10 THINGS YOU NEED TO KNOW ABOUT

CHEMICAL THREAT IDENTIFICATION

FLIR®

WHEN PRECISION AND CONTROL ARE MISSION-CRITICAL

FLIR GRIFFIN G510 CHEMICAL IDENTIFIER

Civilian and military responders face scenarios ranging from intentional chemical attacks and accidental hazardous material (HAZMAT) releases to natural disasters and environmental monitoring or remediation efforts. As the global threat of terrorism continues to rise, security teams and first responders depend more and more on tools and resources that provide fast, actionable information. Chemical identification is not new, but advances in technology have shifted paradigms in intelligence gathering and on-site detection. With multiple deployment and identification methods available, it's easy to get caught up in figuring out what tools are right for your mission.

This guidebook outlines key factors and details that go into deciding on the right chemical identification tool based on the type of incident and your team's needs.

What should I consider before choosing a chemical threat detector?

- What types of chemical threats will be encountered?
- What environments will it need to work in?
- Will the results need to be presumptive, confirmatory, or both?
- What type of deployment is required?

10 THINGS YOU NEED TO KNOW

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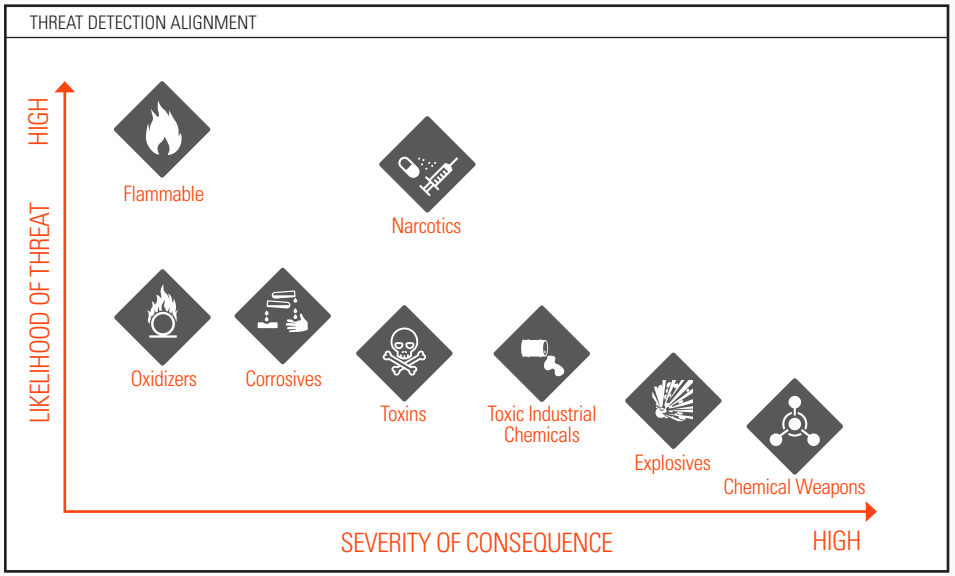
1 CHEMICAL THREAT CLASSES

As you explore the need for a chemical threat detector, it's important to first understand the landscape of chemical threats. One way to categorize chemicals is into the following three parent categories and seven chemical classes:

HEALTH HAZARDS	PHYSICAL HAZARDS	ENVIRONMENTAL HAZARDS
Chemical Warfare Agents (CWAs)	Flammable	Toxic Industrial Chemicals (TICs)
Toxins (Poisons), Irritants, and Sensitizing Agents	Corrosives and Oxidizers	
Narcotics	Explosives	

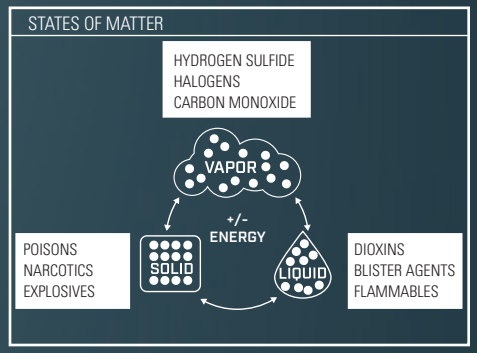
The concerns for each threat class vary. The impact these hazards can have also depends largely on concentration (the amount of substance in a defined space). The likelihood of encountering these chemical hazards and their impact on life, health, and safety is visualized in the chart.



Speak with your FLIR representative about what technology may work best for your application.

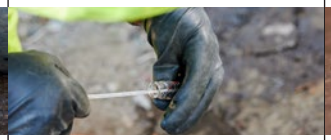
2 STATES (OR PHASES) OF MATTER

Once you are familiar with the different classes of chemical threats, it's important to understand the states (or phases) of matter. Chemical hazards can be in the vapor, liquid, or solid state. Determining the state of matter is a critical, early step in on-scene response, as it impacts the selection of personal protective equipment (PPE), sample or evidence collection procedures, and use of the proper chemical detector or identification system.



Each hazardous chemical may have flammable range or toxicity that impacts safety. Be aware of any ignition risk when approaching a scene that may contain flammable vapors or liquids. Some highly volatile explosives and oxidizing agents can be motion or friction sensitive, or even triggered when exposed to high powered infrared lasers, such as those in a Raman system. Always exercise safe protocols when selecting a tool for sample collection, detection, and identification. Also remember that heat can change a solid to a liquid, or a liquid to a gas. Having access to flexible, on-scene tools that can quickly sample each state of matter is critical in identifying the chemical threat on-scene. Some chemical identification tools, like FLIR's Griffin G510 gas chromatograph mass spectrometer (GC-MS), can sample multiple states of matter.

A variety of tools can be used to sample and detect, or identify each state of matter.

VAPOR	LIQUID	SOLID
		
• Colorimetric tube • Multi-gas meter • Ion Mobility Spectrometer (IMS) • Mass Spectrometer with vapor sampling capability (i.e. High-Pressure Mass Spectrometer - HPMS) • Gas Chromatograph-Mass Spectrometer (GC-MS)	• Colorimetric test strips • Raman Spectroscopy system • Fourier Transform Infrared (FTIR) Spectroscopy system • Direct injection GC-MS • Solid Phase Micro Extraction (SPME) sampling kit in combination with GC-MS	• Colorimetric test kit • Raman • FTIR • Solids introduction method, like the PSI-Probe, paired with GC-MS

FLIR's Griffin G-Series GC-MS products can detect and identify across all states of matter.

3 TRACE AND BULK SAMPLING

Another important consideration is the quantity of a threat that needs to be sampled: bulk or trace. Some response missions include both bulk and trace threats. Consider the most common deployment scenarios and the volume or concentration of a sample that may be encountered before selecting a chemical threat detector.

What is the difference between bulk and trace threats?

A bulk sample can be seen and easily weighed. A trace sample is invisible and can't be weighed. Concealed threats typically have trace residue on the exterior, so a detector with trace-level sensitivity is required to find them. Further, many gas-phase threats can cause harm at the trace-level, so having a system that can perform at the trace-level is a critical part of the responder toolkit. Conversely, solid threats are typically bulk and are best identified using a bulk detection method.

Can trace detectors screen for bulk?

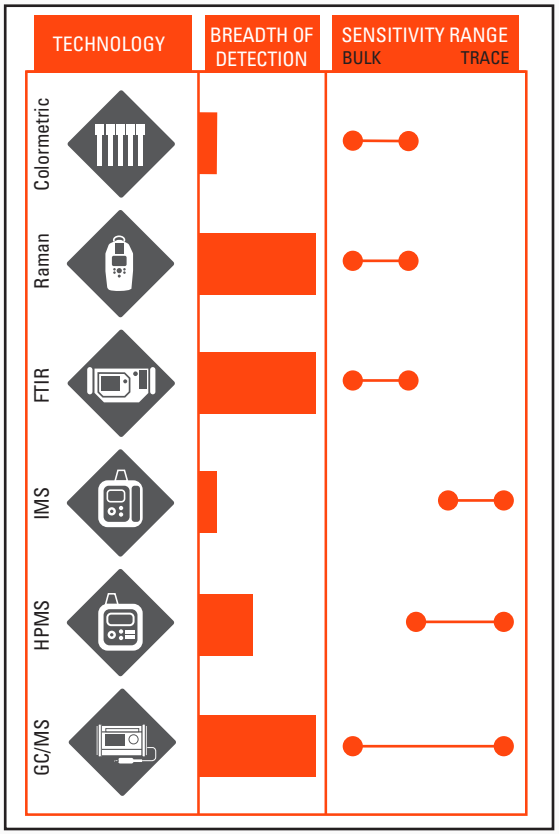
Most trace detectors can detect a bulk sample, but with an impact on system performance. For example, a bulk sample may overload an IMS-based system and take longer to filter out. This can significantly impact operational availability and may result in clear-down times spanning multiple hours, or even require an overnight bake-out to completely clean the system. Some trace technologies require preparation to handle bulk samples. FLIR's Griffin G510 GC-MS is a trace detector that can also perform bulk analysis.

Can bulk detectors screen for trace?

No. Bulk detectors require a visible amount of sample to produce a visual chemical signal, whether it's a colorimetric color change or a spectroscopic signal.

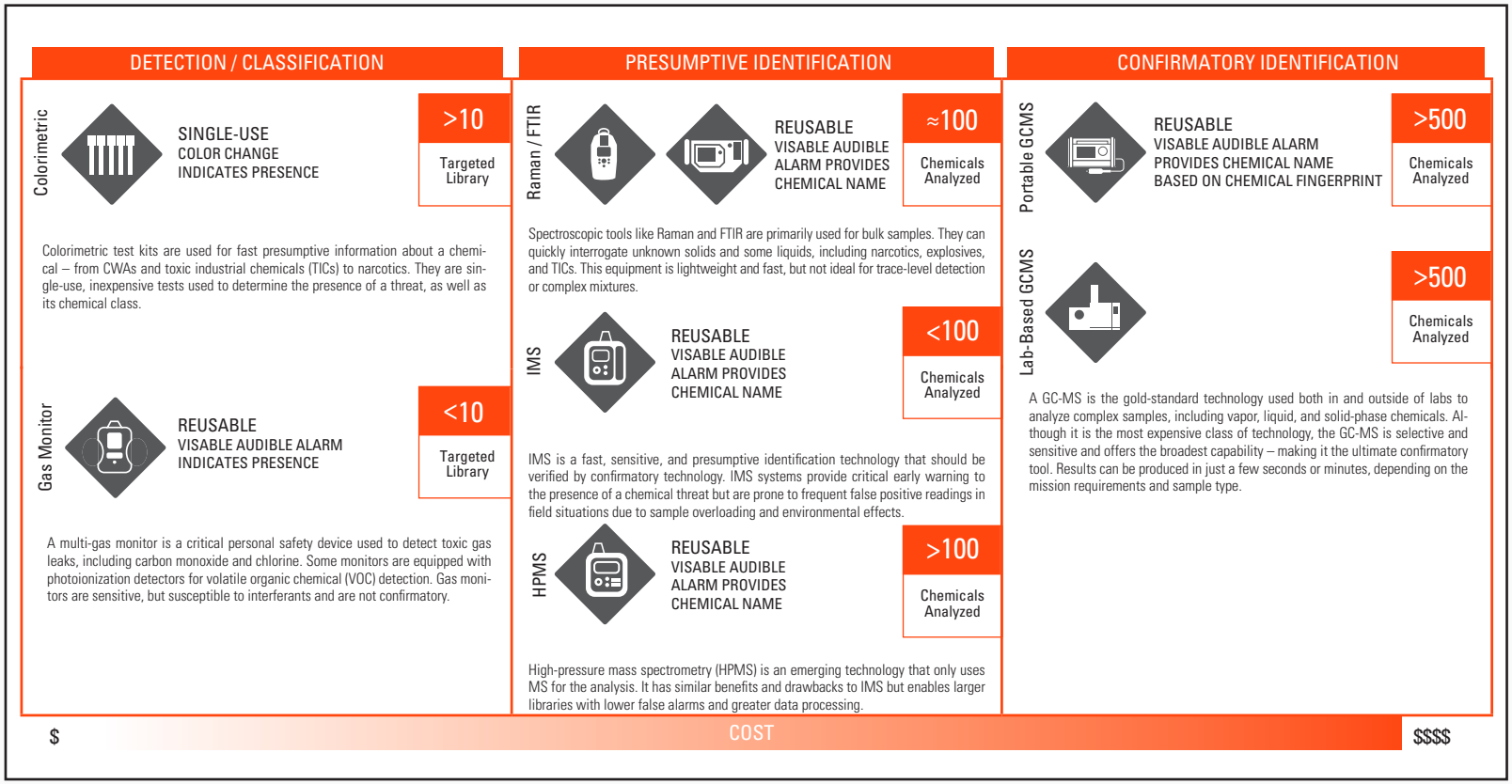
Are there scenarios where trace detection provides a benefit over bulk detection?

Trace detectors provide additional information that bulk detectors may not. For example, trace detectors can determine if a person or item has been in contact with a chemical threat and may detect threats before they become hazardous. Trace detectors, like those based on mass spectrometry, can also provide specific chemical identification. This evidence can provide valuable intelligence to help process a scene and quickly mitigate risk. Conversely, bulk detectors provide a visual indication of an imminent threat in rare cases where no trace is present.



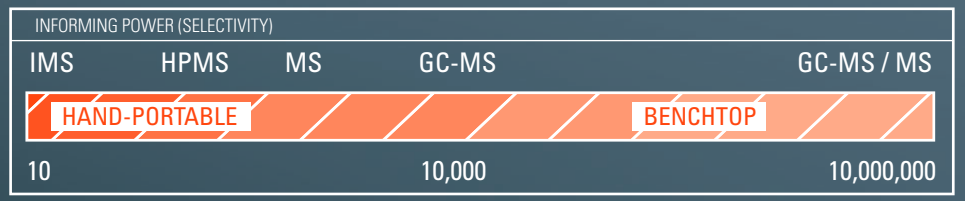
4 CHEMICAL RESPONSE TOOLS

Each mission is different, and no single tool will accomplish every task. Chemical detectors vary in sensitivity (the ability to detect very low levels of chemicals) and specificity (the ability to distinguish and identify targets). Some detectors, like colorimetric test kits, only indicate the presence of a chemical, while GC-MS, specifically identifies and confirms the type and extent of a threat. It is important to understand the capabilities of each technology and use the right tool for the job.



5 PRESUMPTIVE AND CONFIRMATORY IDENTIFICATION

Tools are often described as either presumptive or confirmatory. Each classification is valuable during critical scenarios, but as a responder, it's important to understand the difference between the two.



Presumptive identification is based on limited or reduced quality data. It is used to establish what a substance is NOT and delivers a presumed identity of a threat material based on a limited data set. Equipment that provides presumptive identification does hold merit, in that it helps responders perform initial scene size-up and response tactics. It may be insufficient for further action.

Confirmatory identification uses a sufficient amount of quality data to prove or confirm the identity of a threat material. For example, a confirmatory test can determine that a suspicious white powder is confirmed to be caffeine (a common illicit narcotic cutting agent). Confirmatory information is based on high-fidelity principles found in a traditional laboratory environment.

	CHARACTERISTICS	PURPOSE / ACTIONABLE RESULT
Presumptive Tools (e.g. colorimetric test kits, gas meters, Raman, FTIR, IMS, HPMS)	• Limited amount/quality of data • Handheld • Fast • Lower cost	• Screening tool for further analysis • Helps determine response tactics • Scene size-up • General PPE selection • Baseline personal protection
Confirmatory Tools (e.g.. GC/MS)	• Portable or benchtop • High fidelity data • Definitive in nature; the true "fingerprint"	• Know extent/impact of hazard • Remediation and follow-up • Prosecution/legal determination

Presumptive ID is helpful in sizing up a scene with initial information, whereas confirmatory ID gives you the exact threat. Both are important. Ask how confirmatory ID with the FLIR Griffin G510 can provide actionable intelligence for your mission.

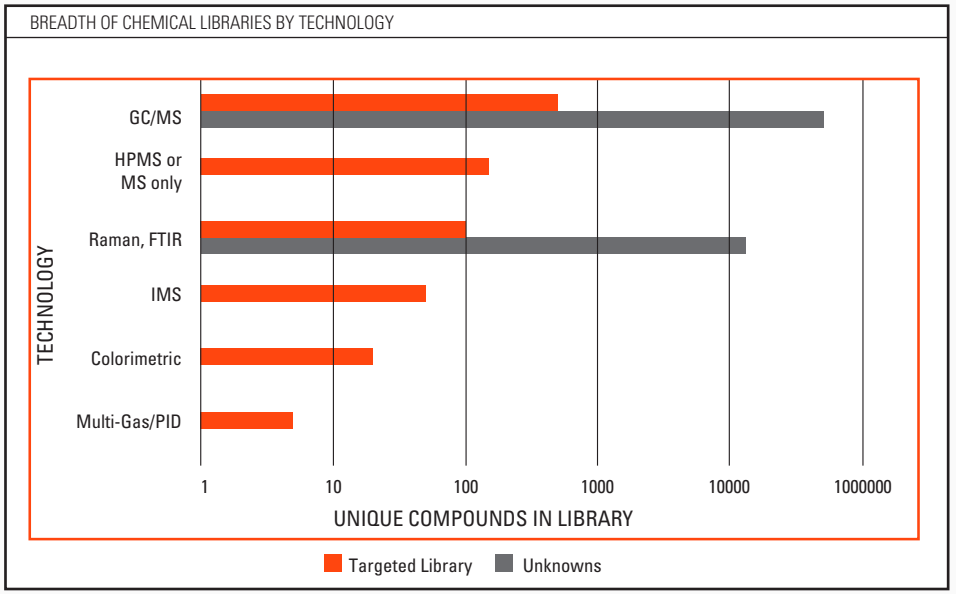
6 CHEMICAL LIBRARIES

When considering a chemical threat detection tool, consider the missions and types of threats that are regularly encountered. Some operators may consistently respond to the same 10-15 threats. For others, the ability to identify unknown chemicals is critical. As mentioned in the section, "Chemical Response Tools", each technology provides unique capabilities to help with a mission. For each technology, the ability to detect depends on their chemical libraries.

Chemical Libraries are the software, electronic, or color change-based templates for the responses of certain chemicals. Libraries range in fidelity from a color shift on pH paper to electronically matching the mass fragment chemical fingerprint in true high vacuum, quadrupole mass spectrometry. Each technology type may have one or more libraries suited for specific applications.

There are systems that provide the flexibility and benefit of both options. For example, the FLIR Griffin G510 GC-MS includes the NIST library for identifying unknown threats, as well as targeted mission-specific libraries for chemical agents, toxic industrial chemicals, and narcotics. Samples can be analyzed in either library for mission flexibility and ease of use. As you consider what type of threats you will face over the next ten years, choose sensors that "can go the distance" against potential threats, both known and unknown. Here are some considerations when using libraries:

- A smaller targeted library helps reduce the "noise" of other chemical possibilities.
- A smaller targeted library can increase operator confidence, make a system easier to use and learn, and quickly lead to a "go/no-go" answer.
- Emerging threats can be added to libraries. However, the National Institute of Standards and Technology (NIST) library updates are released on a less frequent schedule than targeted manufacturer or end-user libraries.
- The NIST library, coupled with a high-fidelity quadrupole mass spectrometer, has been built on multiple reference systems over years of sample collection for thousands of chemicals. It can produce repeatable measurements and be used for unknown analysis.



Chemical detection tools are defined by the libraries that power them. FLIR's Griffin G510 uses the broadest chemical library built on proven, lab-based quadrupole MS technology.

7 MIXTURES AND NEW THREATS

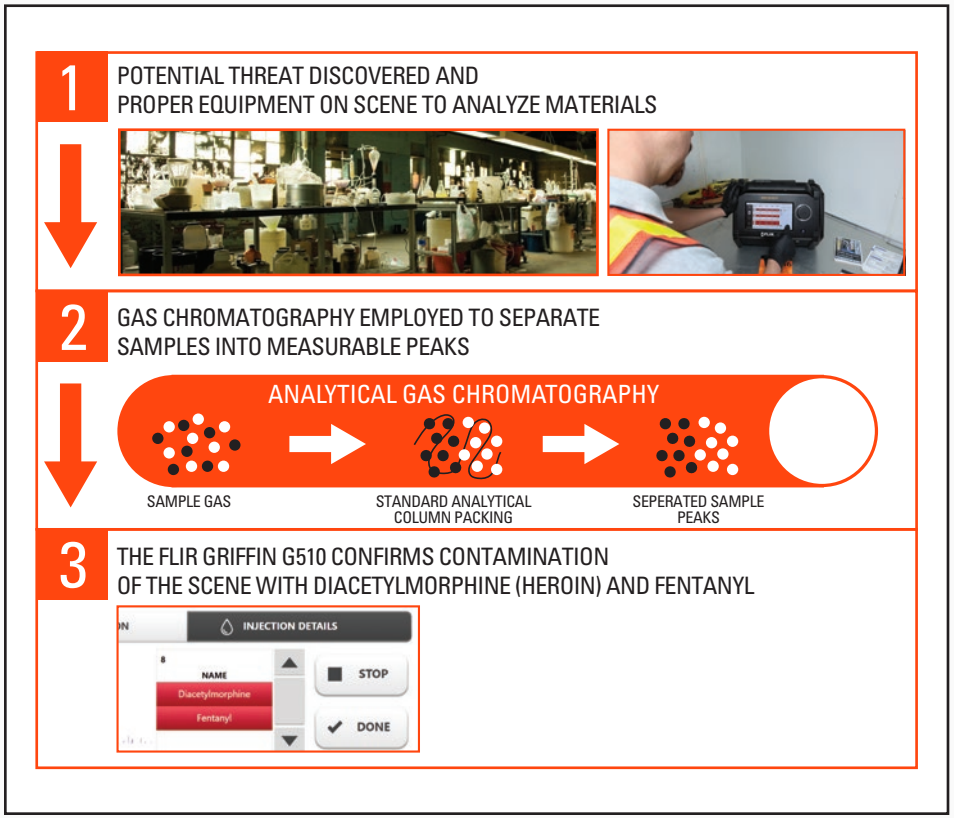
In the perfect scenario, all potential chemical threats would be highly pure, to simplify the identification process and produce an actionable answer as quickly as possible. In reality, potential threats are more likely to be of reduced purity. Intentional and unintentional mixing and cutting of threats is a common challenge that responders encounter.

Not all equipment in a responder's toolkit is effective at detecting threats in a complex mixture. Spectroscopic techniques, such as FTIR and Raman, are appropriate for bulk materials of reasonable purity, but may have difficulties when presented with mixtures. This leads to misidentifications or false negatives and can impact the health and safety of responders and the public. Complex mixtures and impure materials can also affect how a material responds to colorimetric tests, further complicating a simple process.

Due to their ability to separate mixtures into individual components, confirmatory ID techniques, such as GC/MS, generally perform well in the presence of complex chemical mixtures. Confirmation through GC/MS analysis is highly desired for suspected impure materials and where presumptive techniques do not elicit an alarm.

Remember, not all impurities are the result of intentional acts (such as cutting a suspected illicit narcotic with an over-the-counter pharmaceutical), the surrounding environment also plays a critical role. Refer to section 2 – States (or Phases) of Matter. Certain materials can rapidly degrade, react, and change in the presence of atmospheric humidity, light, and heat, complicating the ID process. The extent of a tool's chemical library comes into play once materials begin to react. "Active" material may largely convert into a substance that is not part of a chemical threat library, limiting the tool's effectiveness.

New and emerging threats are a concern, as the chemical detection industry is forced to "catch-up" with the rapid development of new chemical materials. This is especially true with synthetic or "designer" drugs that are generally too new to be included in manufacturers' chemical libraries. The enhanced resolution offered by GC/MS allows for new threats to be added with relative ease compared to limited-resolution techniques, including IMS and HPMS.



8 EASE OF USE AND SURVIVABILITY

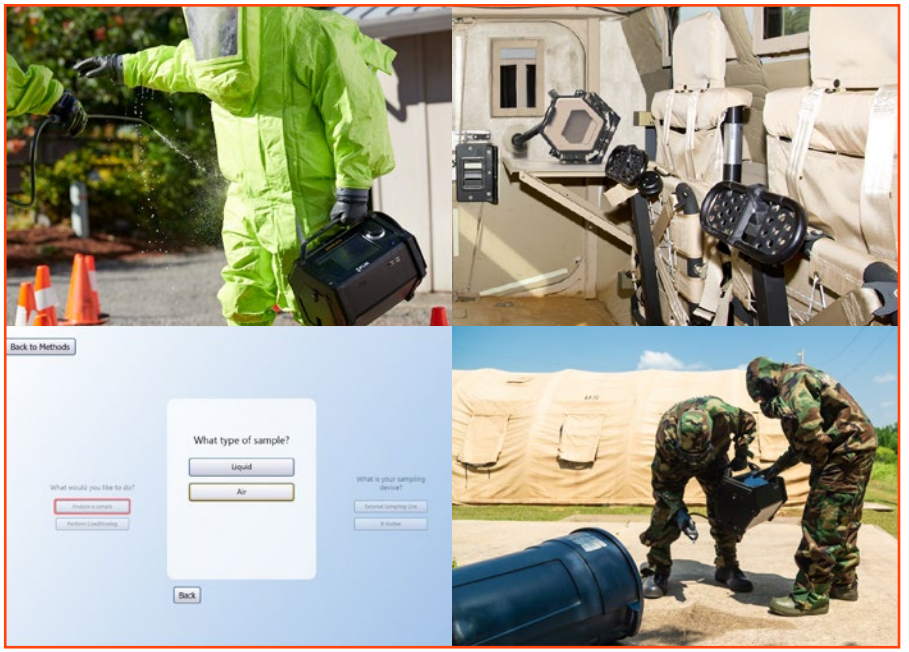
Response missions take place in complex environments. First responders must perform quickly and with limited dexterity when wearing required personal protective equipment (PPE). They are responsible for sample and data collection, and in some cases, real-time decision-making. Hazardous environments demand the ultimate toolbox, with easy to use devices that can survive extreme conditions.

EASE OF USE CONSIDERATIONS

- Can you operate it while wearing full PPE?
- Can you dismount it from a vehicle or is it locked in place?
- Can you use it comfortably while sitting, standing, or walking?
- Is the user interface intuitive?
- Are the results easy to read and understand?

SURVIVABILITY CONSIDERATIONS

- Does it meet your drop requirements?
- Does it meet shock and vibration requirements?
- Do the batteries last long-enough to complete the mission?
- What is the start-up time?
- What happens if it is exposed to contaminants – can it be cleaned?



Seconds matter. When lives are on the line, understanding the limitations and capabilities of a chemical sensor is critical. Talk with your FLIR representative about how its detectors perform in complex environments.

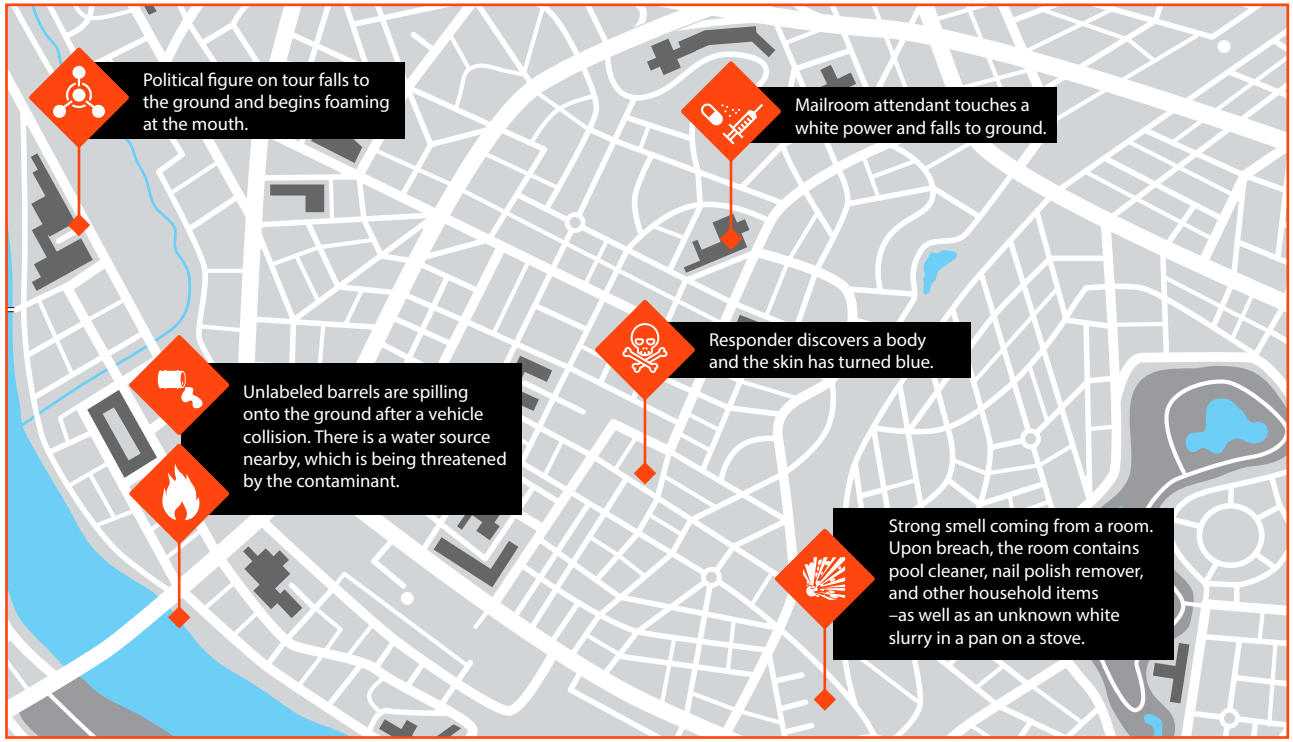
9 MISSION FLEXIBILITY

Most responders are not presented with all the relevant information needed when encountering potential chemical threats. Civilian and military responders face scenarios ranging from intentional chemical attacks and accidental hazardous material (HAZMAT) releases to natural disasters and environmental monitoring or remediation efforts. Responders step on-scene with a diverse toolkit – sometimes small and other times extensive. It is critical to stay familiar with the equipment in the kit, because no single chemical detection tool can provide answers for every scenario.

Scenarios like the ones outlined on this page happen every day. When thinking about responding to chemical threat scenarios, having a tool set that will allow you to respond to any challenge is critical, and can mean the difference between life and death. As you plan for chemical threat detection needs – now and in the future - ensure that you have the right set of tools to address any threat.

GC/MS has long played a critical role in traditional laboratory-based chemical analysis. But chemical emergencies rarely occur in the safety of a laboratory. They can happen anywhere, extending the need for GC/MS beyond the lab. Talk to a FLIR specialist about the FLIR Griffin G510 GC-MS for field-based confirm missions.

EXAMPLES OF POTENTIAL CHEMICAL DETECTION MISSIONS



10 COST OF OWNERSHIP CONSIDERATIONS

The total cost of ownership extends beyond the instrument, consumables, and associated training. It also includes how the instrument and deployment program will be supported over its lifetime. To start, define the expected life of the deployment program and know the life expectancy of the selected instrumentation. This establishes the budgeting window for the total cost of ownership.

If funding is a one-time event, look for an instrument package that includes long-term support that is agreed upon up-front with the initial instrument purchase. FLIR's Griffin GC-MS systems are offered with up-front packages that include equipment, training, consumables, and reachback support. Alternatively, funding may be allocated on an annual basis. It is important to understand what the typical annual cost of support will be over the lifetime to perform a total cost calculation and estimate for budgeting purposes. Don't overlook the amount of time the end-user will spend maintaining the instrument. While not an up-front cost, daily, weekly or monthly maintenance will add to the total cost of ownership.

- Know what is included in the support program.
- How often will the instrument be deployed?
- Consider diversity of deployment scenarios and what that means for your equipment.
- Are the necessary consumables included with the support package?
- Compare the cost per sample for each device.
- What services are provided (i.e. on-device training, reachback, preventative maintenance)?
- What damage coverage is included?
- Consider cross-agency ownership.

PURCHASE PARTNERSHIP

Buying an instrument should be a partnership with the manufacturer, the company, and the people. Evaluate the reputation of the instrument and the reputation of the support team. Consider whether they provide the essential elements to make the path forward as safe, successful, cost-effective, and reliable as possible. Ask for references or talk with other users to get independent feedback of the essential elements discussed here.

Talk to your FLIR representative about how to build a comprehensive threat detection suite that meets the need of your deployment program.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