Portable Forensic Ballistics Examination Instrument: Advanced Ballistics Analysis System (ALIAS)

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Keywords: ALIAS, correlation algorithm, data sharing, forensic ballistics, interferometer, laser, micron, Odyssey Project, Pyramidal Technologies, three-dimensional, topographical, volumetric measurement, bullet mapping, cartridge case mapping, objective instrumental results

ABSTRACT

A portable, measurement instrument and analysis tool for use by forensic ballistics and firearms examiners that creates, compares and analyses three-dimensional, volumetric models of fired cartridge cases and spent bullets. The technology can measure and examine toolmarks as small as two microns. ALIAS includes computer hardware, an open database infrastructure, a high-precision, Swiss-built, application-specific interferometer with a “six-pac” cartridge case or expended bullet holder (patents pending) and an open software architecture.

Introduction: The Most Recent Evolution of Forensic Ballistics Science

Due to an ever-expanding pool of cartridges, bullets and firearms in use globally, an effective automated ballistics analysis system that employs more exacting measurement and correlation methods has been developed. ALIAS is designed as a portable, turnkey system to meet the current needs of the forensic ballistics analysis industry. ALIAS easily integrates into existing IT.

Ballistic Imaging, published by the National Academies Press in 2008, before the introduction of ALIAS, assessed the then-current state of computer-based imaging technology in forensic firearms identification. Because of the limitations of current ballistics analysis, the report recommended against setting up a national reference ballistic image database (RBID). The National Academies summarized the report’s main finding: “Given the practical limitations of current technology for generating and comparing images of ballistic markings, searches of such an extensive database would likely produce too many candidate ‘matches’ to be helpful.” [1]

ALIAS has the potential to remove “practical limitations” like those Ballistic Imaging describes – ALIAS technology generates the best-fit candidate matches from the enormous pool of possibilities. ALIAS may be the foundation for possible RBID creation in the near future.

The Application of Interferometry to Forensic Ballistics Analysis

An interferometer diagnoses the properties of two or more non-synchronous laser beams by analyzing the pattern of interference created by their superposition. Interferometry is well established and already widely used in engineering and scientific fields, including astronomy, fiber optics, oceanography, seismology, metrology (the science of weights and measures), quantum mechanics, physics, and remote sensing. Interferometry is also an instrument ideally suited for use in the meticulous science of ballistics analysis.

ALIAS includes a high-precision, Swiss-built, application-specific interferometer to scan and capture cartridge case and bullet data.

The ALIAS interferometer scans cartridge case or bullet evidence placed in the six-pac holder or bullet holder, affixed to the ALIAS interferometer. For fired bullet scans, the interferometer scans in two separate passes. The first determines the general topography of the bullet, and the second maps the detailed topography. This combination scan takes about one minute, although scanning time varies with the size of area scanned. The ALIAS interferometer includes several adaptors to hold damaged bullets. Damaged bullets do not require more scan time.

Assuming a cartridge case scan area of 6 by 6 millimeters (6 mm = 0.236 inches), a single ALIAS cartridge case scan generates 54 billion points of data representing the total...
number of grid points measured by the interferometer’s smart sensor technology. This data is analyzed using a set of algorithms. A typical scan stores over 30 million pieces of data about the surface of the cartridge case (the X, Y, Z coordinates of surface features) and is maintained in an open database as an approximately 100 MB 3D object.

The result is a three-dimensional, incredibly detailed digital model of the surface of the expended cartridge case or fired bullet, which can then be displayed as a 3D topographical image in order to measure features as small as two microns. A rendered ALIAS image represents a 3D digital clone of the original specimen.

Note: For simplicity, the remainder of this report will discuss only cartridge cases, although ALIAS offers the same forensic ballistic tools and analysis for spent bullets that it does for cartridge cases.

Improving Forensic Ballistics Data Accuracy and Specimen Correlation

ALIAS uses three-dimensional, topographical data derived from an interferometer scan to provide fast and accurate ballistics correlation. The authors of the Ballistic Imaging executive summary specifically recommended a move to “three-dimensional topographical techniques.” [2]

A typical ALIAS generated cartridge case scan stores over 30 million pieces of data about the surface of the cartridge case (the X, Y, Z coordinates of surface features). This data represents the total number of grid points measured by the interferometer’s smart sensor technology. This data is analyzed using a complex set of algorithms.

During correlation, ALIAS compares millions of measurements of the dimensions of specific toolmarks and their position on the cartridge case. The system then sorts the database of cartridge cases, rates the data and “fit” of the subject cartridge case to others in the database, and presents firearms examiners with a list of only those cartridge cases most closely matching the subject cartridge case. This list is presented as a set of large thumbnail images in descending order from the best match to worst, along with a score and a visual indicator as to the confidence of the match between a questioned cartridge case and a reference cartridge case.

The interferometry and imaging abilities of ALIAS – the first steps in advanced forensic ballistics analysis - are exclusively concerned with measuring and presenting topographical data for a subject cartridge case in relation to known cases in a database – of any size. ALIAS provides automated analysis tools to make detailed comparisons of cartridge cases as accurately and as quickly as possible.

Advantages of 3D Visualization Models and Manipulation in Analysis

By manipulating a digital clone of a cartridge case, a forensic examiner could perform an in-depth analysis without any chance of contaminating the actual evidence. The system’s visualization tools apply a textured skin to the underlying volumetric mathematical model in natural color, gray scale, or topographically sensitive color scale. A forensic examiner can view two rendered images side-by-side and manipulate each rendered image separately or in a synchronized fashion. Tool functions include simple visual manipulation, such as rotating, tilting, and scaling, as well as specialized tools for enhancing, comparing, and measuring an object’s features.

The rendered cartridge images are light-independent. By clicking the light source tool, examiners can manipulate a virtual light source to control the direction and angle of the light in order to increase shadows and further highlight minute marks and surface features, in much the same way as is done on a comparison microscope. An examiner can easily and accurately control every aspect of the independent light source with a few mouse movements.

ALIAS has an advantage over a comparison microscope when trying to match a clean cartridge case with one that is tarnished or corroded. Because ALIAS presents a topographical map of the cartridge surfaces, physical appearance to the human eye is not an impediment. Examiners can easily see toolmarks on the rendered images.

Each rendered image includes its own tool dock, as shown in the following figures, which offers options to enhance and view the evidence in true three dimensions.

By increasing the Z-Scale option, examiners can instantly enhance the toolmarks. Figure 1 shows a cartridge case with an increased Z-Scale.

A forensic examiner can view two cartridge case images centered on a virtual hair line, and slide them together to determine a match (see Figure 2).

One of the most useful tools is the ability to measure the microscopic distances between evidence features. By clicking the mouse at the two points of interest, examiners can determine the precise distance between any two points on the subject cartridge case and a potential matching cartridge case and then compare the values (see Figure 3).
The Z-Scale uses non-linear mathematical transformations to bring out microscopic cartridge case details for visual examination.

The correlation results using ALIAS technology are calculated outside the subjectivity of the examiner. By comparing the measurement of toolmarks as small as two microns in size, forensic examiners can present an instrumental result of evidence comparison that can be presented in a court of law.

Instrument Portability Allows for Greater Flexibility, Increased Use

The entire ALIAS system can be transported in three Pelican™ storage and transport cases, set up and deployed in a matter of 15 minutes or less. This advantage differentiates ALIAS from traditional ballistics analysis systems and offers vastly greater flexibility to forensic ballistics labs and firearm examiners.

The physical equipment includes an Apple Mac Pro computer running a 64-bit Unix operating system, a high-definition (HD) display panel and the ALIAS interferometer with six-pac cartridge case holder and bullet holder.

The computer dimensions are:
- Height: 20.1 inches (51.1 cm)
- Width: 8.1 inches (20.6 cm)
- Depth: 18.7 inches (47.5 cm)
- Weight: 41.2 pounds (18.7 kg)

The display panel dimensions are:
- Height: 21.3 inches (54.3 cm)
- Width: 27.2 inches (68.8 cm)
- Depth: 8.46 inches (21.5 cm)
- Weight: 27.5 pounds (12.5 kg)

The interferometer’s dimensions are:
- Height: 17.7 inches (45 cm)
- Width: 13.8 inches (35 cm)
Figure 2: A split screen shows matching cartridge cases.

Figure 3: This ALIAS visualization shows two different cartridge cases with their firing pin impressions measured (the dotted white lines). The distance in microns appears in the lower right of each window.
• Depth: 17.7 inches (45 cm)
• Weight: 55 pounds (25 kg)

An ALIAS system can be customized for the specific requirements of each law enforcement agency or ballistics lab.

**Conclusion:** ALIAS API Allows Data Sharing and Exporting and Produces Evidence More Quickly for Presentation in a Court of Law

To combat global terrorism and crime, law enforcement agencies worldwide must share forensic data.

ALIAS is designed with an open architecture to make data sharing possible. Any law enforcement agency needing to use ALIAS ballistics data in another computer program can access the data through the open Application Program Interface (API). Users can export cartridge case scan data and case-related demographic data in a variety of universal formats (CSV, binary, CAD and more) to departmental, national or international forensic databases, or to private firms for further analysis.

As part of the process of setting and testing standards for the European Odyssey Project - which aims to create standards for ballistics data collection, storage and sharing. [3] - ALIAS will be used to scan 440 test cartridge cases at Germany’s Federal Criminal Police Laboratory (the BKA). ALIAS is a key component of this rigorous study of the data-sharing ability of competing ballistics systems.

The ALIAS architecture promotes data flexibility and recognizes competition as a positive force for forensic ballistics improvements. Ballistic examiners using ALIAS can import customized correlation algorithms, even if they come from another system. In this way, ballistic examiners can extend the power and scope of the correlation mechanism to meet their specific needs, and then share data with the global law enforcement community.

By combining interferometry, complex correlation algorithms, three-dimensional topographical modeling, and micron-level measurement, ALIAS provides an accurate, flexible and easy way for forensic examiners to independently compare and share ballistics data and produce evidence that can be presented in a court of law.

**References**

