1095	High/Pseudoephedrine, Scan # 1096	Pseudoephedrine~92% of the spectrum
SPECIFICITY	**Replicate #1**	**Replicate #2**	**Replicate #3**	**Comments**
Explosives				Model: Explosives MA V0.5
TNT	High/TNT, Scan # 1115	High/TNT, Scan # 1116	High/TNT, Scan # 1117	TNT ~88% of the Spectrum
Inert C4	Unknown Material, Scan # 1118	Unknown Material, Scan # 1119	Unknown Material, Scan # 1120	
Nitrocellulose	High/NC, Scan # 1131, 40%	Unknown Material, Scan # 1132	Unknown Material, Scan # 1133	40% of spectrum for replicate #1
Ammonium Nitrate	High/AN, Scan # 1136	High/AN, Scan # 1137	High/AN, Scan # 1138	AN~51% of the Spectrum
Ammonium Perchlorate	High/APC, Scan # 1139	High/APC, Scan # 1140	High/APC, Scan # 1141	61,61,67 % of the spectrum
C4	High/RDX, Scan # 1143	High/RDX, Scan # 1144	High/RDX, Scan # 1145	91,91,83 % of the spectrum
Urea	Unknown Material, Scan # 1146	Unknown Material, Scan # 1147	Unknown Material, Scan # 1148	
PETN	High/PETN, Scan # 1149	High/PETN, Scan # 1150	High/PETN, Scan # 1151	80,84,80 % of the spectrum

Table 6: Sensitivity Data

Ratios of Controlled Substance to Caffeine (Model: Controlled Substance ID)

SENSITIVITY	(80:20)	(70:30)	(60:40)	(50:50)	(40:60)	(30:70)	(20:80)	(10:90)	(5:95)
Heroin	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID
Replicate#1	High/Heroin, Low/Caffeine	High/Heroin, Medium/ Caffeine	High/Heroin, Medium/ Caffeine	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine	High/Caffeine, Low/Heroin	High/Caffeine, Low/Heroin
Replicate#2	High/Heroin, Low/Caffeine	High/Heroin, Medium/ Caffeine	High/Heroin, Medium/ Caffeine	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine	High/Caffeine	High/Caffeine, Medium/Heroin
Replicate#3	High/Heroin, Low/Caffeine	High/Heroin, Medium/ Caffeine	High/Heroin, Medium/ Caffeine	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine, High/Heroin	High/Caffeine	High/Caffeine, Low/Heroin	High/Caffeine, Low/Heroin
Comments	Scans 954, 955,956	Scans 1004,1005,1006	Scans 957, 958,959	Scans 960, 961,962	Scans 963, 964,965	Scans 975, 976, 977	Scans 978, 979, 980	Scans 989, 991, 992. 990 not used due to instrument movement	Scans 993, 994, 995
SENSITIVITY	**(80:20)**	**(70:30)**	**(60:40)**	**(50:50)**	**(40:60)**	**(30:70)**	**(20:80)**	**(10:90)**	**(5:95)**
Methamphet-amine	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID
Replicate #1	High/ d,l Methamphet-amine	High/d,l-Methamphet-amine, High/Caffeine	High/d,l Methamphet-amine, High/Caffeine	High/d,l Methamphet-amine, High/Caffeine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, High/d,l-Methamphet-amine	High/Caffeine	High/Caffeine
Replicate #2	High/ d,l Methamphetamine	High/d,l-Methamphet-amine, High/Caffeine	High/d,l Methamphet-amine, High/Caffeine	High/d,l Methamphet-amine, High/Caffeine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, High/d,l-Methamphet-amine	High Caffeine/Low d,l-Methamphet-amine	High/Caffeine
Replicate #3	High/ d,l Methamphetamine Low/ Caffeine	High/Caffeine, High/d,l-Methamphet-amine	High/d,l Methamphet-amine, High/Caffeine	High/d,l Methamphet-amine, High/Caffeine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, High/d,l Methamphet-amine	High/Caffeine, Medium/d,l-Methamphet-amine	High/Caffeine	High/Caffeine
Comments	Scans 903,904,905	Scans 1011,1012,1013	Scans 911,912,913	Scans 914,915,916	Scans 917,918,919	Scans 928,929,930	Scans 931,932,933	Scans 942,943,944	Scans 945,946,947
SENSITIVITY	**(80:20)**	**(70:30)**	**(60:40)**	**(50:50)**	**(40:60)**	**(30:70)**	**(20:80)**	**(10:90)**	**(5:95)**
Cocaine Base	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID
Replicate #1	High/ Cocaine Base: Medium/ Caffeine	High/ Cocaine Base: High/ Caffeine	High/ Caffeine, Medium/ Cocaine Base	High/ Caffeine, High/ Cocaine Base	High/ Caffeine, Medium/ Cocaine Base	High/ Caffeine, Low/ Cocaine Base, Low/ Phentermine	High/ Caffeine, Low/ Cocaine Base	High/Caffeine	High/Caffeine

Replicate #2	High/ Cocaine Base: Medium/ Caffeine	High/ Cocaine Base: HIgh/ Caffeine	High/ Cocaine Base: High/ Caffeine	High/ Caffeine High/ Cocaine Base	High/ Caffeine Medium/ Cocaine Base	High/ Caffeine, Low/ Cocaine Base, Low/ Morphine Sulfate, Low/ Phentermine	High/ Caffeine, Low/ Cocaine Base	High/Caffeine	High/Caffeine
Replicate #3	High/ Cocaine Base: Medium/ Caffeine	High/ Cocaine Base: High/ Caffeine	High/ Caffeine, Medium/ Cocaine Base	High/ Caffeine Medium/ Cocaine Base	High/ Caffeine, Medium/ Cocaine Base	High/ Caffeine, Low/ Cocaine Base, Low/ Morphine Sulfate, Low/ Phentermine	High/ Caffeine, Low/ Cocaine Base	High/Caffeine	High/Caffeine
Comments	Scans 857,858,859	Scans 1007, 1008,1009	Scans 860,861,862	Scans 863,864,865	Scans 866,867,868	Scan 877,878,879	Scans 880,881,882	Scans 891,892,894	Scans 895,896, 897
SENSITIVITY	**(80:20)**	**(70:30)**	**(60:40)**	**(50:50)**	**(40:60)**	**(30:70)**	**(20:80)**	**(10:90)**	**(5:95)**
Cocaine HCL	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID	Confidence/ID
Replicate #1	High/ Cocaine HCl (Nothing follows)	High/ Cocaine HCl, Low/ Caffeine	High/ Cocaine HCl, Medium/ Caffeine	High/ Cocaine HCl: High/ Caffeine	High/ Caffeine, Med Cocaine HCl, Low/ Phentermine	High/ Caffeine, Low/ Alprazolam	High/ Caffeine Medium/ Cocaine HCl	High/ Caffeine	High/ Caffeine
Replicate #2	High/ Cocaine HCl, Low/ Caffeine	High/ Cocaine HCl, Medium/ Caffeine	High/ Cocaine HCl: Medium/ Caffeine	High/ Cocaine HCl: High/ Caffeine	High/ Caffeine, Med Cocaine HCl, Low/ Phentermine	High/ Caffeine	High/ Caffeine Medium/ Cocaine HCl	High/ Caffeine	High/ Caffeine
Replicate #3	High/ Cocaine HCl, Low/ Caffeine	High/ Cocaine HCl, Low/ Caffeine	High/ Cocaine HCl: Medium/ Caffeine	High/ Cocaine HCl: High/ Caffeine	High/ Caffeine, Med Cocaine HCl, Low/ Phentermine	High/ Caffeine, Low/ Morphine Sulfate	High/ Caffeine Low/ Cocaine HCl	High/ Caffeine	High/ Caffeine
Comments	Scans 801,802,803	Scans 808,809,810	Scans 811,812,813	Scans 814,815,816	Scans 817, 823, 824	Scans 825,826,827	Scans 836,837, 838	Scans 839,840,841	Scans 850,851,852

Table 7: Portability Data

Portability (Mobile Lab)	Replicate #1	Replicate #2	Model Used
C-4	High/RDx, Scan 1206	High/RDx, Scan 1207	Explosives MA v0.5

Guaifinosen Std	Unknown Material, Scan 1190	Unknown Material, Scan 1191	Controlled Substance ID
Heroin, TS-004	High/Heroin, Med/H2O, Scan 1203	High/Heroin, Med/H2O, Scan 1193	Narcotics MA V1_0
Caffeine Std	High/Caffeine, Scan 1194	High/Caffeine, Scan 1195	Controlled Substance ID
Cocaine HCl, TS-002	High/Cocaine HCl, Low/Borax, Low/Polyethylene, Scan 1200	High/Cocaine HCl, Low/Borax, Low/Polyethylene, Scan 1202	Narcotics MA V1_0

Table 8: Inter-day and Intra-day Reproducibility Study Data (Model Used: Controlled Substance ID)

Cocaine HCl:Caffeine 50:50 Ratio	**Day 1 (07/06/09)** Conf/Material	**Day 2 (07/07/09)** Conf/Material	**Day 3 (07/08/09)** Conf/Material	**Day 4 (07/09/09)** Conf/Material	**Day 5 (07/10/09)** Conf/Material	**Day 6 (07/13/09)** Conf/Material	**Day 7 (07/14/09)** Conf/Material	**Day 8 (07/15/09)** Conf/Material	**Day 9 (07/16/09)** Conf/Material	**Day 10 (07/17/09)** Conf/Material
Replicate #1	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine
Replicate #2	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, Med/Caffeine	High/Cocaine HCl, Med/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, Med/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine
Replicate #3	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, Med/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, Med/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine	High/Cocaine HCl, High/Caffeine
Comments	Scans 799, 800, 801	Scans 805, 806, 807	Scans 1109,1110,1111	Scans 1154,1155,1156	Scans 1159,1160,1161	Scans 1163,1164,1165	Scans 1173,1174,1175	Scans 1176,1177,1178	Scans 1180,1181,1182	Scans 1185,1186,1187

Table 9: Environmental Study Data

	Outside Loading dock @82.2F and 64% Humidity		Inside Laboratory @77.2F		
Environmental Study	Replicate #1	Replicate #2	Replicate #1	Replicate #2	Model Used
C-4	High/RDx, Scan 1209	High/RDx, Scan 1210	High/RDx, Scan 1231	High/RDx, Scan 1232	Explosives MA v0.5
PETN	High/PETN ,Scan 1212	High/PETN, Scan 1213	High/PETN, Scan 1233	High/PETN, Scan 1234	Explosives MA v0.5

Herion, TS-004	High/Heroin, Med/H2O, Scan 1216	High/Heroin, Med/H2O, Scan 1217	High/Heroin, Med/H2O, Scan 1222	High/Heroin, Med/H2O, Scan 1223	Narcotics MA V1_0
Caffeine Std	High/Caffeine, Scan 1218	High/Caffeine, Scan 1219	High/Caffeine, Scan 1224	High/Caffeine, Scan 1225	Narcotics MA V1_0
d,l-Methamphetamine HCl, TS-005	High/Methamphetamine, Scan 1220	High/Methamphetamine, Scan 1221	High/Methamphetamine, Scan 1228	High/Methamphetamine, Scan1229	Narcotics MA V1_0
Comments	equilibration time 5 minutes		equilibration time 5 minutes		

Table 10: Manatee County Sheriff's Office Forensic Laboratory (Adjudicated Case Samples). Model Used: Controlled Substance ID

	Sample #	Results	Methodology	PHAZIR Replicate #1	PHAZIR Replicate #2	PHAZIR Replicate #3
1	46	Cocaine	GC/MS	Scan 1257, High/Cocaine Base	Scan 1258,High/Cocaine Base	Scan 1259, High/Cocaine Base
2	43	Cocaine	GC/MS	Scan 1260, High/Cocaine Base	Scan 1261, High/Cocaine Base	Scan 1262,High/Cocaine Base
3	11	Cocaine	GC/MS	Scan 1263, High/Cocaine Base	Scan 1264, High/Cocaine Base	Scan 1265, High/Cocaine Base
4	927	Cocaine HCl	IR	Scan 1270, High/Cocaine HCl	Scan 1271, High/Cocaine HCl	Scan 1272, High/Cocaine HCl
5	930	BZP	GC/MS	Scan 1278, Unknown Material	Scan 1279, Unknown Material	Scan 1280, Unknown Material
6	940	Cocaine Base	IR	Scan 1288, High/Cocaine Base	Scan 1289, High/Cocaine Base	Scan 1290, High/Cocaine Base
7	40	Heroin	GC/MS	Scan 1293, High/Heroin	Scan 1294, High/Heroin	Scan 1299, High/Heroin
8	8	Fake Crack	Unknown Technique	Scan 1299, Unknown Material	Scan 1300, High/ Polyethylene, Med/ASA, Low/Borax, Low/LSD	Scan 1301, High/ Polyethylene, Med/ASA, Low/Lactose, Low/Phenobarbital
9	31	Heroin	GC/MS	Scan 1302, High/Heroin	Scan 1303, High/ Heroin	Scan 1304, High/ Heroin

10	950	Hydrocodone/APAP	GC/MS	Scan 1305, High/APAP	Scan 1306, High/APAP	Scan 1307, High/APAP
11	955	Oxycodone	GC/MS	Scan 1308, High/ Polyethylene, Med/Lactose Hydrate, Low/Oxycodone	Scan 1309, High/ Polyethylene, Med/Lactose Hydrate, Low/Oxycodone	Scan 1310, High/ Polyethylene, Med/Lactose Hydrate, Low/Oxycodone
12	960	Xanax	GC/MS	Scan 1311, High/Lactose Hydrate	Scan 1313, High/Lactose Hydrate	Scan 1314, High/Lactose Hydrate
13	965	Clonazepam	GC/MS	Scan 1315, High/ Lactose, Low/ Borax, Low/ Mannitol	Scan 1316, High/ Lactose, Low/ Borax	Scan 1317, High/ Lactose, Low/ Borax
14	966	Morphine	GC/MS	Scan 1319, High/ Polyethylene, Med/ Lactose Hydrate, Low/ Morphine Sulfate	Scan 1320, High/ Polyethylene, High/ Lactose Hydrate, Low/Morphine Sulfate	Scan 1321, High/ Polyethylene, High/ Lactose Hydrate, Low/Morphine Sulfate
15	970	Propoxyphene/APAP	GC/MS	Scan 1322, High/ APAP	Scan 1323, High/ APAP	Scan 1324, High/ APAP
16	975	Hydrocodone/APAP	GC/MS	Scan 1325, High/ APAP	Scan 1326, High/ APAP	Scan 1327, High/ APAP
17	977	Hydrocodone/APAP	GC/MS	Scan 1328, High/ APAP	Scan 1329, High/ APAP	Scan 1330, High/ APAP
18	33	Heroin/Caffeine	GC/MS	Scan 1331, High/ Heroin	Scan 1332, High/ Heroin	Scan 1333, High/ Heroin
19	15	Cocaine	GC/MS	Scan 1334, High/ Cocaine Base	Scan 1335, High/ Cocaine Base	Scan 1336, High/ Cocaine Base
20	45	Cocaine	GC/MS	Scan 1337, High/ Cocaine HCl	Scan 1339, High/ Cocaine HCl	Scan 1340, High/ Cocaine HCl, Low/ Phenobarbital

Post-Evaluation Findings

Strengths/Results:

Strengths:

- The PHAZIR™ NIR analyzer was noted to provide the user with extremely quick, reliable results within 8-10 seconds after trigger initiation. Most other portable spectroscopy-based devices using FT-IR or Raman technology can take 2 minutes or more before prompting the user with identification.
- Samples containing mixtures of multiple components can be easily deconvoluted from one another and identified provided the individual components make up at least 25-30% or more of the mixture and the mixture is homogeneous in nature.
- The instrument uses a non-destructive, point-and-shoot analysis technique that requires no sample preparation.
- Analysis can be performed through the original or primary container (polyethylene bags, amber or glass bottles).
- This device can be used to identify powders, solids, and liquids.
- The unit has ergonomically designed features and a total operational weight of only 4 lbs., which includes the rechargeable battery.
- The Graphical User Interface (GUI) of the PHAZIR is very intuitive, easy-to-use and is designed to be operated by non-technical personnel.
- The analyzer possesses a built-in internal white reference for background correction measurements that are automatically performed by the unit when required.
- Adding a compound to an existing chemometrics model was fast and accomplished using an easy two-step process. The user is required to first "Collect" spectra of the reference material using the analyzer, and then upload those spectra into the user-friendly "PHAZIR™ MG" model-building software. Most commercially available NIR analyzers on the market require the use of complicated chemometrics model-building software (e.g., Grams AI software) as well as the knowledge and experience of a spectroscopist.
- This NIR instrument does not require any expensive consumables or time consuming maintenance.
- Fluorescent or dark colored compounds are not a problem for Near Infared spectroscopy as they are for other spectroscopy-based technologies like Raman.

Results:

- After selecting the appropriate chemometric model for identification during the conformity portion of the evaluation, the PHAZIR™ was able to accurately identify pure standard samples containing either controlled substances, cutting agents or explosives with a "high" confidence level. Refer to Table 4 for results.
- Utilizing the manufacturer's "Narcotics_MA_V1_0" model during the specificity section of the evaluation, it was noted by the evaluator that the model was able

to identify the methylsulfone present within the sample with a “high” confidence level. Unfortunately, there was also a range of results reported of Med to Low confidence levels for LSD for the same sample which contained no LSD; only DMS was identified using the “Controlled Substance ID” model. There was difficulty in identifying a sample containing unknown concentrations of a mixture of MDMA and Methamphetamine for both models; both reported “Unknown Material”. The “Controlled Substance ID” model misidentified acetylsalicylic acid (ASA) as Flunitrazepam with a “High” confidence level. Although ASA was not in that particular library, the device should have reported an “Unknown Material” result. The manufacturer’s “Narcotics_MA_V1_0” model had ASA in the library and it was able to correctly identify it. The “Explosives_MA_V0.5” model performed well during this section of the evaluation with only a slight variation in the reporting of a sample containing Nitrocellulose (NC). One of the replicates came back with a “High” confidence for NC, while two other replicates were reported as “Unknown Material”. Refer to Table 5 for data information.

- Using a medium confidence limit as the cut-off, the sensitivity of the PHAZIR was determined to be at a concentration of 30% for Heroin, 20% for Methamphetamine, and 40% for both Cocaine Base and Cocaine HCl. See Table 6 for data and result information.
- The mobile laboratory environment had no noticeable effects on the functionality of PHAZIR™. See Table 7 for results.
- The NIR device performed extremely well during the Inter-day and Intra-day Reproducibility Studies using the 50:50 ratio sample of cocaine HCl to caffeine, which was analyzed each day in triplicate over the ten-day period. Refer to Table 8 for further information.
- The Environmental Study indicated that there is no statistical difference between the results of the same sample set run in a laboratory at a temperature of 25.1°C (47% humidity) with that obtained outside at 27.9°C (64% humidity).

Areas for Improvement:

- Any slight movement of the PHAZIR™ during analysis can be problematic and produce inaccurate results (false negative or false positive). During sample analysis, the unit should be able to determine and prompt the user of any discrepancies regarding varying signal strength as a result of disruptive movements that have occurred during collection.
- The unit needs to be more rugged to meet military 810 F specifications for harsher field environments. Per the manufacturer, the unit is only dust and splash resistant.
- The device’s current design resembles a gun-style type of hand-held analyzer, where the majority of the instrument’s weight is on the top of the grip handle holding the rechargeable battery. A more compact design capable of fitting into the user’s entire hand or into the cargo pocket of their tactical wear would be a more suitable size for field type applications and transport.
- Customizable sample entry information fields should be available to the user for quicker text entry then currently provided via the navigation keys.

Limitations of Technology:

- Some NIR spectroscopy devices require a thorough understanding of complex chemometric software and statistics to build model(s) that meet specific needs and cutoffs for the detection and identification of compounds of interest. Although the PHAZIR™ does not require expertise in spectroscopy to develop a model for use, users may find advanced knowledge of spectroscopy required for model optimization and verification.
- Like any spectroscopy-based technology, mixtures can be problematic if the major component(s) are fillers, binders, diluents, excipients, APAP, etc., and the compound(s) of interest are minor component(s) at low concentrations. For example, the NIR analysis of a crushed 2.0 mg Xanax® would most likely not be able to identify the benzodiazepine alprazolam, a scheduled IV drug, present within the tablet. Only the fillers, binders, diluents, and/ or excipients may be seen. A crushed 5 mg oxycodone/ 500 mg APAP tablet would also present some difficulty. The NIR would identify as having only a High Confidence for the APAP and maybe a few binders or fillers, but not the scheduled II drug oxycodone.
- NIR spectroscopy has limited specificity compared to other spectroscopy based technologies due to its narrow scan range.

Training Requirements:

- A very minimal amount of training is required to operate this instrument. The user need only know which chemometric model to select, be able to place the analyzer in direct contact with the sample, squeeze the trigger, and remain relatively motionless for ten seconds. Most of the training should be focused on the limitations of both the instrument as well as the technology.
- The PHAZIR™ user interface is designed to meet the demands of both technical and non-technical personnel.

Health and Safety Issues:

- There were no noteworthy safety issues concerning the operation of this instrument.
- This unit can be considered safe if personnel are properly trained.