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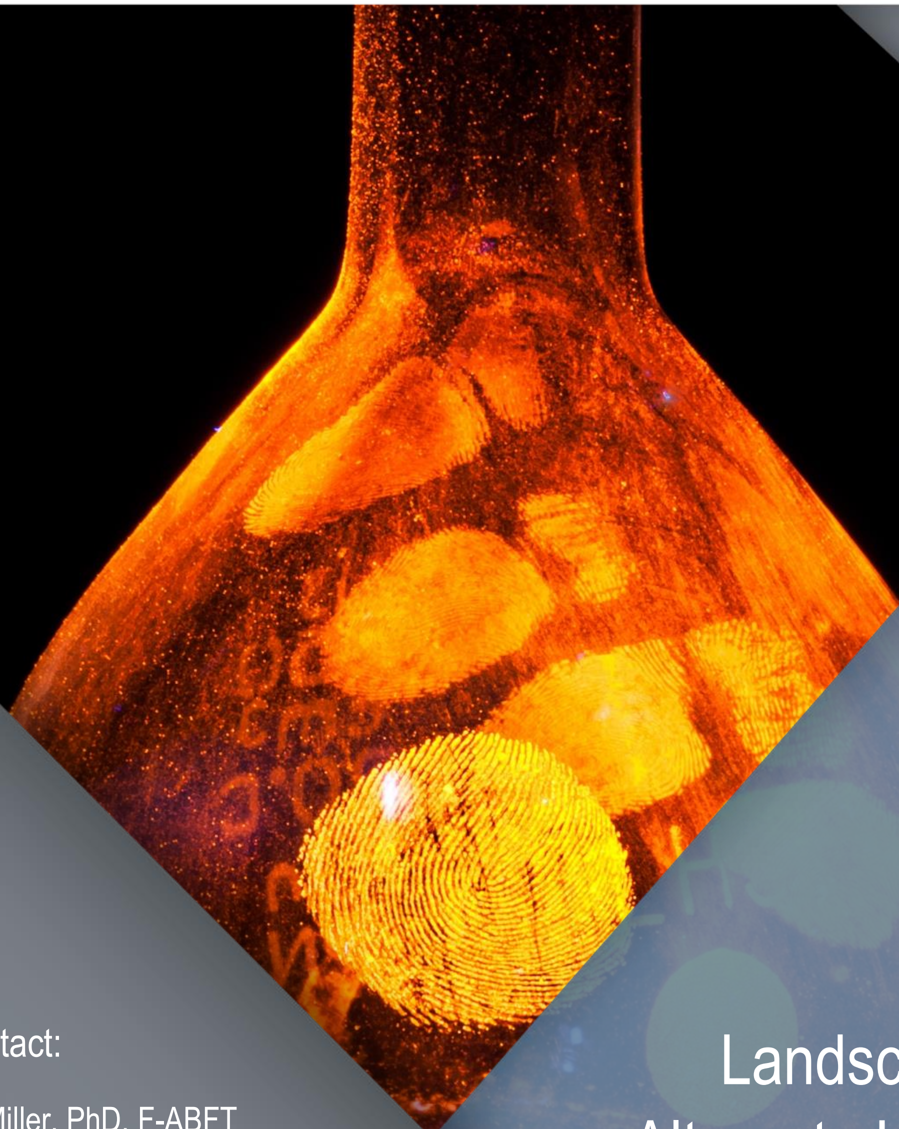

# Landscape Study of Alternate Light Sources

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## Overview of Report

The National Institute of Justice (NIJ)'s Forensic Technology Center of Excellence (FTCoE) at RTI International (RTI) directed this landscape study of alternate light sources (ALS) with input from industry, law enforcement, forensic, and criminal justice system communities.

A landscape study provides a comprehensive overview of market participants, their products, and product features to enable end users to make informed purchasing decisions. This report gives an overview of currently available ALS for crime scene processing and laboratory applications.

This document provides decision makers and end users such as laboratory directors, crime scene investigation unit personnel, forensic photographers, and other stakeholders with the following:

- Background information on ALS, the available products and manufacturers, and applications for which this technology can be used.
- Input from current users to inform potential technology adopters about implementation considerations for ALS, including device performance, applications, and education.
- A comparison of the features and capabilities of ALS instruments.
- Cases illustrating successful adoption of ALS technology.

This report also offers important considerations for decision makers purchasing for either field or laboratory settings. While multiple applications for ALS in forensic science exist, these applications represent scenarios in which ALS is most commonly used based on interviews from field experts.

**This FTCoE landscape study of ALS provides:**

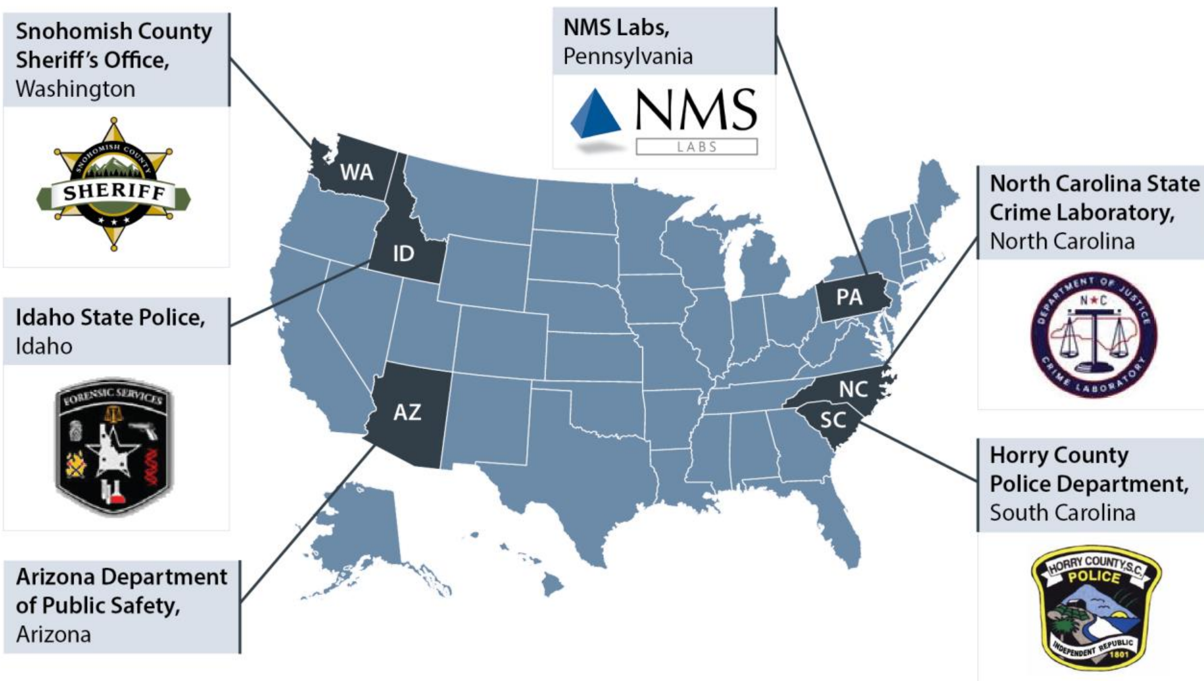
- ► Agencies a better understanding of the types of devices available and recent advances in ALS technology.
- ► User profiles that offer the insight of past experiences with ALS devices to help agencies make informed purchasing decisions.
- ► Emphasis on the value of training ALS users and available training resources.

### Landscape Study of ALS

ALS examples featured in this report emit light in the visible and ultraviolet (UV) region of the electromagnetic (EM) spectrum. These sources cause certain materials to fluoresce, which enhances the ability to visualize specific evidence during searches and examinations in the field and laboratory. Evidence illuminated by these light sources can be visualized by the eye using an appropriate barrier filter or documented using a standard digital camera equipped with an appropriate filter. Other ALS technologies exist in the market, such as reflected ultraviolet imaging systems (RUVIS) and infrared imaging systems. These technologies require specialized cameras or imaging systems to visualize and document evidence and are beyond the scope of this report.

Alternate light sources are available for purchase from over 10 manufacturers. The FTCoE interviewed 21 experts across multiple forensic science disciplines and chose to highlight six instruments consistently referenced by these experts. It is important to note that the FTCoE is not recommending any one instrument over another. Our goal is to present a broad scope of ALS functionalities and applications. The FTCoE suggests considering and potentially testing a variety of ALS devices to ensure an agency's specific needs are met.

While the content of this report has been developed from interviews with over 20 stakeholders, the experiences of six different agencies using ALS devices have been explicitly profiled. Spread amongst the United States, these interviewees provide insight for both crime scene and laboratory applications.




## Research Methodology

To conduct this landscape study, the FTCoE used a process that included the following steps:

- Researched secondary sources—including journal and industry literature—to obtain information related to ALS capabilities, successful use cases, and procurement considerations for the devices.
- Discussed state-of-the-art ALS technology with subject matter experts, including crime scene and laboratory practitioners, technology developers, and key decision makers.
- Attended ALS photography course to better understand the technology, obtain firsthand user experience with the devices, and discuss technology with users.
- Documented, summarized, and released key findings to the forensic community.

**UV Fluorescence Versus Reflected-UV Imaging: What's the Difference?**[a]

► **UV Fluorescence (Focus of this report):** UV can excite electrons in a material, causing it to fluoresce. This emitted light is at a longer wavelength and lower energy than UV, and falls within the visible light range. As a result, UV fluorescence is visible to the naked eye and standard digital cameras.

► **Reflected-UV Imaging (Not in this report):** Reflected-UV imaging is possible when UV reflects off an object and is captured by a camera that is UV-sensitive.

[a]Richards, A., & Leintz, R. (2013). Forensic Reflected Ultraviolet Imaging. *Journal of Forensic Identification,* 63 (1), 48-69. Retrieved from https://www.theiai.org/member/jfi/JFI-2013-1-46.pdf

## Subject Matter Experts and Stakeholders

We would like to thank the various forensic science community stakeholders and practitioners who offered insight, analysis, and review.

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## Glossary of Commonly Used Words and Phrases

For the purposes of this document, the following terms are defined:

**Alternate light source (ALS):** a tool used to help visualize evidence that is not apparent to the naked eye. ALS typically utilize the UV and visible light spectrum. Also known as a forensic light source (FLS).

**Alternating current (AC) power**: a type of power supply where the electric current cyclically changes direction. AC power is the type of power delivered to houses and businesses and is utilized by plugging appliances into wall sockets.

**Bandpass filter:** an optical filter that blocks transmission of light both above and below a certain wavelength range. Bandpass filters are used to filter light to specific wavelength ranges within the alternate light source.

**Barrier filter**: an optical filter that blocks transmission of light either above, below, or between a specific range of wavelengths, which permits certain wavelengths to reach the eye or other detector.

**Brightness (of light):** a measurement of the level of intensity of a light output from a light source. This can be measured in lumens. In this report, the term “intensity” is used as a proxy for brightness.

**Ecchymosis:** discoloration of the skin due to ruptured blood vessels and resulting blood leakage into subcutaneous tissue.

**Electromagnetic (EM) spectrum:** the complete range of wavelengths of electromagnetic radiation. This spectrum includes visible light (red, orange, yellow, green, blue, indigo, and violet) as well as non-visible radiation (ultraviolet and infrared radiation, radio waves, x-rays, and gamma rays).

**Electromagnetic (EM) radiation**: a type of energy that travels as both a wave and a particle. Waves of electromagnetic radiation are made up of oscillating magnetic and electric fields. Visible light is a type of electromagnetic radiation.

**Emission wavelength:** the wavelength of light emitted by a fluorophore when it changes from an excited state to a ground state. This wavelength of light is visualized as fluorescence.

**Excitation wavelength:** the wavelength of light that causes a fluorophore to transition to a higher energy level, or excited state.

**Excited state:** the state in which an atom or molecule has more energy relative to its ground state; a higher energy level.

**Fluorescence:** a phenomenon in which light is emitted, resulting from the excitation of a fluorophore; absorption of a shorter wavelength followed by emission of a longer wavelength.

**Fluorophore:** a molecule that emits light in the form of fluorescence upon excitation.

**Forensic light source (FLS):** see alternate light source (ALS).

***Frye* standard:** a standard of admissibility of evidence based on the ruling of Frye v. United States in 1923, which dictates that expert testimony must be based in established scientific methods generally accepted within the relevant scientific community.

**Frye-Reed hearing:** refers to a Frye hearing in Maryland, named after the first case that extensively discussed the *Frye* standard, *Reed v. State*.

**Ground state:** the lowest energy state of an atom or molecule.

**“Hot spot”:** an area within the light beam emitted from an ALS that is brighter than around the light beam; a hotspot is usually observed in the center of the light beam. Refer to **Figure 5** for an illustration of a hot spot.

**Incandescent light**: a light source that produces illumination through the heating of a filament such as tungsten, which emits radiation in the visible and infrared (IR) region of the EM spectrum.

**Infrared (IR) radiation:** that part of the EM spectrum whose wavelength is above 700 nm usually below 12,000 nm.

**Light Absorption:** a process by which light strikes a surface, causing the material to absorb energy and transition to a higher energy state.

**Light emitting diode (LED)**: a device made from a semiconductor material that emits light when an electrical current is passed through it.

**Longpass filter**: a barrier optical filter that blocks transmission of light below a certain wavelength range. Light with a longer wavelength (and lower energy) is perceived by the viewer.

**Multiwavelength device**: an ALS that emits more than one peak wavelength of light.

**Peak wavelength**: the wavelength of light that is most apparent; most of the light emitted by the ALS is at this wavelength.

**Photon:** an elementary particle of visible light.

**Shortpass filter:** a barrier optical filter that blocks transmission of light above a certain wavelength range. Light with shorter wavelength (and higher energy) is passed onto the viewing area.

**Sensitivity**: the precision of the range of wavelengths of light emitted from the ALS device; devices considered to be more sensitive emit light at a more narrowly focused wavelength range.

**Single-wavelength device**: an ALS that emits a single peak wavelength of light. For the purposes of this report, this term refers to a device that emits a small range of wavelengths surrounding the peak wavelength. For example, a blue light may emit a peak wavelength of 475 nanometers (nm), but also emit light in a small range around that peak wavelength (465-485 nm). This same device is incapable of emitting other ranges of light. Lasers, which emit light at a singular wavelength only, are not included in this report.

**Ultraviolet (UV) radiation:** that part of the EM spectrum below 400 nm and usually above 200 nm.

**Visible light** the part of the electromagnetic (EM) spectrum that is visible to the human eye. Visible light ranges from approximately 400-700 nm. Occasionally in this report the term “visible spectrum” is used to mean the more correct term “the visible region of the EM spectrum.” The same occasionally occurs with the term “UV and IR spectrum” which more correctly means “the UV and IR region of the EM spectrum.” Furthermore, the term “light” strictly applies only to the radiation of the visible region of the EM spectrum, but in this report the term “light” is occasionally used for radiation of the UV region and of the IR region of the EM spectrum.

**Wavelength:** a measure of the distance (nm) between two consecutive peaks (or troughs).

# Introduction to Alternate Light Sources

## Fluorescence

Alternate light sources (ALS) enhance the visualization of evidence not readily apparent to the naked eye, facilitating collection, documentation, and processing of evidence. The technology uses light emitted at a controlled range of wavelengths to improve the contrast of evidence against a background. Alternate light sources that emit light in the visible range (400–700 nanometers [nm] within the electromagnetic spectrum) cause multiple types of evidence to be visualized through fluorescence.

Fluorescence is the emission of light of a longer wavelength by a substance that has absorbed light of a shorter wavelength. When a fluorophore, or molecule capable of fluorescence, is subjected to a light source at a specific wavelength (called the excitation wavelength), it absorbs energy and transitions into a higher-energy excited state. Shortly after light exposure, the molecule returns to its normal state, or ground state, and the excess energy is emitted as light. This wavelength of light (called the emission wavelength) is of a longer wavelength than the excitation wavelength, and is detected as fluorescence.[1]

Some types of evidence important to a crime scene investigation—such as hairs, fibers, or biological fluids that may contain DNA—naturally fluoresce when excited by a certain wavelength or range of wavelengths. Developing agents applied to evidence such as fingerprints may also fluoresce with illumination. ALS devices in the visible spectrum emit light at different colors, which are controlled ranges of visible light wavelengths with specific peak wavelengths (most of the light emitted by the device is at this wavelength). **Figure 1** shows the types of evidence that can be detected at specific wavelength ranges (colors of light).[2] **Table 1** gives the general wavelength ranges for each color of visible light.[3]

**Fluorescence Versus Light Absorption**

Some evidence—such as untreated blood and some treated fingerprints—absorbs the light emitted by ALS and may not fluoresce. Though these types of evidence may not fluoresce, illumination of evidence still enables easier detection and documentation via photography. However, fluorescence of evidence is more common than absorption.

[1] Johnson, I., & Spence, M.T.Z. (Eds.) (2010). Molecular Probes Handbook, A Guide to Fluorescent Probes and Labeling Technologies (11th ed.). Life Technologies Corporation.

[2] SPEX Forensics. Forensic Light Source Applications: Wavelengths and Uses. Retrieved from http://www.horiba.com/fileadmin/uploads/Scientific/Documents/Forensics/fls.pdf

[3] Nichols, H., & Sanfillippo, P. (2017) *Alternate Light Source Workshop: Course material.* Tritech Forensics. St. Louis, MO, June 26-27, 2017.

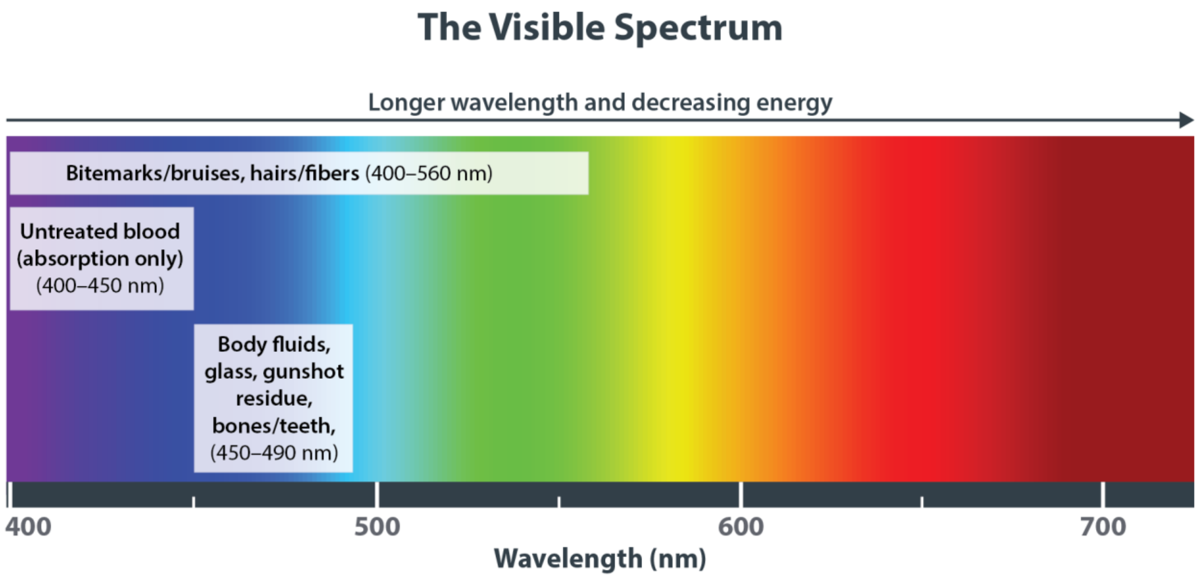


Figure 1. Examples of evidence types detected using different wavelengths of light in the visible spectrum. The evidence and wavelengths listed in this figure are not exhaustive.

Table 1. Wavelength ranges correlated to visible colors of light emitted by ALS, and ultraviolet light. These ranges are approximate.[4]

| Wavelength Range (nm) | Color of Light |
|---|---|
| 630–700 | Red |
| 590–630 | Orange |
| 560–590 | Yellow |
| 490–560 | Green |
| 450–490 | Blue |
| 400–450 | Violet |
| 260–400 | Ultraviolet (invisible) |

## Barrier Filters

Visualizing and documenting evidence by ALS illumination requires use of a barrier filter. During the fluorescence process, light emitted by the ALS (at the excitation wavelength) is reflected back to the eye, overpowering the emitted fluorescence (at the emission wavelength), often rendering it undetectable. Barrier filters enable visualization of fluorescence by preventing transmission of light at the same wavelength as the excitation light to the eye or detector (such as a digital camera).[5] Light produced by the fluorescing compound passes through the barrier filter and is detected by the eye or camera. **Figure 2** demonstrates the role of a barrier filter in visualizing evidence. Barrier filters are manufactured in the form of goggles, flat viewing panes, and filters for digital cameras—any combination of the aforementioned barrier filters and detectors can be used with single and multiwavelength units. The appropriate barrier filter depends on the wavelength of light used; for example, evidence illuminated by blue light can most often be

[4] Nichols, H., & Sanfillippo, P. (2017) *Alternate Light Source Workshop: Course material.* Tritech Forensics.

[5] Marsh, N. (2014). Light as a Forensic Photographer's Tool. In *Forensic Photography: A Practitioner's Guide* (1st ed.) (pp 163-193). River Street, MS: Wiley & Sons.

visualized through an orange barrier filter. Without these filters, the illuminated evidence would most likely be undetectable to the naked eye.

In most circumstances, the barrier filters used for ALS that emit visible light are longpass filters. These optical filters block transmission of light with wavelengths below a certain range. Light with a longer wavelength (and lower energy) cannot be perceived by the viewer. When the appropriate color barrier filter is used, it can effectively block the excitation light emitted by the ALS.

Barrier filters must transmit precise wavelengths of light to effectively detect evidence. Filters that block light transmission at a defined wavelength range may more reliably block the transmission of ALS excitation light, enabling better visualization of evidence. This means that undesired wavelengths of light are less likely to "leak" through the barrier filter, obscuring the fluorescence. **Figure 3** demonstrates the importance of barrier filters with a semen stain illuminated by blue light and visualized (a) with and (b) without an orange barrier filter.

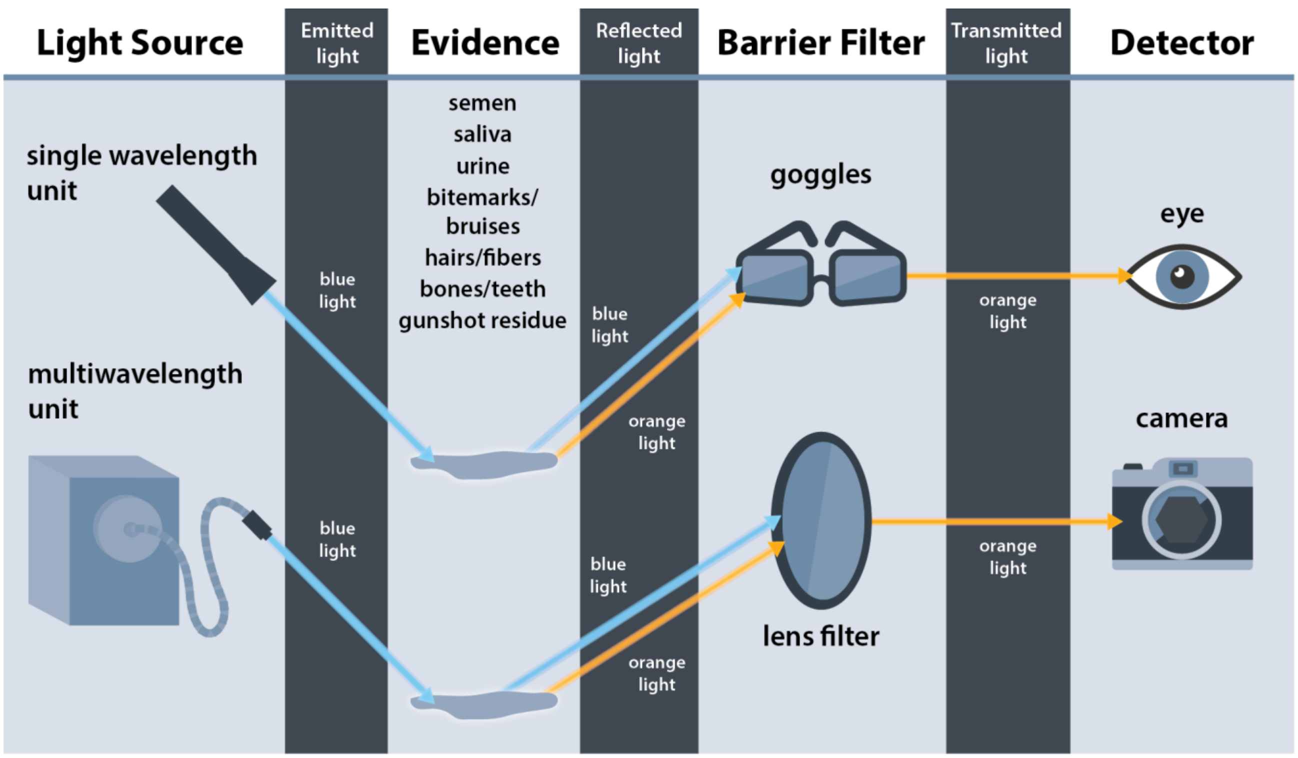


Figure 2. This figure depicts how a detector perceives fluorescence of evidence when using an ALS and a barrier filter, using blue light as an example. Note that the barrier filters and detectors are interchangeable regardless of light source used. Steps in process: 1) Blue light is emitted from a single wavelength or multiwavelength ALS unit. 2) The light hits the surface of interest, which can be multiple types of evidence. A fluorophore absorbs the energy and transitions into the excited state. 3) Light of a longer wavelength (orange) is emitted when the fluorophore returns to its ground state. Both the initial blue light (excitation) and orange light (emission) are reflected off the surface. 4) The use of an orange barrier filter—whether a pair of goggles or a lens filter—allows only orange light to pass through to the eye or camera, leading to better visualization of the detected stain.

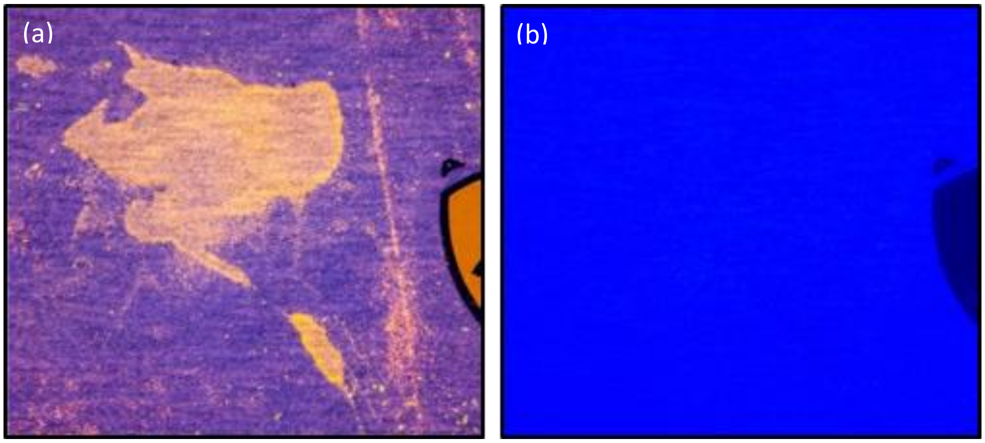


Figure 3. (a) Semen stain illuminated by blue light (475 nm) and visualized with an orange barrier filter, and (b) semen stain illuminated by blue light (475 nm) without an orange filter. The reflected blue light in (b) overpowers the fluorescence of evidence, whereas the blue light is blocked by the orange barrier filter in (a).

## Light Source Technologies

Just as there are various types of barrier filters, there are a variety of ALS technologies on the market. ALS devices are generally powered by three different types of light sources:

- Incandescent bulbs
- Arc lamps
- Light-emitting diodes (LEDs).

Incandescent light bulbs produce illumination through heating a filament, which emits radiation in the visible light spectrum. This light is composed of energy at all wavelengths within the visible light spectrum, and is emitted as white light. Many ALS devices use incandescent bulbs that are filled with xenon, while others are filled with halogens or metal halides.[6] Some light sources use arc lamps, which emit light when a charge is passed through two electrodes in a bulb pressurized by a gas, such as xenon.

To operate as an ALS and emit light at discrete wavelength ranges, units powered by incandescent and arc lamp bulbs must be outfitted with bandpass filters, which allow light in a certain range of wavelengths to pass through. The smaller the range of wavelengths that can pass through the filter, the higher the quality of the filter; generally, these filters allow a range of 40–50 nm to pass through. ALS devices powered by incandescent and arc lamp bulbs—depending on the ranges of bandpass filters incorporated—can be tuned to any color or range of wavelengths. This positions the devices to serve as effective multiwavelength units.[7]

LED-based ALS devices, on the other hand, emit light in a small range of wavelengths viewed as one color. The color of light emitted by LEDs is based on the combination of semiconductors incorporated into the light source.[8] Because LEDs emit light only in a small range of wavelengths (on average, over a 30–50 nm range), this technology is most often used in single-wavelength ALS flashlights.[9]

**Barrier and Bandpass Filters**

Though bandpass and barrier filters have different functions, they operate using the same principles. The bandpass filter within the ALS device allows wavelengths within a certain range to illuminate the evidence, while the barrier filter is used in conjunction with the light source so that the user can visualize the fluorescence emitting from the illuminated evidence.

[6] Norman, M., & Buszka, J. (2013). UV and Narrowband Visible Light Imaging. In *Alternate Light Source Imaging: Forensic Photography Techniques*. (pp 25-61). New York, NY: Taylor & Francis.

[7] Marsh, N. (2014). Light as a Forensic Photographer's Tool. In *Forensic Photography: A Practitioner's Guide* (1st ed.) (pp 163-193). River Street, MS: Wiley & Sons.

[8] Office of Energy Efficiency & Renewable Energy, Department of Energy. LED Basics. Retrieved from https://energy.gov/eere/ssl/led-basics

[9] Marsh, N. (2014). Light as a Forensic Photographer's Tool. In *Forensic Photography: A Practitioner's Guide* (1st ed.) (pp 163-193). River Street, MS: Wiley & Sons.

## General ALS Product Landscape

The market for ALS devices is quite large, with over 15 manufacturers and 50+ products available. This section provides a general product landscape for ALS on the market, and provides an overview of selected manufacturers and products specifically referenced in user interviews (**Table 2**).

### General Product Table

Table 2. An overview of ALS manufacturers and devices on the market. Note that this list is not exhaustive.

| Manufacturer | Instrument | Footprint | Wavelength | Power | Bulb | Wavelengths Available | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flashlight or Unit | Single, Dual, Triple, or Multi | AC, Battery, Rechargeable Battery | LED, Incandescent, or Arc | White | Red | Orange | Yellow | Green | Blue-Green | Blue | Violet | UV |
| CSI CRIME SCIENCES INC™ ISI INVITRO SCIENCES INC™ http://crimesciencesinc.com/ | Glowtorch Forensic Light Sources | Flashlight | Single | Rechargeable Battery | LED | ○ | | ● | | ● | ● | ● | ● | ● |
| | Illumacam-2 | Unit | Dual | Rechargeable Battery | LED | | | | | ● | | ● | ● | ● |
| CAO GROUP, INC. Easier·Faster·Better™ http://www.caogroup.com/ultralite.html | ALS Ultralite | Unit | Multi | Rechargeable Battery | LED | ○ | ● | | ● | ● | | ● | | ● |
| EVIDENT https://www.shopevident.com/ | ORION-LITE 455nm Blue Light | Flashlight | Single | Battery | LED | | | | | | | ● | | |
| | ORION LITE 3-Piece Light Kit | Flashlight | Single | Battery | LED | ○ | | | | | | ● | | ● |
| foster+freeman http://www.fosterfreeman.com/ | CrimeLite 42S | Flashlight | Dual | AC or Rechargeable Battery | LED | ○ | | ● | | ● | ● | ● | ● | ● |
| | CrimeLite 82S | Flashlight | Single | AC or Rechargeable Battery | LED | ○ | ● | ● | | ● | ● | ● | ● | ● |
| | CrimeLite 82L | Unit | Dual | AC or Rechargeable Battery | LED | ○ | | | | | | | | ● |
| | CrimeLite XL | Unit | Multi | AC or Rechargeable Battery | LED | | | ● | | ● | ● | ● | | |
| | CrimeLite 2 | Flashlight | Single | AC or Rechargeable Battery | LED | ○ | ● | ● | | ● | ● | ● | ● | ● |
| FoxFury Lighting Solutions https://www.foxfury.com/ | Hammerhead | Flashlight | Single | Battery | LED | | | | | ● | ● | ● | | ● |
| | Scout Light System | Flashlight | Single | Battery | LED | | | | | | ● | | | ● |
| | MF-1000 | Flashlight | Multi | Rechargeable Battery | LED | ○ | | | | ● | ● | ● | | |
| | Rook NDT | Flashlight | Single | Battery | LED | | | | | | | | | ● |
| | OPTIMAX 450 | Flashlight | Single | Rechargeable Battery | LED | | | | | | | ● | | |

***Table 2** continued on next page*

| Manufacturer | Instrument | Footprint | Wavelength | Power | Bulb | Wavelengths Available | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flashlight or Unit | Single, Dual, Triple, or Multi | AC, Battery, Rechargeable Battery | LED, Incandescent, or Arc | White | Red | Orange | Yellow | Green | Blue-Green | Blue | Violet | UV |
| SPEX FORENSICS https://spexforensics.com/ (a division of HORIBA) | CrimeScope | Unit | Multi | AC | Arc | ○ | ● | ● | ● | ● | ● | ● | ● | ● |
| | Mini-CrimeScope | Unit | Multi | AC | Incandescent | ○ | | ● | ● | ● | ● | ● | ● | ● |
| | Handscope LED | Unit | Multi | AC or Rechargeable Battery | LED | | | | | ● | | ● | ● | ● |
| | HandScope Xenon | Unit | Multi | AC or Single-use Battery | Incandescent | ○ | | ● | ● | ● | ● | ● | ● | ● |
| | Focus LED | Flashlight | Single | Battery | LED | ○ | | ● | | ● | | ● | | ● |
| LABINO http://labino.com/ | TrAC Finder | Flashlight | Single | Rechargeable Battery | Incandescent | | | | | | | | | ● |
| | Labino Astra Crime Kit | Flashlight | Single | Battery | LED | ○ | ● | ● | | ● | ● | ● | | ● |
| | Labino Nova Crime Kit | Flashlight | Single | Battery | LED | ○ | ● | ● | | ● | ● | ● | | ● |
| LUMATEC® http://www.lumatec.de/en/ | Superlite S04 | Unit | Multi | Rechargeable Battery | Incandescent | | | | | | | | | |
| | Superlite 400 | Unit | Multi | Rechargeable Battery | Incandescent | ○ | ● | ● | ● | ● | ● | ● | ● | ● |
| | Superlite M05 | Unit | Single | Rechargeable Battery | LED | ○ | ● | ● | ● | ● | | ● | ● | ● |
| X-Loupe® https://www.x-loupe.com/ | AgileLite System | Unit | Single | Rechargeable Battery | LED | ○ | | | | ● | ● | ● | ● | ● |
| | Portable Microscope Camera System | Unit | Dual | Rechargeable Battery | LED | ○ | | | | ● | | ● | | |
| LYNN PEAVEY COMPANY https://www.lynnpeavey.com/ | BattleLite | Flashlight | Single | Battery | LED | | | | | ● | | ● | | ● |
| NEBO https://www.nebotools.com/ | CSI Quatro | Flashlight | Triple | Battery | LED | ○ | | | | ● | | | | ● |
| ROFIN Forensic http://www.rofinforensic.com.au/ | Polilight PL500 | Unit | Multi | AC | Arc | ○ | ● | ● | ● | ● | ● | ● | ● | ● |
| | Polilight PL400 | Unit | Multi | AC | Arc | ○ | | | | ● | ● | ● | ● | ● |
| | Polilight Flare Plus2 | Flashlight | Single | Rechargeable Battery | LED | ○ | ● | ● | ● | ● | ● | ● | ● | ● |
| | Poliray | Unit | Multi | AC | Incandescent | ○ | ● | ● | ● | ● | ● | ● | ● | ● |
| SIRCHIE® Command Every Scene™ http://www.sirchie.com/ | Bluemaxx Forensic Light Source | Flashlight | Single | Battery | Incandescent | ○ | | | | | | ● | | |
| | Forensic Alternative Light Source 3000 | Unit | Single | Rechargeable Battery | Incandescent | ○ | | | | ● | ● | ● | ● | ● |
| | megaMaxx 3-Watt Alternate Light System | Flashlight | Single | Battery | LED | ○ | ● | ● | ● | ● | ● | ● | | ● |

## Considerations for Selecting an ALS Device

Though the process of investigating a crime scene ultimately varies by case and by jurisdiction, multiple stakeholders are involved. The general steps and personnel in a crime scene investigation are shown in **Figure 4**, with some example considerations for use of ALS in crime scene processing:

| Step | Standard Operating Procedure | ALS Considerations |
|---|---|---|
| **Arrive at and Secure the Scene** | First responders and law enforcement arrive at and secure the crime scene, control any dangerous situations or persons, and ensure that any victims receive proper emergency care.<br>*Key personnel: first responders, law enforcement* | Did first responders or victim(s) mention seeing any bodily fluids, hairs, or fibers?<br>Did the victim(s) or witness(es) notice suspect contact with any surfaces suitable for latent print deposition? |
| **Assess and Document the Scene** | Investigators evaluate scene boundaries, communicate with first responders, conduct an initial walk-through, and document the scene.<br>*Key personnel: law enforcement, crime scene investigators* | Is there a power source?<br>Is ambient light present?<br>How large is the scene?<br>How could an ALS be utilized to search for evidence? |
| **Process the Scene** | Investigators determine whether additional personnel, including specialists, are needed to assist with the investigation. Investigators document, photograph, and sketch the scene. ALS may be used to detect evidence that is not visible to the naked eye.<br>*Key personnel: law enforcement, crime scene investigators, specialists* | Were all possible wavelengths used in the search for evidence?<br>Investigators should take photographs to document evidence visualized by ALS.<br>Was the proper barrier filter used during the search for evidence? |
| **Conduct Laboratory Analysis** | Once the scene has been released and evidence has been collected, the evidence may be sent to additional units for processing. For example, forensic biology and latent print units may use ALS to facilitate the search for evidence.<br>*Key personnel: laboratory analysts* | Would a multiwavelength or single-wavelength device be more beneficial for this instance?<br>Were all possible wavelengths used in the search for evidence?<br>Investigators should take photographs to document evidence visualized by ALS. |

Figure 4. Crime scene investigation procedure, key personnel, and ALS considerations for each step of the process.

As agencies and laboratories look to implement or replace their equipment, they must select the appropriate device from a crowded ALS market. Over 10 manufacturers sell more than 50 products combined that range in price from $20 to $20,000. Today's ALS products incorporate more advanced technologies—such as LEDs, compact packaging, and precise bandpass filters—to improve the user experience, which ultimately leads to better detection and investigative outcomes. This section reviews ALS product types, features, applications, and education to help agencies make an informed decision when purchasing an ALS device for their specific needs.

## Types of Devices

Two main types of ALS exist:

- Devices that emit only one specific wavelength and
- Devices that emit multiple wavelengths to scan for evidence.

Each device type possesses benefits and limitations applicable to most ALS applications; **Table 3** summarizes this information. Single-wavelength ALS devices are typically handheld, battery-powered flashlights. These products use either incandescent light or LEDs. Some single-wavelength ALS products consist of one discrete flashlight per wavelength, while others have one flashlight and interchangeable heads with different wavelengths. These flashlights can be sold individually, as a set that contains multiple flashlights, or as a set that contains interchangeable flashlight heads.

Multiwavelength ALS devices are typically larger devices that produce light at a variety of wavelengths over the visible light spectrum (and in some cases UV). Most multiwavelength devices operate using an incandescent bulb—such as a xenon bulb—which produces a white light that is filtered by a bandpass filter. However, some multiwavelength products on the market use multiple colors of LEDs in the same device. Typically, multiwavelength units must be plugged into a power source to operate. In most cases, these devices emit 5-16 different wavelengths of light; fewer devices on the market emit two or three colors of light in a smaller device. Refer to Table 2 (General Product Table) for more information.

Expert interviews revealed that multiwavelength devices tend to stay in the crime laboratory, especially in circumstances where the crime scene does not have available or reliable power sources. Single-wavelength units, however, are consistently used in both the field and the laboratory setting. They provide value in the field because they operate without outlet power and are small, light, and easily portable. In the laboratory, single-wavelength ALS devices provide easy maneuverability and freedom from cords that could pose a safety hazard in a darkened environment. Single-wavelength ALS devices have comparable intensity to multiwavelength units. Because individual single-wavelength devices typically cost less than multiwavelength units, purchasing flashlights at one or two selected wavelengths offers an economic alternative to purchasing a more expensive multiwavelength device.

Table 3. Benefits and limitations of single-wavelength and multiwavelength devices.

| | Benefits | Limitations |
|---|---|---|
| Single-Wavelength | **Portability**: Battery-powered, can use in sites without available AC power. Smaller size makes the device easier to maneuver. | **Limited search time:** Battery life limits the time an individual can use the instrument. |
| Single-Wavelength | **Cost (individual)**: Individual units are typically more cost-effective than multiwavelength units; can purchase single units with most appropriate wavelength. | **Cost (of whole kit):** Purchasing a kit containing all wavelengths can be more expensive than some multiwavelength devices. |
| Single-Wavelength | **Durability:** Devices are designed for field conditions and can withstand harsh conditions. | **Size:** Smaller devices typically have smaller beams of light, which increases search time. |
| Multiwavelength | **Versatility:** Emits light of multiple wavelengths; can be used for many applications. | **AC Power Dependency:** Most require AC power and wires, which crime scenes may not have available. |
| Multiwavelength | **Ease of use**: All wavelengths are on-hand in one instrument, allowing easy switching between wavelengths. | **Cost:** Typically higher cost than discrete wavelength flashlights. |
| Multiwavelength | **Efficiency**: Typically large light beam produced; can cover a large search area. | **Size:** Large units (compared to flashlights) can lead to user fatigue. |

When evaluating options for implementing a new ALS, decision makers must consider features of both the light source and the barrier filters, which are necessary to visualize the evidence illuminated by the device.

## Device Considerations

Jurisdictions looking to purchase and implement a new ALS device should consider the following properties that influence the quality of the product, regardless of application or ALS type:

**Light Brightness:** Users consistently referenced bright light as a desired characteristic in ALS devices. This quality improves the chance of detecting fluorescence, allowing better detection of evidence in conditions that have background light. Both LED and incandescent bulb-based lights can provide intense light output. In LED products, brightness measurements (in lumens) are typically available. However, information on the intensity of incandescent bulb-based ALS are not typically offered in spec sheets, so comparing intensity among bulb sources is difficult. Brightness can be compared, however, by testing two products at once. More information on testing products can be found on page 19.

**Focused Light:** A high-quality ALS device produces a focused beam with uniform light throughout the beam. There is no "hot spot" where the center is more intense and fades out. This uniformity improves detection of evidence and photography results. **Figure 5** shows an example of a hot spot.

**Size:** In any application, smaller and more portable units are easier to maneuver around the evidence. Lighter devices lead to less user fatigue.

**Battery Life***:* A longer battery life increases the time that investigators can use a handheld device. Interviews with users revealed that battery life was a significant concern when working in field conditions. The representative sample of flashlight ALS devices in the product table are reported to have an operating time of 140–750 minutes (~2-12 hours); however, this operating time depends on factors such as the intensity and peak wavelength of the light used. Interviews revealed that actual battery life is usually shorter than what is needed during an investigation.

**Maintenance:** Products with long life cycles reduce the downtime of the ALS device as well as the replacement costs. In other words, the lifetime of the device's bulb affects that of the entire ALS device. Replacement costs for bulbs can be equivalent to the cost of replacing the entire instrument. Devices with LEDs last considerably longer. Xenon bulbs have a typical lifespan of about 1,500 hours[10] while LEDs have a lifespan of about 50,000 hours.[11]

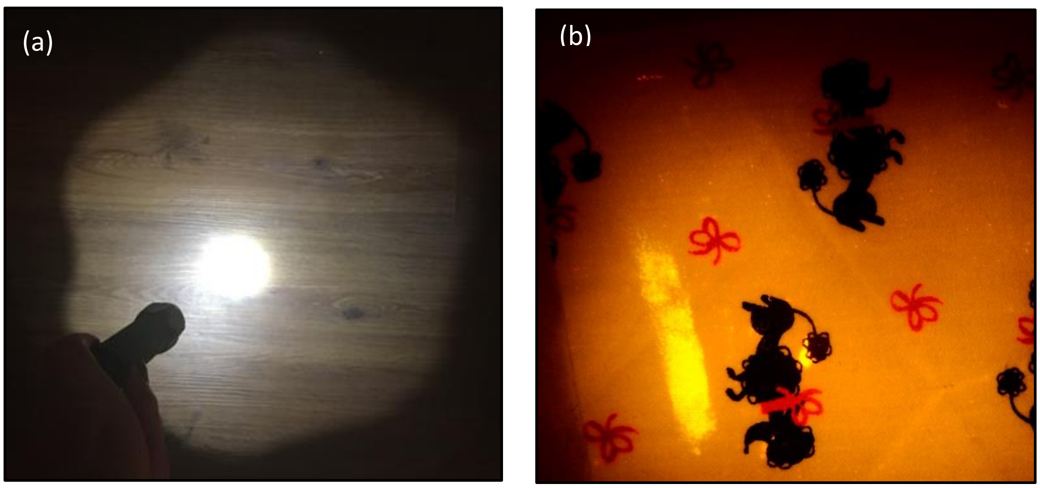


Figure 5. Demonstration of a hot spot (a) with a white light and (b) with a blue ALS visualized through orange barrier filter goggles. The light in the center is more intense than the surrounding light.

**Sensitivity:** The smaller the range of wavelengths of light a device emits, the more sensitive the device. Sensitivity depends on the quality of light source used, as well as the range of wavelengths transmitted by the bandpass filter in incandescent light sources. Typically, manufacturers do not publish the range of wavelengths the ALS emits; rather, they publish the peak wavelengths for each color.

**Barrier Filter:** A variety of different filter types exist, ranging in price from $10 for plastic goggles to more than $2,000 for specialty camera filters. Because barrier filters are necessary to view and document the evidence, agencies are strongly encouraged to invest in high-quality barrier filters that do not easily scratch or allow undesired wavelengths of light to "leak" through the filter. It is especially important that a quality camera filter is purchased to ultimately document the evidence that is being visualized. Potential buyers should consult their ALS manufacturer or distributor representative to identify the barrier filters that best fit their needs and budget.

[10] Schneider, A., & Feussner, H. (2017). Operative (Surgical) Laparoscopy. *In Biomedical Engineering in Gastrointestinal Surgery*. (p 294). Academic Press.
[11] Office of Energy Efficiency & Renewable Energy, Department of Energy. LED Basics. Retrieved from https://energy.gov/eere/ssl/led-basics

While some factors, such as intensity, cannot be determined by referencing a product specifications sheet, they can be evaluated by comparison tests of several products. Consulting other agencies or laboratories for purchasing advice can also provide insight. Agencies should also base decisions on circumstances unique to their jurisdiction, including agency size, specific needs, and budget.

There is no "perfect" ALS device. Many options that balance the aforementioned characteristics are available to support specific needs. For example, a highly sensitive device may have a lower light output due to the precision of its bandpass filter. An overview of specifications for common devices are featured in the Featured Product Tables on pages 38-39. Narrowing down appropriate products requires a look at the specific applications for the ALS.

**Trialing ALS Devices to Find the Best Fit**

Many manufacturers (or neighboring agencies) will allow potential buyers to borrow ALS units before purchasing them. This is an effective way to determine if a device fits their specific needs. Users who have successfully implemented new ALS devices in their jurisdictions have used these methods to test the instruments:

► Using evidence samples from old cases to determine if the ALS can detect the evidence.

► Comparing the brightness of a stain using multiple ALS products, or assessing the lowest concentration at which a stain can be detected by each light.

► Testing the device at different levels of ambient light in various settings.

► Testing the battery life of the device at different power intensities (if adjustable).

► Using the ALS to photograph samples from cases.

► Operating the device under normal conditions and observing the time required to investigate the scene and become fatigued from instrument use.

## ALS Applications

A critical factor in selecting the most appropriate ALS is the application for which the device will be used. While the technology proves to be useful in many types of field and laboratory applications, the most common disciplines in which ALS are used include the following:

- Crime scene investigation
- Forensic biology (laboratory)
- Latent prints (laboratory)
- Trace evidence (laboratory)
- Medicolegal death investigation
- Forensic nursing

This section outlines roles and scenarios in crime scene investigation where ALS is commonly used, and provides factors to consider when purchasing an ALS.

### Crime Scene Investigation

ALS are commonly used to investigate crime scenes to identify and document evidence. The crime scene is the least controlled of environments in which alternate light sources are used. Outdoor crime scenes are subjected to weather conditions and lack available power sources. Crime scenes can range from large areas, such as fields, to tight spaces that limit the investigator's mobility. In this application, the portability and size of the ALS are critical. Generally, the crime scene investigator looks for the widest range of evidence, from biological fluids—such as semen and saliva—to fingerprints. Once discovered, the evidence is collected and allocated to specialized sections in the crime laboratory. The most common wavelengths used and items searched for are presented in **Table 4**.[12]

A compact, handheld, and battery-powered device is necessary to easily and effectively maneuver around a crime scene without causing user fatigue. The size of the device, however, must be balanced with the need for the device to generate a large beam of light. The smaller the beam of the light, the more time it takes for an investigator to cover an entire crime scene. Larger multiwavelength devices usually emit a larger light beam, which allows investigators to cover a larger surface area in a shorter amount of time. In situations where crime scenes are expansive (and an external battery pack or AC power is available in places such as a home or business), multiwavelength units are helpful. Because crime scenes may be in extreme conditions, devices should have ruggedized features such as shock-proof or waterproof packaging.

Due to the uncertainty of AC power being available during a crime scene investigation, ALS powered by batteries are the more common choice. Based on interviews from crime scene investigators, the battery life of a handheld ALS can curtail the duration of the investigation. To ensure proper completion of an investigation, many users suggest having additional batteries or using rechargeable batteries to accommodate the power needs of the individual device.

At a crime scene, lighting conditions are less controlled than those in the laboratory. Devices with a bright light output are helpful in identifying evidence, and can function well in environments where light is present.

Most of the crime scene investigators interviewed use handheld units, with a majority primarily using single-wavelength, handheld lights with a blue light (~450 nm). Blue light with orange goggles can generally detect the largest range of evidence; a jurisdiction with budgetary concerns could purchase a blue wavelength handheld device rather than a larger multiwavelength device or a set of single-wavelength flashlights.

[12] Nichols, H., & Sanfillippo, P. (2017) *Alternate Light Source Workshop: Course material.* Tritech Forensics.

**Table 4.** Common evidence detected in crime scene investigations using ALS and the respective excitation wavelengths/barrier filters necessary.

| | Excitation Light | | | |
|---|---|---|---|---|
| **Evidence** | **UV (260- 400 nm)** | **Violet (400-450 nm)** | **Blue (450-490 nm)** | **Green (490-560 nm)** |
| Bitemarks/Bruises | ● | ● | ● | ● |
| Hair/Fibers | ● | ● | ● | ● |
| Body fluids | ● | | ● | |
| Untreated blood (absorption only) | | ● | | |
| Blood treated with fluorescein | | | ● | |
| Bones/teeth | | | ● | |
| Glass | ● | ● | | |
| Gunshot residue | | | ● | |
| **Barrier Filters** | | | | |
| Clear (or no filter) | ● | | | |
| Yellow | | ● | | |
| Orange | | | ● | |
| Red | | | | ● |

**ALS users in crime scene scenarios have addressed battery life concerns in these ways:**

- ► Choosing devices that are powered by conventional disposable batteries (like AA batteries), and always having multiple backup batteries on hand.
- ► Using products that have tunable intensity—turning down the intensity extends battery life when the battery is getting low.
- ► Purchasing devices with car chargers.

## Crime Scene Investigator User Profiles

The following section provides two examples of successful ALS device implementations to illustrate benefits and highlight implementation considerations for crime scene applications. Key impacts and lessons learned are highlighted. These use profiles detail the experiences of two ALS users in crime scene applications:

- Detective Richard Emmons, Snohomish County Sheriff's Office
- Lieutenant Peter Cestare, Horry County Police Department

## Crime Scene Investigation Use: The Special Investigations Units of the Snohomish County Sheriff's Office visualizes evidence in the field using Foster + Freeman Crime-lite® 82S lights.

Detective Richard Emmons serves in the Special Investigations Unit of the Snohomish County Sheriff's Office in the state of Washington. He has spent 18 years in the field and previously worked for Whatcomb County as a lead crime scene investigator.

**Use Profile:**
The Snohomish County Sheriff's Office Special Investigations Unit focuses on investigating crimes against children and sexual assaults. Detective Emmons uses the Foster + Freeman 82S unit to detect evidence such as body fluids and bruising on strangulation victims. The Special Investigations Unit uses ALS exclusively in the blue wavelength range, but is considering the purchase of ALS in more wavelengths, such as a violet wavelength range to better visualize bruising.

Detective Emmons reported that the device's light intensity enabled illumination of evidence such as latent prints in low light conditions. This facilitates documentation of evidence through ALS photography because high-resolution photos are easier to take with background light. Evidence fluoresces more brightly under illumination from the intense light of the Crime-lite 82S, which improves the quality of forensic photography. The portability and small size of the device also allow for easier maneuverability in crime scenes.

Detective Emmons consulted with other organizations, including the DNA subsection of the Washington State Patrol Crime Laboratory Division, to determine the features of an ALS that would best fit the needs of his unit. After testing several devices that matched these needs, he selected the Foster + Freeman 82S. To communicate the value of purchasing this device, he delivered a presentation to decision makers in his department outlining the advances in ALS technology and the benefits of using these devices in evidence collection.

> *"Intensity is an important factor in choosing alternate light sources, especially for photography applications. Bright lights, such as the Crime-lite 82S, make it easy to document evidence."*
> *— Detective Richard Emmons*

Detective Emmons believes a lack of education for ALS devices remains a big challenge in the forensic community. From his experience in law enforcement, he understands that budget limitations may prevent procurement of devices or, worse, proper training for users. He noted that even the most expensive, high-quality ALS instruments cannot lead to successful evidence collection without proper training. Detective Emmons manages training for the unit and uses mocked-up example evidence to instill best practice guidelines in users.

Detective Emmons had discussions with supervisors about exploring the concept of a centralized facility for storing field equipment, such as a van equipped with all necessary tools. This could allow the department to purchase one high-quality multiwavelength device rather than multiple single-wavelength devices.

**Device Impact:**
Light intensity: Ability to detect evidence in settings with background light.

**Lesson Learned:**
Intense light output in ALS devices enables high-quality documentation of evidence with digital photography.

## Crime Scene Investigation Use: The Horry County Crime Scene Investigations Unit uses Lynn Peavey BattleLite and Sirchie BlueMaxx lights for field work and SPEX Mini-CrimeScopes for evidence analysis in their laboratory.

Lieutenant Peter Cestare is the Commanding Officer of the Crime Scene Investigations Unit for the Horry County Police Department in South Carolina.

**Use Profile:**
The Horry County Crime Scene Investigations Unit supports patrol officers and detectives in capturing and documenting evidence at crime scenes. While a majority of their work lies in the field, the unit conducts preliminary screens of the evidence, such as searches for body fluids on a garment, in a field office before sending the evidence to the crime laboratory. These screens streamline investigations by reducing the amount of evidence a crime lab must process. In both applications, the unit uses ALS for detecting semen, saliva, urine, trace hairs and fibers, and gunshot residue. Different ALS devices are used in these two settings:

1. In the field, the unit typically uses both the Lynn Peavey BattleLite and the Sirchie BlueMaxx, two small flashlights both with a single blue wavelength output. Both devices are small and lightweight; investigators will occasionally strap the portable lights to their wrists, which enables hands-free illumination. Lieutenant Cestare praised both the BattleLite and the BlueMaxx for their high-intensity light output, especially for their compact size. The BattleLite also provides a focused beam of light that allows users to identify potential biological fluids more reliably.

*"I'm pleased with the Mini-CrimeScope because it's versatile—you can take it out to the field and also use it in the laboratory."*
*— Lieutenant Peter Cestare*

*"The BattleLite is small, compact, and gives off intense light for its size. This allows us to search more quickly during an investigation."*
*—Lieutenant Peter Cestare*

2. The field office primarily uses the multiwavelength xenon-based SPEX Mini-CrimeScope. It is most often used as a stationary instrument in the facility because it requires AC power and cannot be as easily maneuvered as the flashlights. Because these investigators search mainly for biological fluids in ALS applications, the blue wavelength is favored; however, multiple wavelengths are used during preliminary evidence processing to ensure that potential evidence fluorescing under slightly different wavelengths can be detected. Because the light from the multiwavelength device covers a large surface area, the device is deployed to the field in situations where large areas need to be covered and AC power is available.

Lt. Cestare recognizes that training is key for quickly and effectively detecting useful evidence for a criminal investigation. He ensures that all ALS users in his department are trained extensively by the manufacturer before using the instrument. As the Commanding Officer, Lt. Cestare makes the final decision on ALS products to use within the unit. He did not rely on other agencies for choosing the devices because these decisions rely heavily on specific needs and available budget. Instead, he conducted a significant amount of research to identify suitable ALS products and tested them himself. He found the previously mentioned products to best suit the needs of his Crime Scene Investigations Unit.

**Device Impact:**

- Reliability: Intense, focused light enables more reliable detection of biological evidence in the field.
- Portability: Small flashlights facilitate efficient searching and are easy to maneuver at a crime scene.

**Lessons Learned:**

- ALS devices with a large beam can cover more area during the search process. These tend to be large multiwavelength devices, but some flashlights produce a large beam.
- Uniform light, in addition to intensity, increases the ability to detect evidence.

## Crime Laboratory

ALS devices are used to identify evidence that requires further laboratory analysis. Evidence collected from a crime scene is brought to the crime laboratory that may be operated at the local or state level, or may be privately owned. Evidence is sent to different units based on forensic discipline. Forensic biology, latent prints, and trace evidence are three major crime laboratory units that commonly use ALS.

In most crime laboratory settings, multiwavelength devices are used because alternating current (AC) power is available. However, some laboratory units use smaller, handheld single-wavelength lights in addition to, or in place of, the larger units. These handhelds are easy to maneuver around evidence and mount on walls for hands-free searching. Many users believe handheld one-wavelength lights have comparable intensity to larger multiwavelength lights. Single-wavelength flashlights also offer versatility for units that have crime scene response teams.

Generally, ALS in the laboratory is utilized in low light conditions to make detecting evidence more effective. However, an intensely bright light allows laboratory personnel to operate in a room under brighter conditions. Devices with intuitive designs facilitate efficient use of the instrument.

This section provides ALS implementation considerations specific to forensic biology and latent print applications.

Interviewees who use ALS in entirely pitch-black or low light conditions prefer devices that can be easily controlled in the dark. These user-friendly features include the ability to

- ► Change wavelengths with one hand (such as with a thumb spinner).
- ► Operate the device using buttons located on the end of flashlights.
- ► Switch between wavelengths without turning the machine completely off.

## Forensic Biology Unit

Personnel working in the forensic biology unit use ALS to identify body fluids such as semen, saliva, or urine on collected evidence to test for the presence of DNA. The DNA found on the evidence is ultimately tested for identification purposes. Most interviewees working in a forensic biology unit use primarily blue light with orange goggles for detection of biological fluids, though other wavelengths can also visualize relevant evidence. **Table 5** depicts commonly detected materials in this application.

Individuals working in this setting must carefully search for biological fluids on evidence, which could range in size from a small garment to a large bedsheet. Having a sensitive light source allows biological fluids present in low levels to be detected, enabling quicker processing of evidence. In addition, an intense light improves the chances of detecting fluorescence emitted by the sample. Because blue light can detect a wide variety of biological materials, a handheld single-wavelength blue flashlight can serve most purposes in the forensic biology unit.[13]

[13] Nichols, H., & Sanfillippo, P. (2017) *Alternate Light Source Workshop: Course material.* Tritech Forensics.

Table 5. Common evidence detected in forensic biology units using ALS and the respective excitation wavelengths/barrier filters necessary.

| | Excitation Light | | |
|---|---|---|---|
| **Evidence** | **UV (260-400 nm)** | **Violet (400-450 nm)** | **Blue (450-490 nm)** |
| Semen | • | | • |
| Saliva | • | | • |
| Urine | • | | • |
| Untreated blood (absorption only) | | • | |
| Blood treated with fluorescein | | | • |
| Bones/teeth | | | • |
| **Barrier Filters** | | | |
| Clear (or no filter) | • | | |
| Yellow | | • | |
| Orange | | | • |

## Forensic Biology User Profiles

The following section provides examples of successful implementation of ALS devices to illustrate benefits and highlight implementation considerations for application in the forensic biology units at different organizations. Key impacts and lessons learned are highlighted. These use profiles detail the experiences of two ALS users in forensic biology applications:

- Dr. Christian Westring, NMS Labs
- Jenny Elwell, North Carolina State Crime Laboratory

## Forensic Biology Use: NMS Labs uses the Rofin Polilight® Flare Plus 2 for biological materials detection in the laboratory.

Dr. Christian Westring is the Laboratory Director of Criminalistics at National Medical Servies (NMS) Labs—a private laboratory with extensive capabilities in forensic services, including DNA testing, body fluid identification, forensic chemistry, and toxicology. He oversees both the Forensic Biology and Forensic Chemistry units.

**Use Profile:**
The Forensic Biology Unit of NMS Labs uses ALS to search for biological evidence ultimately for forensic DNA testing purposes. The laboratory exclusively uses the Polilight Flare Plus 2 flashlights. Because this unit of NMS Labs is primarily searching for biological fluids—including semen, saliva, and urine—the company purchases and uses only the blue flashlights that have 450 nm light.

Dr. Westring and his team have been pleased with the performance and versatility of the Polilight Flare 2 products. The devices are light and can be easily maneuvered around the evidence, yet can be wall-mounted to provide hands-free illumination. Laboratory technicians can operate the instrument with one hand in a darkened room and do not have to worry about electrical cords impeding the analysis or posing a trip hazard. The team enjoys the low-maintenance aspect of these LED-based lights, especially because the team does not have to replace bulbs or units frequently.

NMS Labs employed a systematic validation study process to identify the most appropriate ALS for their needs. They tested multiple instruments and assessed performance-related factors, such as level of detection for various biological materials, brightness of stains, and level of interference from other materials. The Polilight outperformed similar ALS brands and thus was implemented in the Forensic Biology Unit.

> *"The quality [of the Polilight Flare Plus 2] is fantastic—we see brighter stains on our evidence."*
> *—Dr. Christian Westring*

Dr. Westring added that the quality of the barrier filter goggles used in conjunction with the ALS affects the technician's ability to detect evidence. Inexpensive goggles tend to break, scratch, or limit the visualization of evidence.

**Device Impact:**

- Ease of use: Using handheld flashlights instead of large AC power-based multiwavelength units can allow for more freedom to move around the evidence in the lab.
- Sensitivity: High-quality lights allow for better detection of stains, and thus biological evidence.
- Low maintenance: LED bulbs have a long lifespan, and require less maintenance than incandescent devices.

**Lessons Learned:**

- Good quality goggles contribute to successful evidence detection—they must be considered in the budget for ALS.
- Testing light source products is an effective way to identify the most appropriate device for your jurisdiction.

## Forensic Biology Use: The North Carolina State Crime Laboratory Forensic Biology Division uses the Foster + Freeman Crime-lite 82S units for the detection of biological fluids.

Jenny Elwell serves as a Forensic Scientist Supervisor, Technical Leader for the Serology Unit and Special Agent in the Forensic Biology Division for the North Carolina State Crime Laboratory.

**Use Profile:**
The Forensic Biology Division at the North Carolina State Crime Laboratory uses ALS to screen evidence for bodily fluids that may contain DNA. The unit previously employed a large multiwavelength device to screen evidence, but the light source was not intense enough to consistently detect stains containing DNA. As the technical leader and one of the final equipment decision makers for the division, Ms. Elwell tested ALS products and compared their performance in visualizing evidence on samples taken from mock cases and real cases. She found that the Foster + Freeman 82S unit performed the best. She purchased Foster + Freeman 82S units in the blue (445 nm) and blue/green (475 nm) wavelengths, and these are currently the only units used in the laboratory.

The team appreciates that the Foster + Freeman 82S handheld units are lightweight, battery powered and easy to maneuver in the laboratory. More importantly, these compact instruments are powerful enough to visualize evidence at low concentrations. The output of these LED-based devices are intense enough that, unlike with other ALS lights, the room does not need to be entirely dark. Ms. Elwell ensures that all laboratory analysts are trained on these instruments before using them.

> *"The Foster + Freeman 82S product is a great product for what we need. It is lightweight and easy to handle. It may be small but it gets the job done and has made body fluid screening on bulky evidence much easier."*
>
> *—Jenny Elwell*

**Device Impact:**

- Effectiveness: Foster + Freeman 82S units emit high-intensity light that can detect previously undetectable stains.
- Maneuverability: Handheld ALS devices are lighter and less cumbersome to use than larger multiwavelength units.

**Lessons Learned:**

- LED-based light sources give off comparable or higher-intensity light than traditional incandescent-based sources.
- Using evidence from past cases is an effective method to identify the best ALS devices to fit an agency's needs.

## Latent Print Unit

Laboratory technicians in latent print units use ALS to visualize fingerprints, palm prints, footprints, and other impressions. ALS is commonly used in conjunction with reagents to either enhance the contrast of the evidence with the background or cause the evidence to fluoresce. The Federal Bureau of Investigation (FBI)'s Processing Guide for Developing Latent Prints documents ALS as a laboratory tool for a largely diverse set of enhancement techniques. A wide variety of wavelengths and goggles are used in conjunction with developing agents for latent prints, but the most common light wavelengths used are blue, green, and yellow. **Table 6** gives some examples of reagents, their respective excitation wavelengths, and recommended barrier filters.

Table 6. Common fluorescent fingerprint reagents used and the respective excitation wavelengths/barrier filters necessary. For a more extensive list of reagents and specific excitation maximums and visualization instructions, please visit the Chesapeake Bay Division International Association for Identification (CBDIAI) website. An asterisk (*) denotes the absorption maximum.

| | | Excitation Light | | | | | |
|---|---|---|---|---|---|---|---|
| **Processing Reagent** | **Excitation Wavelength; Absorption Maximum*** | **UV (260-400 nm)** | **Violet (400-450 nm)** | **Blue (450-490 nm)** | **Green (490-560 nm)** | **Yellow (560-590 nm)** | **Recommended Barrier Filter(s)** |
| Ardrox | 280-365 nm; 435-480 nm | ● | ● | ● | ● | | Clear, Yellow |
| Basic Yellow 40 | 415-485 nm | | ● | ● | | | Yellow, Orange |
| DFO | 495-550 nm; 514* | | | | ● | | Orange, Red |
| 1,2-Indanedione | 515-570 nm | | | | ● | ● | Orange, Red |
| Liqui-Drox | < 400 nm (UV) | ● | | | | | Clear (none) |
| M.B.D. | 415-470 nm; 415–505 nm; 450 nm* | | ● | ● | ● | | Yellow, Orange |
| M.R.M. 10 | 430-530 nm | | ● | ● | | | Orange |
| Nile Red | 450-560 nm; 530 nm* | | | ● | ● | | Orange |
| R.A.M. | 415-485 nm; 460 nm* | | | ● | ● | | Orange |
| Rhodamine 6G | 495-540 nm; 525 nm* | | | | ● | | Orange |
| Safranin O | ~500 nm region | | | | ● | | Orange |
| TapeGlo | 450 nm | | | ● | | | Orange |
| Thenoyl Europium | Long-wave UV (~350 nm) | ● | | | | | Clear (red for photography) |
| UV-sensitive powders/dyes | < 400 nm (UV) | ● | | | | | Clear |

When purchasing an ALS unit, latent print units should consider the types of reagents they use to enhance prints, as well as the environment in which they operate. Based on accounts of laboratory personnel with a latent print focus, many units use larger, incandescent bulb-based multiwavelength devices that rely on AC power. Compared to many applications, more wavelengths of light are employed to visualize prints and impression evidence. In latent print units with a crime scene response team, the large instrument usually stays in the lab when there is no available or reliable AC power at the scene, and teams use smaller single-wavelength flashlights, generally with a blue or green wavelength.

Documenting latent prints through photography is a very common practice. A practical ALS device must be sensitive and emit intense light so that the camera's sensor can detect the fluorescence of fingerprints against the background. More information on ALS device considerations for photography applications can be found on pages 34-35.

## Latent Print Unit User Profiles

The following section provides examples of successful implementation of ALS devices to illustrate benefits and highlight implementation considerations for applications in latent print units. Key impacts and lessons learned are highlighted. These use profiles detail the experiences of two ALS users in latent print units:

- Jennie Ayers, Idaho State Police
- Penny Dechant, Arizona Department of Public Safety

## Latent Print Use: The Idaho State Police use the Polilight® PL400, SPEX Mini-CrimeScope, and the Polilight Flare Plus 2 Devices within their Latent Print Section.

Jennie Ayers is a Forensic Scientist and Crime Scene Coordinator for the Latent Print Section of the Idaho State Police. She has been in the field over 16 years, and serves as an instructor for fingerprinting, evidence collection, and crime scene investigation in her unit.

**Use Profile:**

The Idaho State Police Forensic Services Latent Print Section uses ALS in the central lab and field to detect latent prints on evidence using powders, chemicals, and other treatments. These labs use the Polilight PL400 and the SPEX Mini-CrimeScope, both of which are xenon bulb-based instruments. Due to their size and power requirements, the instruments often remain in the laboratory; however, they occasionally bring these larger instruments into the field when they respond to crime scenes that have electrical sources, such as homes or businesses.

Both instruments provide multiple wavelengths of light, which is necessary for efficient evidence detection in the lab. Ms. Ayers prefers the Polilight PL400 due to its ability to provide an intense white light and switch between wavelengths without having to turn off the light.

> *"Intensity of light is important in both field and lab settings- it's hard to find evidence with a weak light, which is frustrating. The Polilight PL400 provides strong light for investigations, and it's easy to switch between wavelengths, even in low light."*
>
> *— Jennie Ayers*

**Device Impact:**

- Intensity: Intense light plays a large role in detecting evidence both at the scene and in the lab.
- Efficiency: Easy switching between wavelengths streamlines the process of searching for evidence.

**Lessons Learned:**

- Good-quality products have intuitive designs that facilitate searching for materials in dark environments.
- Having multiple wavelengths available for lab use is more important than having multiple wavelengths in the field.
- Being able to change wavelengths without having to turn the light off is a worthwhile convenience.

## Latent Print Use: The Latent Print Unit at the Arizona Department of Public Safety uses the SPEX CrimeScope and Rofin Polilight Flare Plus 2.

Penny Dechant serves as the technical lead for the Latent Print Unit at the Arizona Department of Public Safety. In addition to her role in casework, she is also involved in developing policies and procedures for the Latent Print Unit and has experience teaching latent print processing courses.

**Use Profile:**
The Latent Print Unit uses two different types of ALS: the SPEX CrimeScope CS-16-500W and the Polilight Flare Plus 2 flashlight. Because the CrimeScope is a large multiwavelength unit that requires outlet power, it typically stays in an examination room. While technicians use all wavelengths in the CrimeScope device, they typically focus on wavelengths that enhance visualization of evidence treated with certain processing techniques. For example, the team typically uses light at a blue wavelength for processing with superglue and fluorescent dye stain. Ms. Dechant reports that the CrimeScope provides consistently high-quality lighting for documenting processed evidence with photography.

In addition to the CrimeScope, the unit purchased Polilight Flare Plus 2 flashlights to provide more ALS options for their examiners beyond the multiwavelength device. The Latent Print Unit decided to purchase the Polilight Flare Plus 2 flashlights after attending the International Association for Identification (IAI)'s International Forensic Educational Conference and testing the products there. The examiners in Ms. Dechant's unit were pleased with the portability of the devices, which allows her team to use the ALS at their desks rather than the examination room. The handheld Polilight Flare Plus 2 is easy to maneuver around evidence, which allows the team to work more efficiently. Ms. Dechant noted that examiners use these devices to photograph the processed evidence, in addition to the CrimeScope.

> *"The CrimeScope lighting is consistent and reliable. It has the capability to be used in the field but we haven't had the need as of yet. The [Flare Plus 2's] portability is a big sell for our examiners because they can do searching from their desk instead of going to the [examination] room."*
>
> *—Penny Dechant*

**Device Impact:**

Efficiency: Having portable ALS devices available allows for efficient evidence processing.

**Lessons Learned:**

- The wavelengths necessary for latent print detection usually depend on the developing agents they use to process the prints.
- Portability of ALS device provides value to laboratory applications as well as field applications.

## Trace Evidence Unit

Trace evidence units in crime laboratories search for and test materials—such as glass, fibers, and residues—both at the crime scene and on evidence collected at the crime scene. ALS are used to better visualize this evidence, which is tested and identified through analytical laboratory techniques. **Table 7** shows common wavelengths used to identify trace evidence.

Table 7. Common trace evidence types detectable and the respective excitation wavelengths/barrier filters necessary.

| | Excitation Light | | | |
|---|---|---|---|---|
| **Evidence** | **UV (260-400 nm)** | **Violet (400-450 nm)** | **Blue (450-490 nm)** | **Green (490-560 nm)** |
| Hair/Fibers | ● | ● | ● | ● |
| Gunshot residue | | | ● | |
| Metallic Residue | | ● | | |
| Glass | ● | ● | | |
| **Barrier Filters** | | | | |
| Clear (or no filter) | ● | | | |
| Yellow | | ● | | |
| Orange | | | ● | |
| Red | | | | ● |

Like the latent print unit, trace evidence uses a wider variety of light wavelengths at the scene and in the laboratory. Flashlight sets with multiple wavelengths or multiwavelength units work well for trace evidence analysts. While the evidence analyzed in the trace evidence unit differs from that analyzed in the forensic biology and latent print units, ALS-specific protocols are very similar. For this reason, trace evidence examiners were not explicitly profiled in this report.

## Other Applications

ALS are useful in applications beyond crime scene and laboratory settings, such as forensic nursing and medicolegal death investigation.

### Medicolegal Death Investigation

Medical examiners investigate homicides and suspicious deaths both in context at the crime scene and in the morgue. By examining the body of a deceased victim, medical examiners provide insight to investigators about the cause and manner of death and can assist in identifying and collecting evidence for further analysis. Medical examiners may use ALS in a darkened examination room to search for biological evidence on the body—such as semen and saliva—as well as patterned and unusual injuries. Blue light or UV is usually employed for detecting biological materials; for bruising and patterned injuries, multiple wavelengths and barrier filters can detect ecchymosis, depending on how deep the injury penetrates the skin. Ecchymosis is defined as discoloration of the skin due to ruptured blood vessels, and it results in blood leakage into subcutaneous tissue. Multiwavelength ALS devices, therefore, are very useful in these settings. Because the room is darkened, devices with intuitive features (refer to page 24) are valuable for ease of use. Evidence collected from the body is photographed in this context; therefore, valuable ALS sources for this application emit intense light to detect evidence at low concentration levels.

### Forensic Nursing

Forensic nurses treat victims who have survived violent crimes, often domestic violence and sexual assault, in a clinical setting. The nurse can alert law enforcement to potential evidence, such as semen or saliva, on the victim for collection and processing. Additionally, forensic nurses can detect pattern injuries on the victim, such as ligature marks from victim-reported strangulation. Similar to medical examiners, forensic nurses use blue or UV to search for biological fluids and use a wide variety of wavelengths and barrier filters to search for bruising. High-intensity light is critical to penetrating layers of skin to visualize bruising, and multiwavelength units are preferred. Photography of the noted injuries is also very important. Read more about the importance of ALS photography on pages 34-35.

Generally, ALS is used as a court-admissible screening tool to identify evidence that will ultimately be tested in a laboratory. For example, suspected body fluids on a garment detected by ALS will be tested for the presence of DNA. In forensic nursing, however, ALS does not act as solely a screening tool to detect bruising on crime victims. Forensic nurses must speculate the presence of bruises through ALS imaging and, unlike medical examiners, are unable to confirm the presence of bruising in an autopsy.

The use of ALS as a method to diagnose sub-clinical bruising has remained a controversial topic. Multiple publications have argued for and against the admissibility of bruising detected by ALS. In 2010, a Frye-Reed hearing was conducted in the state of Maryland; the judge ruled that use of ALS in forensic nursing was acceptable and permitted inclusion of testimony based on use of ALS devices.

Publications and news articles regarding the use of ALS in forensic nursing include the following:

*Baltimore Sun*: New Technology Helps Convict Domestic Abuse Suspect

*Journal of Forensic Sciences*: Is Fluorescence Under an Alternate Light Source Sufficient to Accurately Diagnose Subclinical Bruising?

*Journal of Forensic Nursing*: Use of an Alternative Light Source to Assess Strangulation Victims

## ALS Photography

Photography is an essential tool for documenting the processing of a crime scene. ALS photography is a type of forensic photography that visualizes and documents evidence—such as fingerprints and biological materials—that is not always visible to the naked eye. In most cases, ALS photography takes place in a controlled setting, such as a laboratory or a windowless examination room in a morgue. The room is darkened to enhance the effect of the light source on the evidence. However, ALS photography may also occur at crime or death scenes where the user has less control over the light conditions.

ALS are not only used to detect evidence, but are also used to document it for court purposes through photography. Therefore, basic photography skills are a critical prerequisite for effectively documenting evidence through ALS photography. The user must fully understand how to manually operate camera settings and cannot rely solely on the automatic setting. If the photographs taken at the scene or in the lab do not accurately reflect the visualized fluorescence, then the importance of the evidence cannot be effectively communicated to the jury.

**Key ALS features that are especially important for photography include the following:**

► Light intensity and device sensitivity, so evidence fluoresces brightly against the background.

► Large light beam that uniformly illuminates the evidence and minimizes incidence of false positives.

► Effective heat dissipation so that evidence illuminated by an ALS is not warped, melted, or destroyed in the photography process.

**Figure 6** provides examples of common mistakes made when searching for and photographing evidence with ALS. **Figure 6** also demonstrates the importance of using the correct barrier filter and camera settings when photographing evidence. The wavelength, barrier filter, and camera settings used all play an integral part in obtaining a photograph that accurately represents the evidence that has been detected.

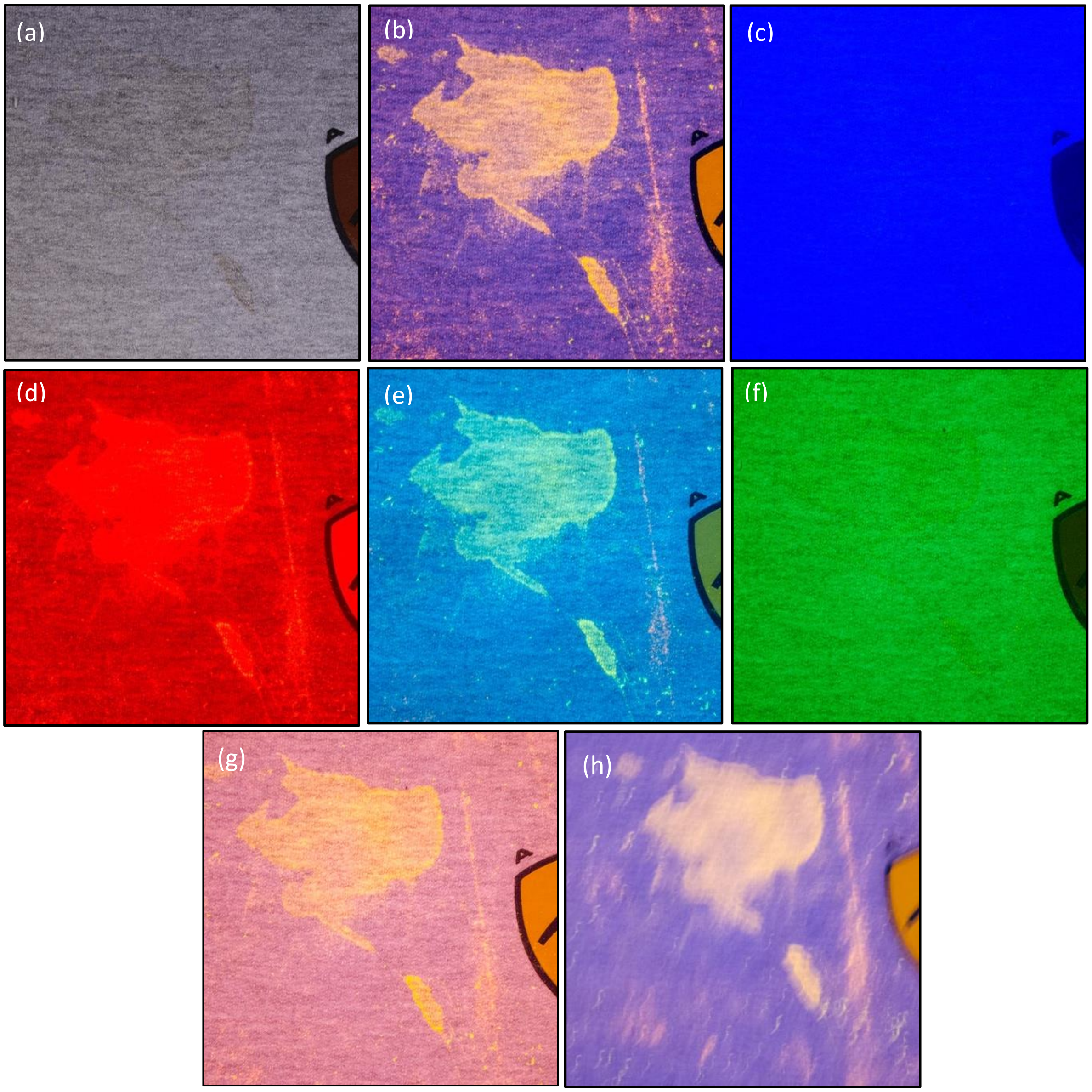


Figure 6. Semen stain illuminated under various lighting conditions using different camera settings. (a) white light; stain is hard to visualize, and there is little contrast between the stain and the background (b) blue (475 nm) light with orange barrier filter; proper camera settings; well-defined stain (c) blue light with no barrier filter; blue light overpowers fluorescence (d) blue light with incorrect (red) filter; stain not clearly defined (e) blue light with yellow barrier filter; some contrast, but not optimal (f) green light (515 nm) with orange barrier filter; incorrect wavelength of light used, so no visible fluorescence (g) blue light with orange barrier filter; built-in camera flash used (h) blue light with orange barrier filter; no tripod used; blurry. Photo credit: Heidi Nichols, Miami-Dade County Medical Examiner Department.

## ALS Device Education

Educating both purchasers and users on the capabilities and limitations of alternate light sources is critical to successful procurement and implementation of these devices. The following section illustrates the importance of educating both buyers and users of the technology.

> *"99% of the time, people don't read the manual, and don't know how to use the instrument. Most of the problems we encounter come from user error. You need to take the time to read the instructions that come with the equipment and practice the applications so there is no confusion or questions in the field. Practice builds proficiency!"*
>
> *—Lieutenant Peter Cestare, Horry County Police Department*

### Education for Decision Makers and Purchasers

User interviews have indicated that in many agencies and laboratories, the users of ALS devices often do not have the authority to purchase them. It is therefore critical to communicate the value of this technology to decision makers and purchasers. These stakeholders need to understand the technology behind the ALS devices as well as clear capabilities and limitations of these instruments.

> Detective Emmons, who serves in the Special Investigations Unit of the Snohomish County Sheriff's Office, communicates the value of ALS devices to his department's decision makers by giving detailed presentations on the technology and circulating literature on selected products. These presentations provide decision makers with the necessary background and justification for purchasing a specific device.

In addition to educating decision makers about the benefits, capabilities, and limitations of ALS devices, agencies must convey the necessity of training users on the device. The following section justifies the importance of training in ALS implementation.

### Training for Users

The capabilities of ALS, regardless of quality and price, depend heavily on the user's ability to operate the device correctly. There is no universal standard operating procedure or training protocol for these devices; agencies must train their ALS users for their specific needs. Some jurisdictions bring in trainers from manufacturers, distributors, or training companies, while other jurisdictions may develop their own curriculum or do on-the-job training. Training users on the technology requires both time and financial investment, and its value should be communicated to decision makers. Benefits of training include the following:

**More reliable detection of evidence:** Users who fully understand how to operate ALS devices and have practiced using them with real samples are more likely to detect evidence in the crime scene or laboratory. The more experience users have with the devices, the more likely they are to successfully use them during casework (Figure 6).

> *"We assume that people who buy the high-end lights know how to use them, but that's not the case."*
>
> *—Detective Emmons, Snohomish County Sheriff's Office*

**Quicker processing time**: Trained users develop a keen eye for fluorescent materials over time. Those individuals who developed a solid training foundation are more confident to correctly handle equipment and conclude that no relevant evidence is present. Because trained individuals know what to look for, they can identify and collect evidence more quickly. Additionally, field and laboratory technicians may submit fewer "false positive" samples to the laboratory, which speeds up the processing time.

**Better documentation:** Field and laboratory users who detect evidence using ALS must be able to document the information so that it may be used in the investigation. ALS photography requires not only knowledge on how to effectively operate the ALS device, but how to capture these results with a digital camera. Users who have refined these skill sets in training can more effectively document the evidence they can visualize.

**More confidence in court**: Crime scene investigators and laboratory technicians who understand the technology, as well as the capabilities and limitations of ALS, are better able to confidently testify in court. Interviews with ALS users at a training course revealed that many investigators did not feel comfortable defending the subject matter in court without undergoing ALS training. Training provides experts with the background and vocabulary to effectively relay information to jurors, lawyers, and judges.

Training opportunities, especially those that foster the collaboration between multiple agencies, can promote the dissemination of proper techniques in the field. Attending conferences such as the International Association for Identification (IAI) can help agencies to find training opportunities to fit their needs.

## Featured ALS Product Landscape

This section provides a more detailed product landscape for selected ALS devices consistently referenced in user interviews. **Tables 8 and 9** provide useful information for purchasing both single-wavelength and multiwavelength devices. Note that these tables only include devices that were mentioned in the user profiles.

## Selected Single-Wavelength ALS Devices

**Table 8.** This table provides a detailed product landscape for selected single-wavelength ALS devices.

| | Manufacturer | Foster + Freeman | Lynn Peavey | Rofin Forensic |
|---|---|---|---|---|
| | Website | http://www.fosterfreeman.com/ | https://www.lynnpeavey.com/ | http://www.rofinforensic.com.au/ |
| | Instrument | CrimeLite 82S | Battle-Lite | Polilight Flare Plus2 |
| | |  |  |  |
| Cost | $: $0-$500<br>$$: $500-$2,500<br>$$$: $2,500-$10,000<br>$$$$: $10,000-$15,000<br>$$$$$: $15,000+ | Full set: $$$$$<br>Per flashlight: $$$ | Full set: $<br>Per flashlight: $ | Full set: $$$$<br>Per flashlight: $$ |
| Light Source | Bulb | LED | LED | LED |
| | Power/Intensity | 5280 lumens | 700 mW (high on 455nm) | 3300 lumens (white) |
| | Flashlight Type | Discrete | Switchable heads | Discrete |
| Wavelengths (nm) | White | x | x | x |
| | Red | 640 | - | 620 |
| | Orange | 590 | - | - |
| | Yellow | - | - | - |
| | Green | 520 | 505 | 530, 545 |
| | Blue-green | 472 | - | 505 |
| | Blue | 445 | 455 | 450 |
| | Violet | 410 | - | 415 |
| | UV | 365 | 395 | 365 |
| User Experience | Power Source | Battery | Battery | Battery |
| | Battery Type | Rechargeable Lithium Ion | Lithium Ion | Rechargeable Lithium Ion |
| | User replaceable? | Yes | Yes | No |
| | Battery life (at 100%) | up to 750 minutes | > 2 hours | Up to 300 minutes |
| | Weight (lbs.) Including batteries if applicable | 1.2 | 0.3 (including batteries) | 1.5 |
| | Ruggedization | Yes | Dust, shock, and weather resistant | Submersible up to 100 m., salt water resistant |
| | Available as a set | Yes. Kits of 1 to 9 lights | Yes | Yes |
| | Available Individually | Yes | Yes | Yes |
| | Warranty | 1 year | 1 year | 1 year |
| Training | Availability of Training | Yes | Yes | No |
| | Additional Charge | Yes | No | N/A |

## Selected ALS Multiwavelength Units

**Table 9.** This table provides a detailed product landscape for selected multiwavelength ALS devices.

| Manufacturer | | Horiba Scientific SPEX Forensics | | | Rofin Forensic | |
|---|---|---|---|---|---|---|
| Website | | https://spexforensics.com/ | | | http://www.rofinforensic.com.au/ | |
| Instrument (Model #) | | CrimeScope | Mini-CrimeScope | | Polilight PL400 | |
| | |  |  | |  | |
| | | (CS-16-500W-15F) | (MCS-400-8F) | (MCS-400-16F) | PL400 Forensic | PL400 Forensic Plus |
| Cost | $: $0-$500<br>$$: $500-$2,500<br>$$$: $2,500-$10,000<br>$$$$: $10,000-$15,000<br>$$$$$: $15,000+ | $$$ | $$ | | $$$ | $$$$ |
| Light Source | Bulb | Xenon Arc | Metal Halide | | Metal Halide | |
| | Power/Intensity | 500W | 400W | | 400W | |
| Wavelengths (nm) | White | x | x | x | x | x |
| | Red | 635, 670 | - | 630 | - | 620, 650 |
| | Orange | 600 | - | 600 | - | 560, LP560*, 570, 590 |
| | Yellow | SP575† | - | SP575†, 575 | - | - |
| | Green | SP540†, 515, 535, 555 | SP540†, 515, 535, 555 | SP540†, 515, 535, 555 | 530 | 515, 530, 550 |
| | Blue-green | 495 | - | 495 | 505 | 505 |
| | Blue | 445, 455, 475 | 455 | 445, 455, 475 | 450, LP350*, 490 | 430, 450, LP350*,470, 480, 490 |
| | Violet | 415 | 415 | 415 | 415 | 415 |
| | UV | 365 | 365 | 365, 390 | 350 | 350 |
| User Experience | Power Source | AC Power | AC Power | | AC Power | |
| | Weight (lbs.) Including batteries if applicable | - | - | | 14.3 | |
| | Warranty | 1 year | 1 year | | 1 year | |
| Training | Availability of Training | Yes | Yes | | No | |
| | Additional Charge | N/A | - | | N/A | |

* - denotes longpass filter

† - denotes shortpass filter

## Manufacturer Profiles

While the ALS market has many players, these four manufacturers were consistently referenced during user interviews:

### Foster + Freeman

Foster + Freeman was established in 1978 and has developed numerous products for forensic examination, with applications including questioned documents, fingerprint examination, and trace evidence analysis. One of the company's goals is to create products with end users in mind, ensuring that products are rugged and easy to use.

Foster + Freeman offers handheld and benchtop alternate light sources, both of which use LED technology. The Crime-lite 82S is their flagship handheld ALS device—this flashlight has 16 LEDs chosen for brightness and wavelength accuracy. ML2, a benchtop ALS product, features a rotating arm and an attachable filter so that the user is not required to wear goggles. Foster + Freeman offers training courses and workshops for all of their products.

#### Unique Product Features

- These LED-based products are designed to give the same light output even when the battery decays or the light heats up. This ensures that the intensity of the light does not change, resulting in consistent search results.
- The 82L floor lamp is an ALS device that brightly illuminates large floor or wall sections with white or UV source.
- The Crime-lite Eye is a pocket-sized LED device that helps crime scene examiners achieve dark adaptation before using an alternate light source.

### HORIBA Scientific SPEX Forensics

HORIBA was established in 1953 as a company that manufacturers a large range of analytical devices for many markets—including automotive, medical, and pharmaceutical applications. HORIBA Scientific was created to better meet customers' needs in the scientific markets of fluorescence, forensics, spectroscopy, particle characterization, and more.

The HORIBA Scientific SPEX Forensics Division was established in 1993 as a forensic light source manufacturer. Today, the SPEX division sells more than just FLS, including fingerprint image enhancement systems, automated fingerprint identification systems (AFIS), and the Reflective Ultra Violet Imaging System (RUVIS). Some of the FLS manufactured by SPEX Forensics include the CrimeScope, the HandScope® LED, the HandScope Xenon, and the FOCUS flashlight.

The SPEX division of HORIBA Scientific provides forensic training programs for law enforcement, crime scene investigators, and other personnel who use forensic light sources. SPEX Forensics will train individuals how to use SPEX products as well as other ALS that are already implemented within the agency.

#### Unique Product Features

- SPEX ensures that their products do not produce hotspots—all light is distributed evenly. Hotspots can reduce quality of the fluorescence emission that is seen.
- Typically, multiwavelength units are powered by incandescent bulbs. However, SPEX offers a multiwavelength LED device—the HandScope LED—which emits light at five different wavelengths.

- The SPEX warranty covers both the device and the battery. This is unique because most companies do not provide battery warranties.

## Lynn Peavey Company

Lynn Peavey Company—based in Lenexa, Kansas—has been in the forensic science business for 65 years. In addition to supplying ALS, this company provides latent fingerprint developing reagents, evidence seals, laboratory supplies, and more. The BattleLite is Lynn Peavey's portable, LED-powered 455-nm blue light that is built for military and law enforcement applications. Lynn Peavey offers training for their ALS products.

### Unique Product Feature

- The BattleLite is built to be military-grade and is resistant to dust, shock, and weather.

## Rofin Forensic

Rofin Australia Pty Ltd was established in 1978 as a marketing company for scientific instruments and expanded into the forensic science business in 1988. Rofin's forensic instrument product line is used in more than 3,000 locations in 77 countries by leading agencies including the FBI, Central Bureau of Investigation (CBI) and Scotland Yard. Rofin Forensic offers both multi wavelength and single wavelength ALS devices, which use either arc lamps or LED-based bulbs. Their Polilight Flare Plus 2 is a battery-operated, portable, LED forensic light source (FLS) that was designed for use at a crime scene. Their Polilight PL500 is their flagship forensic light source with a 500-watt xenon arc lamp. Recently a newer version, the PL-550XL was released. Both are housed in an aluminum case for shock protection and easy transportation. Rofin does not offer formal training, but training on their products is offered through their local distributors.

### Unique Product Features

- The Polilight Flare Plus 2 flashlights have an effective cooling system that does not require a fan, which is more reliable and prevents disruption of evidence at the scene or laboratory.
- A high performance bandpass filter is incorporated into the LED-based Flare Plus 2 flashlights, improving the sensitivity of the device. The units are waterproof and submersible.
- Flashlight intensity is adjustable, which facilitates searches and evidence documentation by photography.
- The PL550XL xenon system offers higher output through a unique lamp boost mode feature and fan speed controller. Output power is user controlled.
- Wavelength fine-tuning of the 12 to 20 Bands provides many thousands of output color options
- The PL500 and PL550XL offer various length light guides and mounting points for use in the lab and at crime scenes.
- The PL500 and PL550XL are available with full featured remote controls for operation up to 5 meters away from the unit.

## Summary

Alternate light sources are an integral part of crime and death scene processing and evidence analysis, and agencies looking to replace their outdated or broken instruments must navigate a crowded market of over 15 manufacturers and 50 products. The goal of this landscape study is to enable laboratory directors, crime scene investigation units, and other decision makers to make better informed decisions when purchasing ALS devices. The information contained herein is derived from current literature and interviews with technology experts, developers, and users in a wide variety of applications. This document provides the reader with a basic understanding of alternate light source technology, implementation considerations, user experiences with the technology, and a comparison of selected ALS devices.

Alternate light sources are used in both field and laboratory applications within forensic science. While agencies must consider the end applications of these devices when purchasing these products, general implementation considerations include the following:

***Type of ALS Device***: ALS devices are generally offered as large, multiwavelength units with AC power or handheld, battery-operated single-wavelength flashlights. The multiwavelength units tend to stay in the laboratory, while single-wavelength units are consistently being used in both field and laboratory applications. User interviews indicate both types of devices have comparable light intensity and sensitivity in detecting evidence.

***Key Features of ALS Devices***: Device purchasers should consider quality drivers of the product that include the following:

- Light brightness
- Focused light
- Size
- Battery life
- Maintenance
- Sensitivity

***Barrier Filters***: Purchasers must invest in quality barrier filters with a documented cutoff wavelength to facilitate visualization of evidence illuminated by ALS.

***Device Education***: It is critical that users are properly trained in both visualizing and documenting evidence using ALS, and that decision makers understand the capabilities and limitations of these devices.

***Cost:*** Agencies must consider the cost of the ALS device, barrier filters, maintenance, and training when determining the best ALS options for their budget.

While alternate light source technology has been used in forensic science for multiple decades, today's products incorporate advanced technologies—such as LEDs, compact packaging, and precise bandpass filters—that improve the user experience and may lead to better detection outcomes. The FTCoE hopes that the information provided in this report will help users and purchasers to make an informed decision regarding the procurement of ALS devices for their units so that ALS can help identify and document evidence, ultimately supporting law enforcement efforts.

## Image Credits

**Cover Photo** – fired/shutterstock.com

**Figure 3** – Heidi Nichols, Miami-Dade County Medical Examiner Department

**Figure 5** – 5(a) RTI staff, 5(b) Heidi Nichols, Miami-Dade County Medical Examiner Department

**Figure 6** – Heidi Nichols, Miami-Dade County Medical Examiner Department

All device graphics in Tables 8 and 9 are used with permission from the respective manufacturers. All agency logos are used with permission from the respective agency.

January 2018

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RTI International (RTI) and its academic and community based-consortium of partnerships, including its Forensic Science Education Programs Accreditation Commission partners, work to meet all tasks and objectives put forward under the National Institute of Justice (NIJ) Forensic Technology Center of Excellence (FTCoE) Cooperative Agreement (award number 2016-MU-BX-K110). These efforts include determining technology needs; developing technology program plans to address those needs; developing solutions; demonstrating, testing, evaluating, and adopting potential solutions into practice; developing and updating technology guidelines; and building capacity and conducting outreach. The FTCoE is led by RTI, a global research institute dedicated to improving the human condition by turning knowledge into practice. The FTCoE builds on RTI's expertise in forensic science, innovation, technology application, economics, data analytics, statistics, program evaluation, public health and information science.

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