SECTION 1: FUNDING OPPORTUNITY DESCRIPTION

IARPA often selects its research efforts through the Broad Agency Announcement (BAA) process. The use of a BAA solicitation allows a wide range of innovative ideas and concepts. The BAA will appear under Contract Opportunities on https://sam.gov and a link will be placed on the IARPA website at http://www.iarpa.gov. The following information is for those wishing to respond to this Program BAA.

This BAA is for the Pursuing Intelligent Complex Aerosols for Rapid Detection (PICARD) program. IARPA seeks innovative solutions for fieldable sensing platforms for the rapid identification of chemical aerosol particles in plumes. The PICARD program is envisioned as a 42-month effort.

1.A. Program Overview

1.A.1 Aerosols as a National Security Issue

The need to rapidly identify aerosols is vital to national security because many chemical threats are, or could be, delivered as aerosols. These threats include chemical warfare agents (CWAs), pharmaceutical based agents (PBAs) such as fentanyl and its analogs, toxic industrial chemicals (TICs)/toxic industrial materials (TIMs), environmental pollutants, explosives, and radioactive materials. As an example, sulfur mustard commonly referred to as mustard gas, is actually an aerosol of liquid droplets suspended in the air. The primary component of tear gas (2chlorobenzalmalonitrile, CS) is often dispersed as an aerosol of fine powder. Dangerous compounds, including some emerging threats or their precursors, are readily obtainable by threat actors and can be distributed beyond the U.S. Government's (USG's) current ability to rapidly detect and identify them. Additionally, seemingly innocuous chemicals, such as organic material from plants and microbes, may exacerbate climate change which may lead to conflict over resources and regional instability.[1]

Table 1 summarizes the technologies needed to address the various national security threats that aerosols pose. While these use cases vary greatly, they all require sensors able to provide accurate information on chemicals of interest in complex environments. Highly complex background chemistry, such as that found in proximity to forest fires, in combination with wind, temperature variations, and other environmental factors create a measurement challenge that requires novel approaches to address.

Table 1: Technology Needs for Various Applications

Application	Description	Technology Requirements
Drug Enforcement	Monitoring suspected drug manufacturing sites; tracking shipment of drugs and precursors	• Broad range of chemicals of interest • Complex background chemistry and environmental factors • High sensitivity (< 5 $\mu g/m^3$)
Industrial Monitoring	Monitoring industrial and nuclear sites (public safety and compliance); early warning for intentional or accidental release; illicit dumping of materials	• Small size, weight, and power • Complex background chemistry and environmental factors • Broad range of chemicals of interest

Application	Description	Technology Requirements
Domestic Counterterrorism	Monitoring for suspected chemicals/aerosols (explosives, CWAs, or incapacitants); screening and early warning at large public gatherings, emergency response	• Rapid response (hourly) • Complex background chemistry and environmental factors • Obscurants • Low false alarm rate
Environmental Security	Monitoring forest fires; early warning of volcanic eruptions; long term monitoring of climate change issues	• Highly complex background chemistry and environmental factors • Rapid response • High sensitivity and specificity (clutter up to 10 mg/m^3)

1.A.2 Program Concept

The PICARD program intends to develop fieldable sensing platforms for the rapid chemical identification of aerosol particles in plumes. The program will address both point detection (*in situ*) and standoff capabilities that focus on the complexity of aerosols with non-uniform sizes, morphologies, and chemical composition as well as, dispersion in challenging environments. For this program, we define the *aerosol* as **a suspension of solid particles or liquid droplets in air**. The goal of PICARD is to develop integrated hardware and software tools that will improve measurement capabilities beyond the current state of the art with respect to chemical specificity, accuracy, response time, and sensitivity.

The key objective of the PICARD program is not to develop a sensor that can detect at very low concentrations of chemicals in the laboratory, but rather to develop a fully integrated system that can identify target chemicals within aerosol particles at *mission-relevant* concentrations in *real-world* environments. Figure 1 illustrates the notional concept for PICARD integrating aerosol sampling, sensing, and analysis.

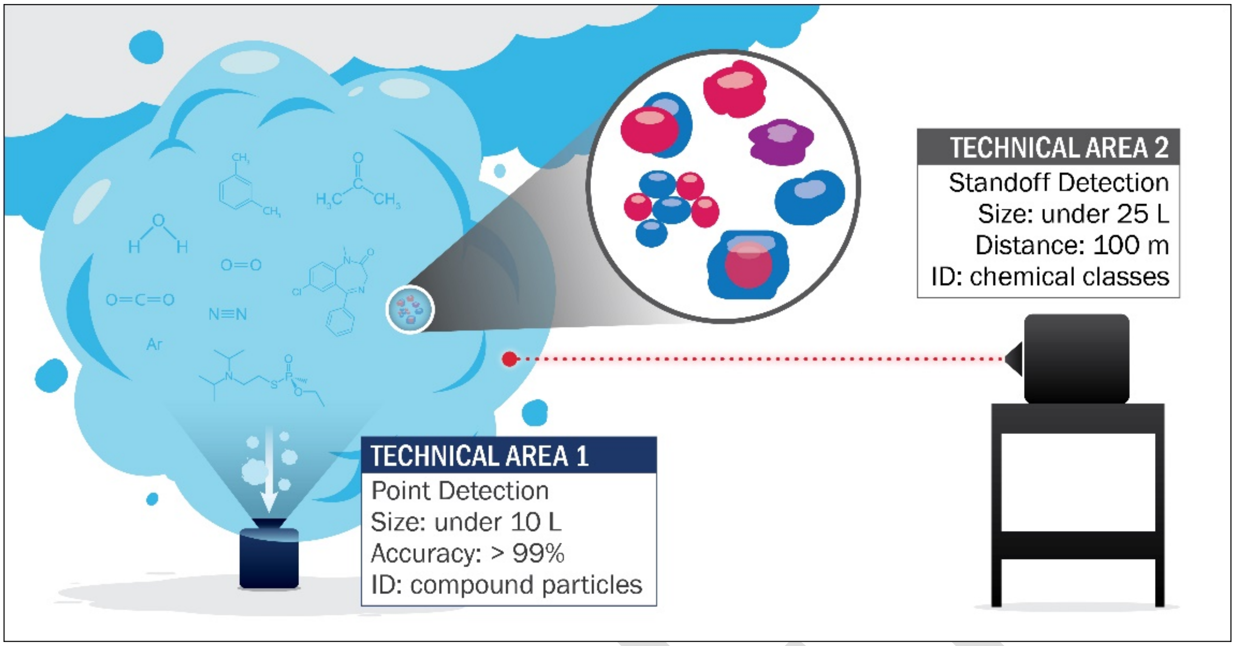

Figure 1: Concept Illustration of PICARD Point Detection (Technical Area 1) and Standoff Detection (Technical Area 2)

As shown in Figure 1, the PICARD program will consist of two Technical Areas (TAs). Technical Area 1 (TA1) will develop a point detector for *in situ* identification of the chemical and physical properties of the aerosol. Sensors in TA1 will need to address embedded or encapsulated chemicals of interest within an arbitrarily shaped aerosol particle at low concentrations in challenging environments. Sensors in technical Area 2 (TA2) will develop a standoff detector for chemical class identification. Sensors in TA2 must address the challenge of distance from the chemicals of interest as well as low concentrations, arbitrarily shaped particles, and challenging environments.

1.A.3 The Challenges of Aerosol Identification

It is a significant challenge to identify an individual target chemical in aerosols for multiple reasons: chemical complexity, physical complexity, and diverse environmental factors.

- First, the aerosolized substances of interest (e.g., chemical weapons, toxic industrial chemicals, pollutants, toxins, explosives) may be difficult to distinguish from other benign chemicals present in the environment, decomposition products or precursors with the same or similar chemical fragments as the chemical of interest. Identification of specific compounds from within a class may be difficult due to the number of similar analogues of the same compound, requiring superior analytical resolution capability between candidates for identification purposes (e.g., there are over 1400 fentanyl analogues found in scientific and patent literature, with hundreds of millions theoretically possible[2]). Table 2 shows some representative examples of chemicals in a range of classes, and possible interferents and co-indicators for each.
- Second, aerosol particles often have complex physical structures with hazardous chemicals of interest adhered to, encapsulated by, or shielded by environmentally common species (e.g., dust, pollen, bacteria, water). These outer species may mask the desired signal both chemically and physically.

- Third, the size and shape of aerosol particles may greatly affect the signal that is generated. Aerosol particles of a single type (e.g., soot) can vary in size by several orders of magnitude due to their production method, water content, and/or age. The size, mass, and shape of the particles also influences how long they may be suspended in the air creating a dynamic challenge for sensing them.

Finally, the environment where aerosols occur plays an important role in their form, lifetime, and reaction dynamics. The environmental factors include temperature variations, humidity, wind speed and direction, topographical features, and background chemistry. Additionally, different geographical regions (e.g., desert, woodland, coastal), seasons (e.g. high concentrations of pollen in the spring), and population levels (e.g., urban, industrial, rural) play their own role in the complex process of aerosol dynamics.

Table 2: Representative Chemicals, Interferents, and Co-Indicators*

	Chemical Target	Relevant Threat Levels[3-8]	Interferents and Co-Indicators
Chemical Warfare Agents (CWAs)	VX	> 0.02 mg-min/m^3	Phosphonic acid, parathion, DMMP, DIPA, methyl chloride, ethanol
Pharmaceutical Based Agents (PBAs)	Fentanyl	> 0.002 mg-15min/m^3	Carfentanil, remifentanil, methylphenidate, mannitol, lactose
Toxic Industrial Chemicals (TICs)	Methyl Isocyanate	> 0.32 mg-30min/m^3	triethylamine, CO_2, methylamine, dimethylurea
Pollutants	Black Carbon	> 3.5 mg/m^3	Hydrocarbons
Explosives	RDX	> 9 mg-min/m^3	Diesel fuel (paraffines, alkyl benzenes, naphthalene), nitromethane, HMX, hexamine, oxidizers
Metals	Chromium (VI)	> 0.005 mg/m^3	Nitrates, Sulfates, Iodide

1.A.4 Existing Aerosol Identification Methods and Limitations

Traditional methods for *in situ* chemical characterization of aerosols often use mass spectrometry due to the complex nature of aerosols described above.[9] Mobile instruments capture the aerosols particles into a chamber for characterization either in the field or after being transported to the laboratory. Unlike in the study of naturally occurring aerosols, in detection of national security threats, the aerosols may be harmful to operators and/or instruments. Thus, it is desired to characterize the aerosol before placing personnel or high-value equipment at risk.

Aerosol detection based on single particle point detection sensors have been successful in classifying biological aerosols based on fluorescence[10], but the same techniques cannot be applied for chemical aerosols as many chemicals do not exhibit intrinsic fluorescence.

Traditional methods for standoff chemical detection have often focused on trace chemical residues, overlooking vapor and aerosols. These methods include IR (Infrared) spectroscopy[11] and several types of measurements based on Raman scattering.[12] In recent years, significant progress has been made towards detection of vapor via mass spectrometry,[13] photonic integrated circuits (PICs),[14] and colorimetrics.[15] Point Standoff capabilities for chemical aerosols have proven more difficult to apply due to the limited sensitivity of techniques such as Raman spectroscopy and IR spectroscopy to individual particles. Development of standoff detection approaches for chemical characterization of aerosols is limited; recent progress has been shown via photo-acoustic spectroscopy and a suite of optical methods.

1.B Program Structure

The PICARD program is anticipated to be a 42 month effort, comprised of two (2) phases with both phases being solicited under this BAA. Phase 1 will be 18 months in duration and Phase 2 will be 24 months in duration. The PICARD program will be comprised of two Technical Areas (TAs): TA1 - Point Detection (*in situ* sensors) and TA2 - Standoff Detection (sensors at a distance). Anticipated developments by program phase are discussed in Section 1.B.3. Associated metrics for each technical area and associated program phase are provided in Section 1.D. Proposals must address both phases to be considered, but may address one technical area or both (see submission details for additional information). Partial solutions to a single technical area will not be considered.

1.B.1 Technical Area 1: Point Detection

Technical Area 1 – TA1 - will focus on the development of an *in situ* sensor for point detection. The sensors developed in TA1 shall integrate sampling, collection, separation, and/or vaporization, detection, and analysis into a single, small form factor device (less than 10 L). Specifically, TA1 sensors should be designed to address compound particles. These include aggregated (chemicals stuck together irregularly), coalesced (chemicals evenly mixed throughout), embedded (target chemical partially encased by others), and encapsulated (target chemical is fully encased by others) particles. As TA1 is focused on *in situ* detection, orthogonal approaches that can be integrated into the device may be practical depending on the collection method deployed. By the end of Phase 2, TA1 sensors will demonstrate automated identification with very low false alarm rates in complex chemical mixtures. As an optional metric, sensors that can also identify specific morphologies or particle asphericity (difference from a sphere) alongside chemical composition will be considered.

1.B.2 Technical Area 2: Standoff Detection

Technical Area 2 – TA2 - will focus on the development of a standoff sensor for detection from a distance (100 m by the end of Phase 2). Technology developed in TA2 shall integrate optical, spectroscopic, or photoacoustic sensors with on-board analytical tools to identify chemical classes of interest, such as fentanyls or organophosphates. The focus of TA2 sensors will be on high accuracy and short response time. Technologies developed in TA2 need to address a broad range of particle concentrations and environmental factors. Compound particles (such as aggregated, coalesced, or embedded) should be considered, while fully encapsulated chemicals of interest are considered out of scope.

1.B.3 Program Phases

As previously stated, the PICARD program is anticipated to be 42 months long and structured into two phases. Both phases are being solicited under this BAA. The two-phase program structure is designed to capture the challenges of increasingly complex aerosol mixtures and environments as summarized in Table 3.

In each Phase, progress will be determined for both hardware and software. The goal of Phase 1 (18 months) is to develop each of the necessary components and integrate them into a breadboard level device. **The PICARD program defines a breadboard as an early prototype, with a non-optimized footprint, developed to test the combined system components in a laboratory environment.** Algorithm development should progress in parallel to the breadboard development with manual identification of processed data (e.g., background removal, baseline flattening, binning). There will be three performer system evaluations in this phase. The first will take place at the performer site; the latter two will take place at a government facility with a testbed developed for PICARD.

The goal of PICARD Phase 2 (24 months) is to advance the capabilities developed in Phase 1 to more complex environments. Brassboard level hardware will be integrated with algorithm development into a single device. **A brassboard is defined as a self-contained prototype with the functionality and approximate physical configuration of the final product intended for testing in relevant environments.** Please see Tables 4 and 5 for a complete list of size, weight, and power (SWaP) metrics for the PICARD program. Automated identification of processed data (no "human in the loop") with an easy-to-understand output (with confidence levels as appropriate) should be achieved by the end of Phase 2. There will be three evaluations in Phase 2, each taking place at a government facility.

Table 3: Program Structure

	Phase 1	Phase 2
Duration	18 months	24 months
Technical Area 1: Point Detection	• Hardware: breadboard traceable to all program metrics • Software: demonstration of manual identification of chemicals (including unknowns) • T&E: quantitative chemical mixtures in controlled environments where target is at least 5% of mixture	• Hardware: brassboard traceable to all program metrics • Software: demonstration of automated identification of chemicals (including unknowns) • T&E: indoor and outdoor testing with highly complex mixtures and environments where target is at least 1% of mixture
Technical Area 2: Standoff Detection	• Hardware: breadboard traceable to all program metrics • Software: demonstration of manual identification of chemical classes • T&E: quantitative chemical mixtures in controlled environments at distances of at least 10 m	• Hardware: brassboard traceable to all program metrics • Software: demonstration of automated identification of chemical classes • T&E: indoor and outdoor testing with highly complex mixtures and environments, to distances at least 100 m

The Government will use the timeline shown in Figure 3 to help the program maintain its 42-month schedule. In Phase 1, the T&E (Test & Evaluation) team will assess progress multiple times. Assessment #1 will take place at the performer site with members of the T&E team using standardized methodologies and protocols to evaluate component level technology. All other assessments will take place at a facility determined by the Government team. Technical reviews will be held in both Phases to assess the feasibility of the proposed technology to meet program goals, identify risk areas, evaluate laboratory results, and provide feedback on the detailed design, performance, and test characteristics of the technology. Additionally, Government Interaction Workshops will be held in both Phases to provide an opportunity for stakeholders to interact with performers, discuss research progress, ask technical questions, and provide feedback.

In Phase 2, the PICARD program will be focused on increasingly complex environments for aerosol sensing. To inform planning for test events and reduce risk, a series of monthly challenges will be provided to performers and results reviewed by the Government team. Phase 2 will include three T&E assessments at a facility determined by the Government team.

Site visits by IARPA and/or T&E partners in the months prior to test events, design reviews, or workshops may be added as needed.

Figure 3: Schedule

Phase 1 (18 months)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Program Kickoff	■																	
Final Waypoints Due			■															
Site Visit					■	■	■											
T&E Evaluation #1					■	■	■											
T&E Evaluation #2												■						
Design Review														■				
Government Interaction Workshop															■			
T&E Evaluation #3																■		
Phase 1 Final Report																		■

Phase 2 (24 months)	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Phase 2 Kickoff	■																							
Adjusted Waypoints Due			■																					
Site Visit						■																		
Monthly Challenges							■	■	■	■	■	■	■	■	■	■	■							
T&E Evaluation #1								■																
T&E Evaluation #2																■								
Design Review																		■						
Government Interaction Workshop																				■				
T&E Evaluation #3																						■		
Phase 1 Final Report																								■

1.C Team Expertise

It is anticipated that PICARD solutions will require multidisciplinary efforts and may necessitate expertise and experience in multiple fields to achieve program goals. Therefore, collaborative efforts and teaming among Proposers are highly encouraged. Proposals should include a description of the mix of skills and staffing that the Proposer determines will be necessary to carry out the proposed research and achieve program metrics as well as key personnel involved.

IARPA anticipates Proposer teams may include, but are not limited to, experts in the following technical areas:

- Aerosol science
- Environmental science

- Particle size measurements
- Aerosol sampling methods
- Pre-concentrators or trap and purge devices
- Gas chromatography
- Liquid chromatography
- Ionization techniques
- Mass spectrometry
- Raman spectroscopy
- Infrared spectroscopy
- Light Detection and Ranging (LIDAR)
- Photoacoustic spectroscopy
- Integrated photonics
- Micro-fluidics
- Micro-electro-mechanical (MEMS) device design and fabrication
- Computational fluid dynamics and general circulation models
- Spectral library development and use
- Machine learning
- Low signal-to-noise data analysis
- Miniaturized vacuum pumps
- Low power electronics
- Device size, weight, and power (SWaP) optimization

1.D Program Scope and Limitations

Proposals shall explicitly address ***ALL*** elements listed below.

- Underlying theory – light/matter interactions, aerosol dynamics, and spectroscopy of particles.
- Research and Development technical approach for a fully integrated system.
- Technical risks and possible mitigations.
- Analysis software development – tailored algorithms and specific background/clutter filter approaches.

The following areas of research are ***out of scope*** for the PICARD program:

- Bioaerosols - bioaerosols, such as viruses, bacteria, and pollen, are out of scope as target chemicals for the PICARD program. This does not preclude their existence as background chemicals during testing as the focus of PICARD is on real world scenarios and environments.
- Research that does not have strong theoretical and experimental foundation for the Proposer's claims.
- Approaches that are likely to result in only incremental improvements over the state of the art.
- Development of component technologies that does not advance the proposer's proposed approach.
- Approaches with significantly limited operation parameters such as not accommodating day/night, wind variations, or temperature fluctuations.

- Development of component level technology (such as sources, detectors, or optical components) that are not required for the Proposer's proposed approach.

1.E Test and Evaluation (T&E)

The PICARD program will pursue rigorous and comprehensive T&E to ensure that research outcomes are well characterized, and deliverables are aligned with program objectives. T&E activities will not only inform Government stakeholders on PICARD research progress but will also serve as valuable feedback to Performers for improving their research approaches and system development during each phase. The PICARD program will work closely with Government stakeholders to ensure relevance of T&E methodologies at each testing event.

T&E results will be provided to performers to inform and improve their R&D approaches and methods. T&E results will also be presented at program Government Advisory Panel (GAP) meetings, workshops, and shared with USG external stakeholders (including contractors as appropriate).

1.F Program Metrics

Achievement of metrics is a key performance indicator under IARPA research programs. IARPA has defined PICARD program metrics to evaluate the effectiveness of the proposed solutions in achieving the stated program goals and objectives, and to determine whether satisfactory progress is being made throughout the life of the program. The metrics described in this BAA are shared with the intent to scope the effort, while affording maximum flexibility, creativity, and innovation to proposers proposing solutions to the stated problem.

T&E protocols and evaluation methodologies for the PICARD program are currently under development and additional details will be provided at program kickoff. Program metrics may be refined during each Phase of the PICARD program; if metrics change, revised metrics will be communicated in a timely manner to performers. The evaluation methodology may be revised by the Government at any time during the program life cycle to better meet program needs.

In accordance with professional project management principles, proposals must include a section that identifies, and documents technical and project implementation risks relevant to meeting program goals identified in this BAA. Technical risk identification includes elements of research and development that indicate objectives that are particularly at risk, such as particular component level technology, supply chain logistics, or limited available data to name a few. Proposal implementation risks include elements such as cost, schedule, and/or risk management. Proposals that do not fully address technical risks in their narrative will be considered technically non-compliant and not eligible for an award.

Table 4: Metrics for Point Detection (in situ) (TA1)

	Metric	Phase 1	Phase 2	Stretch Goal
Sampling	Particle Type	Solid, liquid, and combinations		
	Particle Size	0.05 – 5 μm	0.01 – 10 μm	0.005 – 20 μm
	Target Chemicals	CWAs, PBAs, environmental pollutants, combustion products, TICs/TIMs, and associated chemistries		Quantification of target chemicals
		Neat particles	Compound particles	
	Response Time	1 response every 3 h	1 response every h	1 response every 30 min
Sensing	Specificity	ID of individual chemicals, including unknowns with or without background/interference		
	Clutter	< 1 mg/m^3	< 10 mg/m^3	> 10 mg/m^3
	Interferents	Performer defined chemicals/waypoints (see Section 1.H)		
	Dynamic Range	1000x	10,000x	> 10,000x
	Limit of Detection	$< 50\ \mu g/m^3$	$< 5\ \mu g/m^3$	$< 1.0\ \mu g/m^3$
Analysis	Limit of Identification	< 1 mg/m^3	< 0.1 mg/m^3	< 0.01 mg/m^3
	True Positive Probability	0.90	0.95	0.99
	False Positive Probability	0.10	0.05	0.01
	Library	100 chemicals	250 chemicals	500 chemicals
	(Optional) Morphology	Measurement of particle asphericity (difference from spherical)		
Integration	Device Size	20 L (breadboard)	10 L (brassboard)	< 10 L
	Device Weight	20 kg	10 kg	< 10 kg
	Device Power	COTS, on-board, swappable, 24 hour operation		
	Data Format	.csv or similar (manual ID)	.csv or similar (automated)	-
Environment	Temperature	25°C range	50°C range	> 50°C range
	Humidity	25 – 75% RH	10 – 90% RH	> 90% RH
	Wind Speed	0 – 5 km/h	0 – 10 km/h	> 10 km/h
	Electromagnetic Radiation	10 W/m^2		

Table 5: Metrics for Standoff Detection (TA2)

	Metric	Phase 1	Phase 2	Stretch Goal
Sampling	Particle Type	Solid, liquid, and combinations		
	Particle Size	0.05 – 5 µm	0.01 – 10 µm	0.005 – 20 µm
	Target Classes	CWAs, PBAs, environmental pollutants, combustion products, TICs/TIMs, and associated chemistries		Fully encapsulated targets
		Neat particles	Compound particles	
	Distance	< 10 m	< 100 m	< 1 km
	Safety	Traceable to Class 1M operation at device output aperture		
Sensing	Specificity	ID of chemical class		ID of individual chemicals
	Cloud Depth	10 (mg/m³)*m	100 (mg/m³)*m	> 100 (mg/m³)*m
	Dynamic Range	1000x	10,000x	> 10,000x
	Limit of Detection	< 0.1 mg/m³	< 0.01 mg/m³	< 0.005 mg/m³
Analysis	Limit of Identification	< 1 mg/m³	< 0.1 mg/m³	< 0.01 mg/m³
	True Positive Probability	0.90	0.95	0.99
	False Positive Probability	0.10	0.05	0.01
	Library	100 chemicals	250 chemicals	500 chemicals
Integration	Device Size	75 L (breadboard)	25 L (brassboard)	< 25 L
	Device Weight	50 kg	30 kg	< 30 kg
	Device Power	COTS, on-board, swappable, 24 hour operation		
	Data Format	.csv or similar (manual ID)	.csv or similar (automated)	-
Environment	Temperature	25°C range	50°C range	> 50°C range
	Humidity	25 – 75% RH	10 – 90% RH	> 90% RH
	Wind Speed	0 – 5 km/h	0 – 10 km/h	> 10 km/h
	Electromagnetic Radiation	10 W/m²		

Table 4 & 5: Associated Legend

- **Particle** – A collection of solid or liquid chemicals (or combinations of both) suspended in air; individual aerosols are referred to as particles in this document. Neat particles are those that are comprised of a single chemical constituent while compound particles are those comprised of multiple chemical constituents. Compound particles may be aggregated (chemicals stuck together irregularly), coalesced (chemicals evenly mixed throughout), embedded (target chemical partially encased by others), or encapsulated (target chemical is fully encased by others).
- **Specificity** – Ability to correctly identify a given chemical species (TA1) or class (TA2) based on its signature. Tested both for pure compounds using clean (neat) single-component signature data and for mixtures to analyze the ability to correctly assign signal response features in a multi-component system to the constituent species.
- **Clutter** – Particles in the air which comprise the background chemicals but are not in the particle containing the target. In PICARD, the ability to correctly identify chemical targets of interest in the presence of a complex background will be important. All background compounds do not have to be correctly identified, enabling algorithmic flexibility.

- **Interferents** – Chemicals or systems of chemicals (particles) that comprise the chemicals in a single particle; these are chemicals or particles that exhibit signatures similar to the chemical of interest, confusing the sensor's ability to detect target chemicals.
- **Limit of Detection** – Measurement of the smallest quantity of a chemical that can be reliably measured by the system above the signal to noise level without other chemicals present.
- **Limit of Identification** – Measurement of the smallest quantity of a chemical that can be correctly identified by the system with other chemicals present.
- **Library** – Chemicals used in algorithm development, either to create a searchable collection or as training data for a machine learning algorithm.
- **Morphology**- The measurement of a particle's shape, form, and physiochemical structure
- **Unknowns**- Chemicals not in the performer library or training data but based on the technical approach should be manually identifiable.
- **Cloud Depth –** A measure of the total mass of particles that may be encountered over a certain volume. The units of $(mg/m^3)*m$ correspond to the concentration of particles over a given distance.

1.G Government Furnished Resources (GFR)

At kickoff of Phase 1, the Government will provide performers with the following information:

- Chemical list – A non-exhaustive list of chemicals that may be used in test and evaluation - Performers will be responsible for any characterization of these compounds that is necessary to choose system materials and components, build libraries for compound identification, or train machine learning algorithms. Additional chemical lists will be provided 6 months into Phase 1, at Phase 2 kickoff, and 6 months into Phase 2. Performers will not be expected to acquire controlled substances as part of the PICARD program. Testing will focus on surrogates to reduce risk to personnel whenever possible. Additional chemicals may be used in testing as unknowns.
- Test plan – This document will describe the tests planned for each test event so performers can plan appropriately and ask questions.
- Aerosol generation protocols – In order to ensure understanding between performers and T&E partners, detailed protocols for the generation of aerosols will be provided to performers at kickoff. These will need to be used in results presented to the Government team throughout the program.
- Custom sorbent materials – Performers who may be interested in waveguide enhanced approaches or integrated photonics technologies can utilize custom sorbent materials developed by the T&E team as appropriate.
- Simulated aerosol spectra for a limited number of chemicals based on performer approaches

1.H Program Milestones, Waypoints, and Deliverables

Milestones, waypoints, and deliverables are key program components that are established at the program's onset to ensure alignment with PICARD program goals. These organize research activities in a logical and reportable manner, enable long term records management of the program, and facilitate consistent and efficient communication among all stakeholders – IARPA, the PICARD T&E Teams, USG stakeholders, and Performers.

Milestones are program meetings, T&E events, and important dates that define the workflow for the PICARD program. A preliminary schedule of PICARD program Milestones is shown in Table 6.

Table 6: List of Program Milestones

Phase	Program Months	Description	Comments
1 & 2	All	Monthly Progress Meeting	Monthly teleconference with PICARD Government team
1	1	Phase 1 Kickoff Meeting	(WMA) Performers present Phase 1 plans and T&E outlines guidelines for metric evaluation
1	~6	Site Visit	IARPA and T&E team with invited USG stakeholders visit Performer locations for technical discussions and laboratory tours
1	~6	T&E Event #1	This test event will take place at Performer locations with selected members of the IARPA and T&E teams present over the course of 3 days
1	12	T&E Event #2	This test will take place at a government test site over the course of 3-5 days
1	14	Technical Review #1	(Performer locations) PICARD Government team evaluates technical designs provided by Performers
1	15	Government Interaction Workshop #1	(WMA) Performers, IARPA and T&E team with invited USG stakeholders meet for technical discussions
1	16	T&E Event #3	This test will take place at a government test site over the course of 3-5 days
2	19	Phase 2 Kickoff Meeting	(WMA) Performers present Phase 2 plans and T&E outlines guidelines for metric evaluation
2	24	Site Visit	IARPA and T&E team with invited USG stakeholders visit Performer locations for technical discussions and laboratory tours
2	26	T&E Event #4	This test will take place at a government test site over the course of 3-5 days
2	34	T&E Event #5	This test will take place at a government test site over the course of 3-5 days
2	36	Technical Review #2	(Performer locations) PICARD Government team evaluates technical designs provided by Performers
2	38	Government Interaction Workshop #2	(WMA) Performers, IARPA and T&E team with invited USG stakeholders meet for technical discussions
2	40	T&E Event #6	This test will take place at a government test site over the course of 3-5 days

In addition to meeting the program metrics (Tables 4 or 5) and achieving all program milestones, Proposers shall define interim "check in" performance measurements called *Waypoints* which indicate technical progress of each task on the project. Waypoints help the program management team to assess project progress and the need for any course correction during the program. At a minimum, each project task should include Waypoints every 3-6 months. More frequent waypoints are encouraged for key project tasks. A sample table of Waypoints is shown in Table 8.

Waypoints should be developed for all project tasks to track progress towards specific goals. These may include, for example, development of samplers, optical components, algorithms, libraries, spectrometers, and system integration. Additionally, waypoints addressing chemical interferents specific to the performer approach should be included. Interferents are chemicals with signal responses similar to the target materials, therefore causing an additional challenge to correct identification. Defining interferents and testing those throughout the program will be necessary for all performers.

Table 8: Sample Waypoint Table

Phase	Program Month	Waypoint	Metric	Success Criteria
1	5			
1	…			

In conjunction with the program Milestones listed in Table 7, *Program Deliverables* are given in Table 9. These are the documents to be submitted before or after each Milestone.

Presentations (Kickoff, Site Visit, or Workshop) are slide decks presented at meetings with any related videos or references. Read ahead slides are due 5 days prior to the event, with a finalized version due 24 hours after the event.

Technical Review Packages (both Phase 1 and 2) include presentation slides, technical drawings, bill of materials, prototype design specifications, and any raw data, modeling, or calculations used in the development of the design. The purpose of the technical review is to determine if the detailed design meets program goals, establish compatibility between components, assess technical results, and identify risks and potential mitigation pathways. Draft packages are due 15 days before the presentation. The Government team will provide feedback and final packages will be due 30 days after that.

Phase 1 and 2 *Technical Reports* will be due by the last day of the Period of Performance for that Phase.

Phase 1 *Test and Evaluation results reports* will include chemical identification guesses, software necessary to process raw data, and all raw data collected during the test event. This is due no later than 7 days after the conclusion of the test event.

Phase 2 *Test and Evaluation "quick look" reports* will include initial chemical identification guesses and are due within 4 hours of the conclusion of testing each day. A summary results report will include updated chemical identification guesses, software necessary to process raw data, and all raw data collected during the test event. This is due no later than 7 days after the conclusion of the test event.

Table 9: List of Program Deliverables

Phase	Program Months	Description	Comments
1 & 2	All	Monthly Status Report (MSR)	Due on the 15th of each month; technical and financial
1 & 2	3 & 21	Final Milestones due	Performer defined milestones driven by approach and metrics
1 & 2	1 & 19	Kickoff Meeting Presentations	Read ahead slide packages due 5 days before meeting date; corrected slides due 15 days after meeting date
1 & 2	6 & 24	Site Visit Presentations	Read ahead slide packages due 5 days

Phase	Program Months	Description	Comments
			before meeting date; corrected slides due 15 days after meeting date
1 & 2	13 – 14 & 35 - 36	Technical Review Packages	Draft packages due 15 days before presentation; corrected packages due 30 days after receipt of feedback
1 & 2	15 & 38	Workshop Presentations	Read ahead slide packages due 5 days before meeting date; corrected slides due 15 days after meeting date
1 & 2	18 & 42	Phase 1 and 2 Reports	Final reports for each Phase are due prior to the end of the technical Period of Performance
1	6, 12, & 16	T&E Results Report	All results, including raw data, are due to the Government team 7 days after the conclusion of the test event
2	26, 34, & 40	T&E Results Report	Quick Look results, including initial chemical identification, are due within 24 hours of the conclusion of the testing each day; a summary report, including raw data, is due 7 days after the conclusion of the test event

1.I Meeting and Travel Requirements

Proposers are expected to assume responsibility for administration of their projects and to comply with contractual and program requirements for reporting, attendance at program workshops, meetings, test events, and site visits. The following paragraphs describe expectations for program related meetings and travel for the PICARD program, as well as the estimated frequency and locations of such meetings.

Program Phase Kickoff Meeting – All Performer teams are required to attend Program Phase Kickoff Meetings, including key personnel from prime and subcontractor organizations. Kickoff meetings will be held within the first month of each of the two phases of the PICARD program. The dates and locations of these meetings will be set later by the Government team. For planning purposes, Proposers should use the preliminary dates outlined in Table 6. These meetings are likely to be held in the Washington, D.C. metropolitan area, but IARPA may opt to co-locate the meeting with a relevant external conference or workshop to increase synergy with stakeholders. IARPA reserves the right to hold the meeting virtually for logistical, health, and/or safety reasons.

The Phase 1 Kickoff Meeting will be two days in duration and will focus on program plans, performer planned research, and internal program discussions. The Phase 2 Kickoff Meeting will also be two days in duration and will focus on performer planned research, adaptations for Phase 2 based on lessons learned in Phase 1, and internal program discussions.

Both meetings are designed to facilitate open technical exchanges, interaction, and sharing among the various program participants and interested Government stakeholders. Program participants will be expected to present the technical status and progress of their projects to other participants and invited guests.

Research and data of a proprietary nature will be presented in closed sessions with Government transition partners, T&E partners, and IARPA.

Site Visits – Site visits by the Government team (IARPA, T&E partners, and invited stakeholders) are anticipated to take place annually during the life of the program. These visits will take place at the Performer's facility with participation from prime and subcontractor organizations. Reports on technical progress, details of successes and issues, contributions to the program goals, and technology demonstrations will be expected at each site visit. IARPA reserves the right to conduct additional site visits on an as-needed basis or reduce the number of site visits for logistical, health, and/or safety reasons.

Test Events – The PICARD program will include six (6) Test & Evaluation events split evenly between Phases. Performers should plan for 3-5 days of testing at a T&E site for each event. The location of each test will be determined later depending on the research approaches that are being pursued and how they match with T&E team capabilities.

In Phase 1, the first test event will take place at the Performer site and will be conducted in tandem with the site visit. The second and third test events will take place at Government T&E sites. Results, including chemical identification, will be required no more than one week after the conclusion of testing. The Government team will provide a written report summarizing their evaluation within one month of the conclusion of testing.

In Phase 2, all three test events will take place at Government T&E sites or a relevant facility. Results, including chemical identification, will be required no more than 24 hours after the conclusion of testing. The Government team will provide a written report summarizing their evaluation within one month of the conclusion of testing.

Technical Reviews – In each phase, a technical review will be conducted. This is to include a documentation package consisting of prototype engineering diagrams, component lists, development risks, timelines, and cost estimates. Performers will be expected to present this data package to the Government team, respond to questions, and adapt the research plan as needed.

Technical review presentations will take place at the Performer sites with participation from IARPA, T&E partners, and Government stakeholders. Hardware/software demonstrations will not be required but are encouraged.

Workshops – Two Government Interaction Workshops will be held during the PICARD program, towards the end of each phase. The purpose of these workshops is for Performers to provide technical updates on research efforts and Government stakeholders to have a chance to ask questions and discuss the program goals. All Performer teams are expected to attend, including key personnel from prime and subcontractor organizations. Hardware and software demonstrations are highly encouraged.

Each workshop will be a 2-day event in the Washington, D.C. metropolitan area. Dates and locations will be set later by the Government team. IARPA reserves the right to hold the meeting virtually for logistical, health, or safety reasons.

Monthly Review Meetings – To ensure that all necessary details of developed hardware, software, and operational instructions are clear and complete, each Performer will be required to be available for questions and troubleshooting from the T&E team in Performer status meetings each month. These virtual meetings will be established after PICARD Program Kickoff Meeting to facilitate regular communication between the Performer and Government team. These meetings will present the previous month's research activities, review open action items, discuss upcoming research, and identify any concerns or issues which could impact the program. If IARPA or a performer determines it is beneficial to program goals, virtual meetings may be established every two weeks.

1.J Period and Place of Performance

Technical R&D (Research and Development) performance will be conducted at the Performers' sites. In Phase 1, T&E events will be held at either the Performer site (Evaluation #1) or a T&E site (Evaluations #2 and #3). In Phase 2, all T&E events will be held at a T&E site.

1.K Research Conferences and Publications

Performers may plan to publish their research in academic journals or present their research at appropriate research conferences, and accordingly they may include an expectation to participate in these events in their proposal. During the program, a request to travel must be submitted to the contracting office (CO), contracting officer's technical representative (COTR), and the IARPA technical team. IARPA will expect a courtesy copy of publications, posters, or presentations associated with PICARD research at least ten (10) days in advance of the submission deadline. All published material shall include the proper acknowledgement to IARPA and the contracting organization, including contract information. IARPA and/or the Contracting Agent will provide appropriate language to use for acknowledgement of papers, presentations, and posters.

Glossary

Term	Definition
Aerosol	a suspension of solid particles or liquid droplets in air
Asphericity	difference from spherical
BAA	Broad Agency Announcement
BPA	Bisphenol A
Brassboard	self-contained prototype with the functionality and approximate physical configuration of the final product intended for testing in relevant environments
Breadboard	early prototype, with a non-optimized footprint, developed to test the combined system components in a laboratory environment
Cloud Depth	A measure of the total mass of particles that may be encountered over a certain volume. The units of (mg/m3)*m correspond to the concentration of particles over a given distance.
Clutter	Particles in the air which comprise the background chemicals but are not in the particle containing the target. In PICARD, the ability to correctly identify chemical targets of interest in the presence of a complex background will be important. All background compounds do not have to be correctly identified, enabling algorithmic flexibility.
CO	Contracting Office
COTR	Contracting Officer's Technical Representative
COTS	Commercial Off The Shelf
CS	tear gas 2-chlorobenzalmalonitrile
CWA	Chemical Warfare Agent
Design Review Packages	presentation slides, technical drawings, bill of materials, prototype design specifications, and any raw data, modeling, or calculations used in the development of the design
GAP	Government Advisory Panel
GFR	Government Furnished Resources
IARPA	Intelligence Advanced Research Projects Activity
IDLH	Immediately Dangerous to Life or Health
Interferents	Chemicals or systems of chemicals (particles) that comprise the chemicals in a single particle; these are chemicals or particles that exhibit signatures similar to the chemical of interest, confusing the sensor's ability to detect target chemicals.
IR	Infrared Spectroscopy
Library	Chemicals used in algorithm development, either to create a searchable collection or as training data for a machine learning algorithm.
LIDAR	Light Detection and Ranging
Limit of Detection	Measurement of the smallest quantity of a chemical that can be reliably measured by the system above the signal to noise level without other chemicals present.
Limit of Identification	Measurement of the smallest quantity of a chemical that can be correctly identified by the system with other chemicals present.
MEM	Micro-electro-mechanical
Milestones	program meetings, T&E events, and important dates that define the workflow for the PICARD program
Morphology	The measurement of a particle's shape, form, and physiochemical structure
MSR	Monthly Status Report
Particle	A collection of solid or liquid chemicals (or combinations of both) suspended in air; individual aerosols are referred to as particles in this document. Neat particles

Term	Definition
	are those that are comprised of a single chemical constituent while compound particles are those comprised of multiple chemical constituents. Compound particles may be aggregated (chemicals stuck together irregularly), coalesced (chemicals evenly mixed throughout), embedded (target chemical partially encased by others), or encapsulated (target chemical is fully encased by others).
PBA	Pharmaceutical Based Agent
PIC	Photonic Integrated Circuits
PICARD	Pursuing Intelligent Complex Aerosols for Rapid Detection
Presentations	Slide decks presented at meetings with any related videos or references
Program Deliverables	documents to be submitted before or after each Milestone
R&D	Research & Development
RDX	Research Department eXplosive
Specificity	Ability to correctly identify a given chemical species (TA1) or class (TA2) based on its signature. Tested both for pure compounds using clean (neat) single-component signature data and for mixtures to analyze the ability to correctly assign signal response features in a multi-component system to the constituent species.
SWaP	Size, Weight, and Power
T&E	Test and Evaluation
TA	Technical Areas
TA1	Technical Area 1 a point detector for in situ chemical type identification
TA2	Technical Area 2 a standoff detector for chemical class identification
TIC	Toxic Industrial Chemical
TIM	Toxic Industrial Material
Unknown	Chemicals not in the performer library or training data, but based on the technical approach should be manually identifiable.
USG	United States Government
VX	Venomous agent X
Waypoints	check in performance measurements
WMA	Washington Metro Area

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