Satellite methane detection response playbook

November 2025

AERSCAPE

OIL AND GAS CLIMATE INITIATIVE

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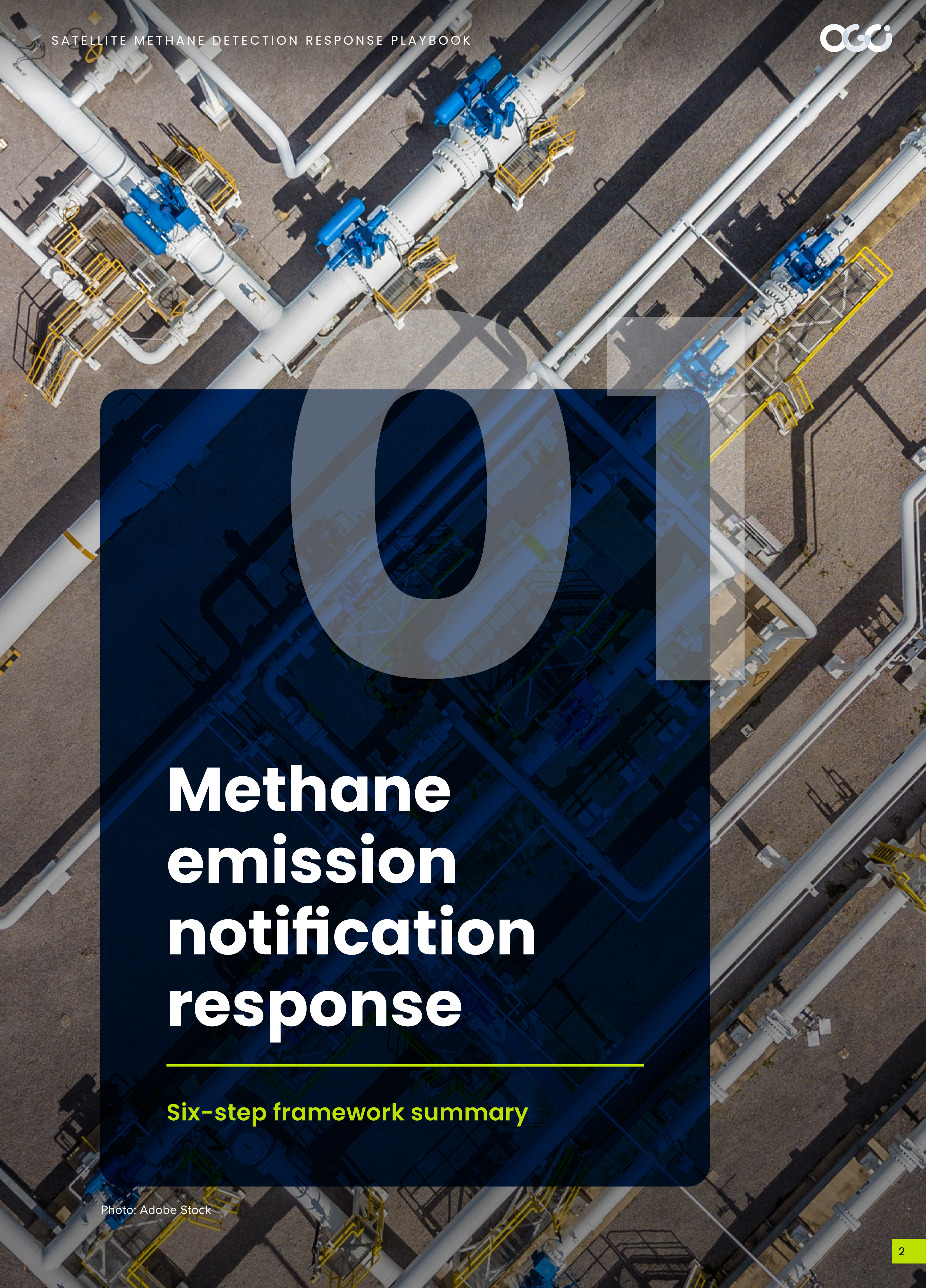

01

Methane emission notification response

Six-step framework summary

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Methane emission notification response

Six-step framework summary

The reality of satellite detection

Modern satellite technology can detect methane plumes from space and the number of platforms measuring methane is increasing. Multiple organizations publicly release global methane detections as well as alert regulatory agencies and sovereign nations that emissions were detected.

Here, we have developed a structured approach to follow-up on satellite detections that will facilitate your organization's ability to respond to these events. This playbook is intended to be useful for a wide variety of operators globally and does not assume the availability of advanced methane detection technologies such as optical gas imaging cameras, handheld lasers, continuous methane monitors, drone deployed sensors or aircraft-based methane detection technology. If available, the addition of advanced technologies will provide value to operators in their investigations and should be incorporated into the steps outlined below.

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Step 1: Initial assessment and location review

Verify facility ownership and emission potential

- Check if your company owns/operates facilities or pipelines near detection coordinates
- Confirm facility has potential to emit methane during normal or upset conditions
- Review detection data: location, timing, emission rates, environmental conditions
- **Important:** Ensure coordinate systems match to avoid location errors

Step 2: Source investigation and identification

Conduct order of magnitude analysis

- Categorize facility equipment by emission potential
- Evaluate equipment under normal, maintenance, and upset conditions
- Focus on sources capable of half of reported detection rate and higher (to account for uncertainty)
- Consider that multiple smaller sources may combine within the satellite footprint.

This step narrows down the scope of the next investigation steps to equipment and processes that have the potential to explain the satellite observation.

Desktop investigation: Review maintenance logs, operational records, process data, flare status, equipment malfunction reports, and security footage to identify potential sources and timing.

Field investigation: If desktop analysis cannot identify a probable source related to normal operations or maintenance activities that have ended, conduct on-site verification using:

- Audio/visual/olfactory assessment including equipment-specific inspections for flare systems, storage tanks, compressors and valves
- Temperature differential measurements at valves and outlet points
- Gas detection equipment (LEL meters, OGI cameras, continuous monitoring data, aerial measurements) if available

Prioritize safety of field team during all field investigations and mitigation efforts.

Step 3: Repair prioritization and implementation

Address identified emission sources

- Prioritize repairs based on emission rate, company risk criteria, regulatory requirements and safety thresholds
- Document specific work performed, parts replaced, and personnel involved
- Record completion timestamps and operational adjustments

Step 4: Post-repair validation

Verify repair effectiveness

Return to emission source location to verify that the repair was successful and that emissions have ceased. Use available technologies to confirm successful mitigation or monitor process parameters for stable operation if available. Document verification methodology and results.

If emissions continue: Return to Step 3 for additional corrective action.

Step 5: Response preparation and documentation

Prepare comprehensive reporting

Internal: Document facility details, source identification, investigation methodology, event timeline, and investigative analysis. Learnings should be compiled for both emission events driven by malfunctions and emissions that were part of normal operations.

Regulatory: Review compliance requirements and reporting obligations.

External: Prepare response to emission event notifier following company protocols.

Step 6: Continuous improvement and learning

Transform investigation into operational excellence

Prevention and process improvement: Use the information learned during the emission response to evaluate opportunities to avoid future high-rate emission events. Focus on prevention of malfunctions, optimization of work practices to avoid high-rate events and opportunities to route vented gas streams to sales.

Knowledge sharing: Share learnings across operations teams, engineering, and industry working groups to facilitate progress across industry.

02 Introduction

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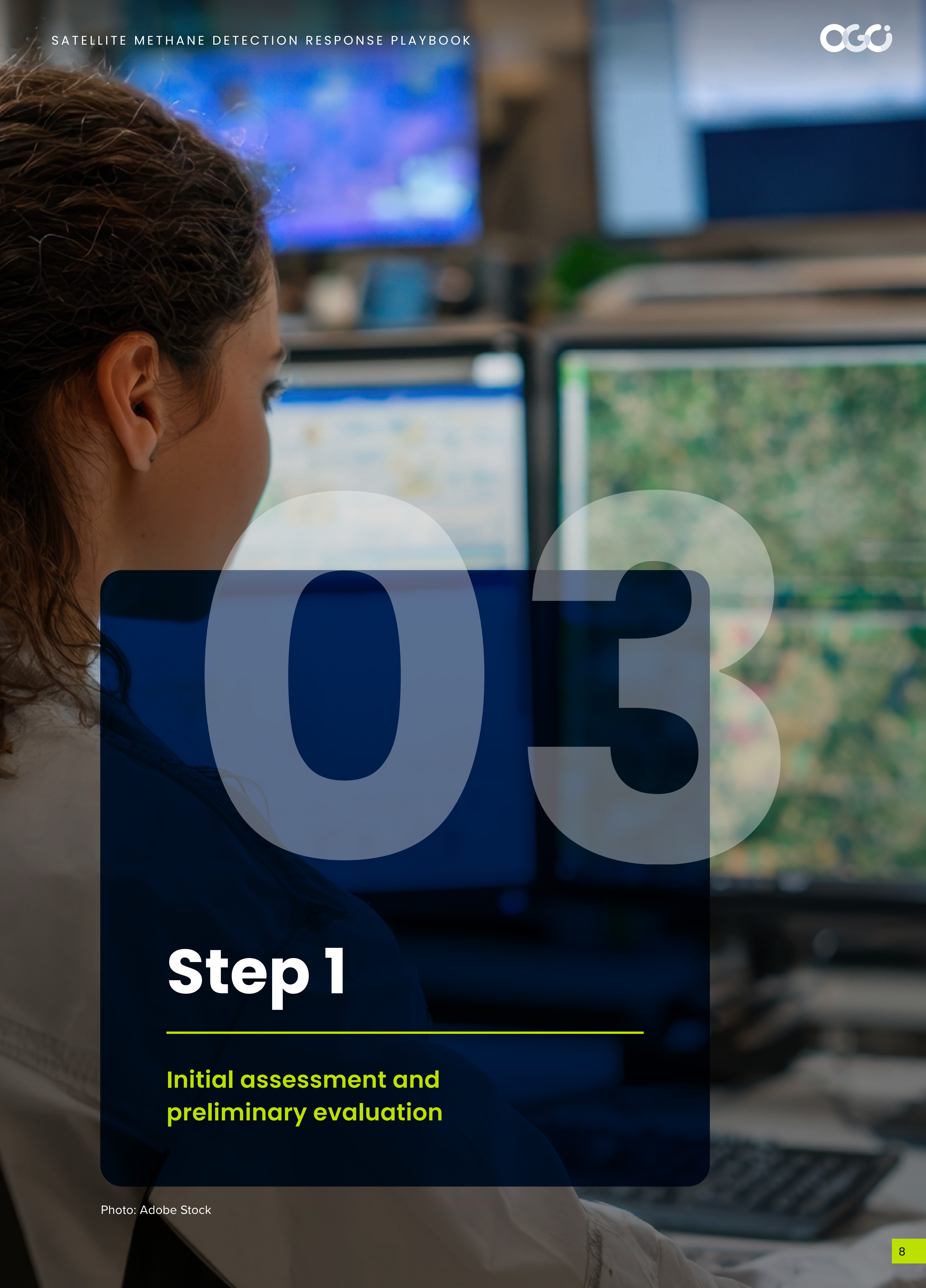
Introduction

This guide provides a systematic, step-by-step approach for responding to methane emission notifications detected by satellite and aircraft methane monitoring systems. These notifications are released by a variety of organizations such as the UN Environment Programme International Methane Observatory's Methane Alert and Response System (UNEP IMEO MARS), the Carbon Mapper data portal, as well as local regulatory bodies. The playbook is intended for global operators that may not have mature methane management programs or experience with responding to external notification of emission events and can also be applied to a company's own internal satellite monitoring program. It does not assume the availability of advanced methane detection technologies such as optical gas imaging cameras, handheld lasers, continuous methane monitors, drone deployed sensors or aircraft-based methane detection technology which are not available across the world. Importantly, this guide focuses on the response process for a single notification but does not cover the development of an internal governance system within your company to manage such events in the context of your wider methane management program. Prior to receiving any third party notifications, it is helpful to identify a single point of contact within your company where these notifications should be directed. This should be communicated across your company, as third parties may send notifications to individuals that are not directly responsible for methane emissions.

When you receive a notification about a potential methane emission near your facilities, this process will guide you through suggested investigation techniques, help you identify possible emission sources, enable you to take appropriate corrective action, and assist you in identifying 'learnings' from the event and follow-up to help you manage your methane emissions in the future. It does not assume that you have access to additional advanced methane monitoring technologies but if you have these at your disposal, they may also facilitate your investigation.

Satellite-based methane detection warrants investigation

Modern satellite monitoring technology has advanced methane detection capabilities, providing visibility into localized atmospheric emissions across the globe. These systems can detect methane plumes from space and several organizations are focused on compiling and releasing global methane detections publicly (e.g. UNEP IMEO MARS, Carbon Mapper and EDF). Understanding how to respond effectively to these notifications is essential for operations personnel, environmental managers, and technical staff across the oil and gas industry.



03

Step 1

Initial assessment and preliminary evaluation

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Step 1
Initial assessment and preliminary evaluation

Location review and geographic analysis

When you receive a methane emission notification, the priority is to conduct an assessment to determine how the detection correlates with your operational facilities and activities.

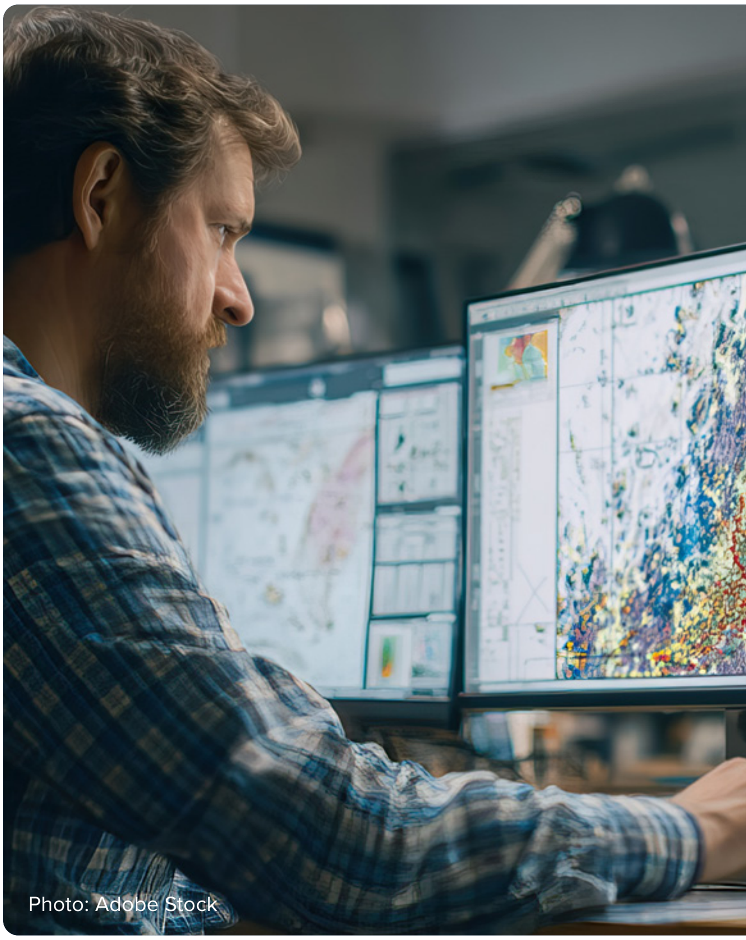
Summarize the following information that will be received with a notification to facilitate your review (Note that these items are generally helpful, but may not all be provided with the emission notification. Some information, such as wind speed, can be obtained from other sources):

- **Precise location coordinates** of the emission source provided as well as the size, shape, and area covered by the methane plume. Note that there may be some uncertainty in the location of the emission source and that this is variable depending on the detection technology. In general, the emission source will be located either within the boundaries of an observed plume or within ~100m of the plume edges. In rare cases, plumes may 'detach' from their source location and may transport as a coherent unit, generally dispersing within a couple of hours.

- **Time-related information** including date, time, and duration of detection event. Most detections from satellite platforms are nearly instantaneous measurements, but occasionally notifiers will provide more than one detection in the same area collected at different times. You may receive notifications well after an event occurred (months or even years) and this will impact your ability to follow up on the event.

- **Quantitative data** such as estimated emission rate and measurement uncertainty ranges. If no uncertainty ranges are given, a working default assumption is half to twice of the detected rate.

- **Environmental conditions** including wind speed, direction and temperature at the time of detection. If this information was not included with the emission notification you may be able to obtain some information on the environmental conditions at the time of detection from 3rd parties such as government weather agencies.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Mapping your facilities relative to methane emission sources

Prior to receiving any notifications, your company will benefit by compiling a list of operated facilities and pipelines along with their latitude and longitude if one does not already exist. It is important to note that many oil and gas operators do not use the same mapping projection internally that many notifiers and web-based mapping tools use (For example – Google Earth uses WGS84/EPSG4326). Pay careful attention to potential discrepancies between coordinate systems, as projection differences can result in location errors of hundreds of meters.

Decision point 1
Do you own or operate facilities or pipelines within ~100m of the boundaries of methane plume associated with the detection? During your investigation, avoid overlooking facilities or equipment labeled as "inactive" or "shut-in" in operational databases.

If NO
Proceed to prepare a response indicating that the detection is not associated with your operations. If you are familiar with the owner/operator of the site nearest the reported event, consider sharing the information with them if appropriate.

If YES
Continue with assessment procedure.

Decision point 2
Does your nearest facility (or facilities) have the potential to emit methane during normal operations, maintenance activities, or upset conditions?

If NO
Proceed directly to response preparation, but document your technical basis for concluding that your facility lacks the potential to emit methane.

If YES
Continue with assessment procedure.

Advanced imagery analysis and visual assessment

Examine available satellite imagery, aerial photography, and remote sensing data provided with the emission notification.

Look at the plume image overlain on visible imagery focusing on whether the imagery clearly indicates a source site. In some cases, plumes are clearly attributable to individual sites but in other cases it is not clear from a visual analysis exactly where the plume originated.

If plume characteristics show clear association with a specific site but the source location is not clear to distinguish the primary equipment type contributing to emissions (See case study 5 on page 40 for an example): Advance to Section 2 and plan for a more comprehensive, facility-wide order of magnitude analysis to identify possible emission sources.

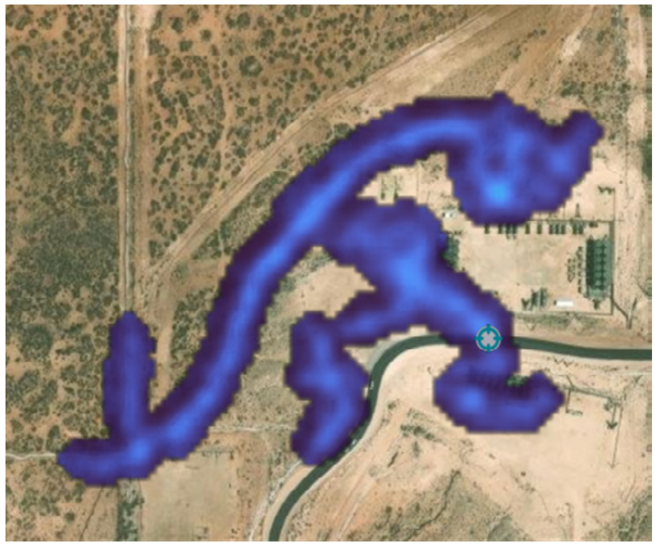
If plume characteristics show clear association with specific equipment or operational zones (See case study 4 on page 38 **for an example):**

- Focus your investigation efforts on that particular equipment group or operational zone
- Advance to Section 2 and plan for a targeted, equipment-specific order of magnitude analysis to identify possible emission sources

If plume location does not clearly identify an individual site: Advance to Section 2 and plan for a more comprehensive analysis of nearby sites to identify possible emission sources.

If plume characteristics appear to exactly follow the shape of a site, adjacent roadways or other surfaces visible in imagery: Reply to notifier and ask whether the plume has been evaluated for albedo artifacts. In this case the plume may be a legitimate detection where retrieval was only successful over some of the surfaces in the image, or it may be an artifact of processing.

FIGURE 1: Example plume image where detection traces roadways near the identified source. In these cases it is recommended to follow up with the notifier about the quality and reliability of the emission rate estimate and detection. Visual imagery data from ESRI. Plume image from Carbon Mapper.



Treat satellite detections as legitimate emission events

Satellite-based methane detection systems represent sophisticated, scientifically validated measurement technologies that detect atmospheric emissions. While these systems incorporate inherent measurement uncertainties and detection limits, and false positives do occur, confirmed detections often represent actual methane emission events. The quantitative emission rates reported by these systems reflect instantaneous measurement values rather than time-averaged totals. In controlled release studies, many of these measurements averaged together can constrain the rate of emissions from a source. Individual measurements have a higher uncertainty, and a reasonable working uncertainty for individual emission events is approximately half of the emission rate to twice the rate (-50% to +100%) unless more specific information is provided. The event may appear to have unrealistically high emission rates (such as more methane emissions than the total gas production of the well), but may be reasonable when the uncertainty is considered. In some cases, methane plumes observed by satellites did not originate directly below the plume, and instead have been transported away from the original source location. While there are no best-practices defined for evaluating the accuracy of the origin of an observed plume, it is best to consider any possible events that may have occurred near the plume location reported by the Notifier.

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Step 2

Source investigation and identification

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Step 2
Source investigation and identification

Order of magnitude analysis to identify sources with the potential to emit at levels reported by the notifier

Develop a categorization of equipment at the facility (or facilities) of interest and evaluate the potential to emit methane for each of these categories. If the plume image correlated with a specific equipment group, you can restrict your analysis to that equipment group. You should estimate potential emission rates for equipment categories under various operational scenarios including normal operations, startup/shutdown/maintenance/completion activity and malfunctions.

You will compare these potentials to emit with the emission notification and restrict your follow-up of possible sources to those that are capable of emitting methane at approximately half of the levels observed. The objective is to narrow the list of possible equipment types that may have contributed to the observed event to facilitate efficient follow-up analysis. It is important to remember that satellite observations of methane emissions are generally nearly instantaneous measurements, so the order of magnitude analysis should consider the peak possible instantaneous rate of emissions from each source category.

If the satellite plume does not suggest a concentrated source at a single equipment group and your initial order of magnitude/desktop analysis does not identify a likely single source, the detection may be viewing multiple emission sources simultaneously. In this case aggregated total of those individual sources may be more comparable to the reported emission rate (See case study 5 on page 40 for an example).

Concentrate your desktop analysis (and field follow-up) on emission sources capable of releasing approximately half or more of the reported satellite detection rate. For example, if satellite monitoring detected emissions at 500 kg/hr, investigate equipment and processes capable of emitting 250+ kg/hr under normal, upset, or maintenance conditions.

> Order of magnitude analyses can be completed more generally for sites and equipment prior to receiving any detection notifications. Cataloging a list of sources capable of producing emissions at different thresholds across your operations may facilitate more rapid follow-up in the event of a notification.

Example order of magnitude analysis for a facility

Note that this table is not representative of any site and is intended to only serve as a conceptual model. The range of possible emissions from various equipment in the field is highly variable depending on the local operating conditions.

Rate range	Possible sources
0-10 kg/hr (0-520 scfh)	Individual compressor engine exhaust systems, small-diameter valve seat leakage, low-pressure pneumatic device venting, standard rod packing emission sources, minor tank breathing losses
10-100 kg/hr (520-5,203 scfh)	Multiple compressor unit engine operations, pressure relief valve malfunction or weeping, smaller-capacity vent stack releases, flare systems with low (<96%) combustion efficiency, planned maintenance activities with controlled venting
100-1,000 kg/hr (5,203-52,032 scfh)	Well flowback and cleanup operations, significant tank containment system issues, unlit or malfunctioning flare systems, major maintenance activities, pipeline blowdown operations, vent stack releases, some equipment failures
1,000-10,000 kg/hr (52,032-520,317 scfh)	Large-scale well blowdown procedures, major flare system malfunctions, extensive maintenance operations requiring system depressurization, multiple simultaneous equipment failures, larger-capacity vent stack releases
10,000+ kg/hr (520,317+ scfh)	Multiple coordinated equipment blowdowns, direct well venting to atmosphere, catastrophic equipment failures, large-scale emergency response activities such as site emergency shut-down (ESD) and blowdown

Important: Spatial aggregation effects in satellite measurements

Satellite methane detection systems typically integrate emissions across spatial areas ranging from a few to over 100 m, depending on sensor resolution and deployment mode. This pixelization means that multiple smaller emission sources located within the satellite's measurement footprint may appear as a single, combined detection event. Your analysis should first focus on individual sources that are capable of emitting approximately half of the reported emission rate, but if no individual sources can be identified, consider that emissions from multiple sources within the satellite detection footprint may combine. For example, the engine exhaust from multiple closely spaced natural gas driven compressors may lead to emissions in excess of 100 kg/hr at individual sites.

Contextual analysis and historical pattern recognition

Conduct a search of available resources such as public data portals or internal databases to determine whether the current detection represents an isolated emission event or fits into a recurring pattern that may indicate recurring emissions at this location. In many cases, once a site has been identified as a location of interest in public records, notifiers and data providers process more historic and future data at that location. Performing this historical analysis prior to beginning your desktop investigation will help facilitate your follow-up and will help you and your operations team understand whether this was truly an isolated event or is a repeated issue. The companion case-studies to this playbook give several examples.

If multiple detections have occurred over time: Utilize the comprehensive longer-term emission record to inform your current analysis, as this pattern suggests either persistent emission sources that may be process emissions, unexpected sources or recurring intermittent events that may be linked to specific operational practices, process conditions or equipment upsets. In some cases, the spatial location of sources can be better inferred by multiple detections as they may cluster around specific equipment groups. In the case of multiple detections at the same facility, the operations team should be contacted to access historical detection records at the site and any known issues from previous detections.

If this represents an isolated detection event: Proceed with standard desktop investigation protocols focused specifically on the time-period surrounding the detection, while maintaining awareness that isolated events may indicate equipment malfunction, operational activity or intermittent events that occur infrequently.

Desktop investigation

Conduct a thorough investigation of your operational records, operator notes/logs, maintenance databases, and process information to identify specific activities, equipment conditions, or operational circumstances that could reasonably explain the observed emission event.

Review information that is available for your facility and attempt to identify potential sources as well as beginning and end times for emission events. Use your order of magnitude analysis to focus your investigation on sources that have the potential to emit methane at approximately half of the reported volume or greater.

Important: Aligning time series information correctly

Satellite detection timestamps are generally reported in Coordinated Universal Time (UTC), while your operational records may use local time zones. Always account for time zone differences (e.g., daylight saving time transitions) to avoid temporal misalignment that could lead to incorrect source attribution or missed operational correlations. Consider calibrating your field instrumentation for clock drift on a periodic basis. GPS based time synchronization across all data collection devices is ideal.

I. POSSIBLE DESKTOP DATA ANALYSIS INFORMATION SOURCES (WHEN AVAILABLE):

- **Meteorological data, especially wind direction and wind speed,** from a nearby weather station or from modeled weather products can help determine the direction of plume travel during the event.
- **Leak detection and repair records** may be useful to identify the source as well as to place time-bounds on the duration of emission events.
- **Maintenance logs** including preventive, corrective, and emergency work performed.
- **Operational startup/shutdown/completion activity records** documenting high-emission potential operations.
- **Blowdown records** with specific timing, duration, equipment involved, and estimated gas volumes released.
- **Process monitoring data** including pressures, temperatures, flow rates, and control system responses throughout the period surrounding the emission event.
- **Equipment malfunction and upset condition reports** including alarm histories, process deviations, and their documented resolution procedures and timing.
- **Visual flare inspection records** documenting flare status (lit/unlit). Flare instrument records: flow to flare or flare volume metering, pilot monitoring, air or steam assist status of flare etc.
- **Metered gas production and sales volumes** that may be useful to estimate potential to emit from sources such as flares and tanks.
- **Onsite methane measurements** such as gas/LEL detection monitors, continuously monitoring methane sensors or cameras that can help identify the general area of the site that may be responsible for emissions as well as constrain the duration of any emission event.
- **Aerial methane measurements** such as drone, helicopter or fixed-wing aircraft data that were collected near the time of the event of interest.
- **GPS vehicle tracking data** indicating personnel presence and movement patterns that may correlate with maintenance or operational activities.
- **Security camera footage** providing visual documentation of site activities and personnel presence.
- **Third party imagery data** may be available for purchase. If a high-resolution image is available near the time of detection it may contain information about site activity (e.g., presence of vehicles, temporary equipment, flare status)

Distinguishing root cause process location from source location

During your analysis, maintain a clear distinction between the physical geographic location where methane was ultimately released to the atmosphere (i.e., source location) and the underlying mechanical, operational, or process condition that caused the release to occur (i.e., process root cause analysis). For example, a storage tank thief hatch may represent the physical source location where emissions were detected, but the fundamental root cause may be a malfunctioning upstream dump valve, inadequate liquid level control, or production conditions. Understanding this distinction is crucial for implementing effective corrective measures to address underlying causes and improve performance.

II. DESKTOP ANALYSIS POTENTIAL OUTCOMES:

If you successfully identify a probable emission source AND can definitively confirm that emissions ceased:

- Advance directly to Section 5 (prepare response)
- Document your findings, supporting analysis, and the evidence basis for your conclusions. An example of a definitive investigation would be a maintenance blowdown event that occurred simultaneously with the detection of interest (See case study 3 on page 36 for an example). Ideally, you were able to access logs of the start/stop time of the blowdown and the estimated peak rate of emissions from the blowdown event was within the range of uncertainty of the notification emission rate.

If you identify a probable emission source BUT cannot determine whether emissions have ended:

- Proceed to Section 2.4 (field investigation) for direct verification
- Provide field investigation teams with summary of suspected sources (if available), list of equipment identified in the order of magnitude analysis with a potential to emit at or above half of the reported emission rate, supporting evidence, historic detections at this facility and specific investigation recommendations.

If comprehensive desktop analysis cannot identify a probable emission source:

- Proceed to Section 2.4 (field investigation) for on-site investigation
- Provide field teams with the order of magnitude analysis results and prioritized investigation suggestions based on equipment potential to emit.


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Field investigation and repair prioritization

I. GOALS

Conduct field verification of suspected emission sources identified during the desktop analysis.

1. **Emission status verification** to determine if releases are ongoing or have ceased. This is a physical investigation in the field that looks for ongoing releases.
2. **Suggested field investigation procedures** are detailed in Appendix I and don't assume the availability of advanced methane detection technologies.
3. **Document findings** with photographic evidence, measurement data, and observations.

If emissions are ongoing but represent normal process operations:

- Document investigation and advance to Section 5 (prepare response) for appropriate notification and documentation
- Consider Section 6 (learning journey) for evaluation of emission reduction opportunities and operational improvements.

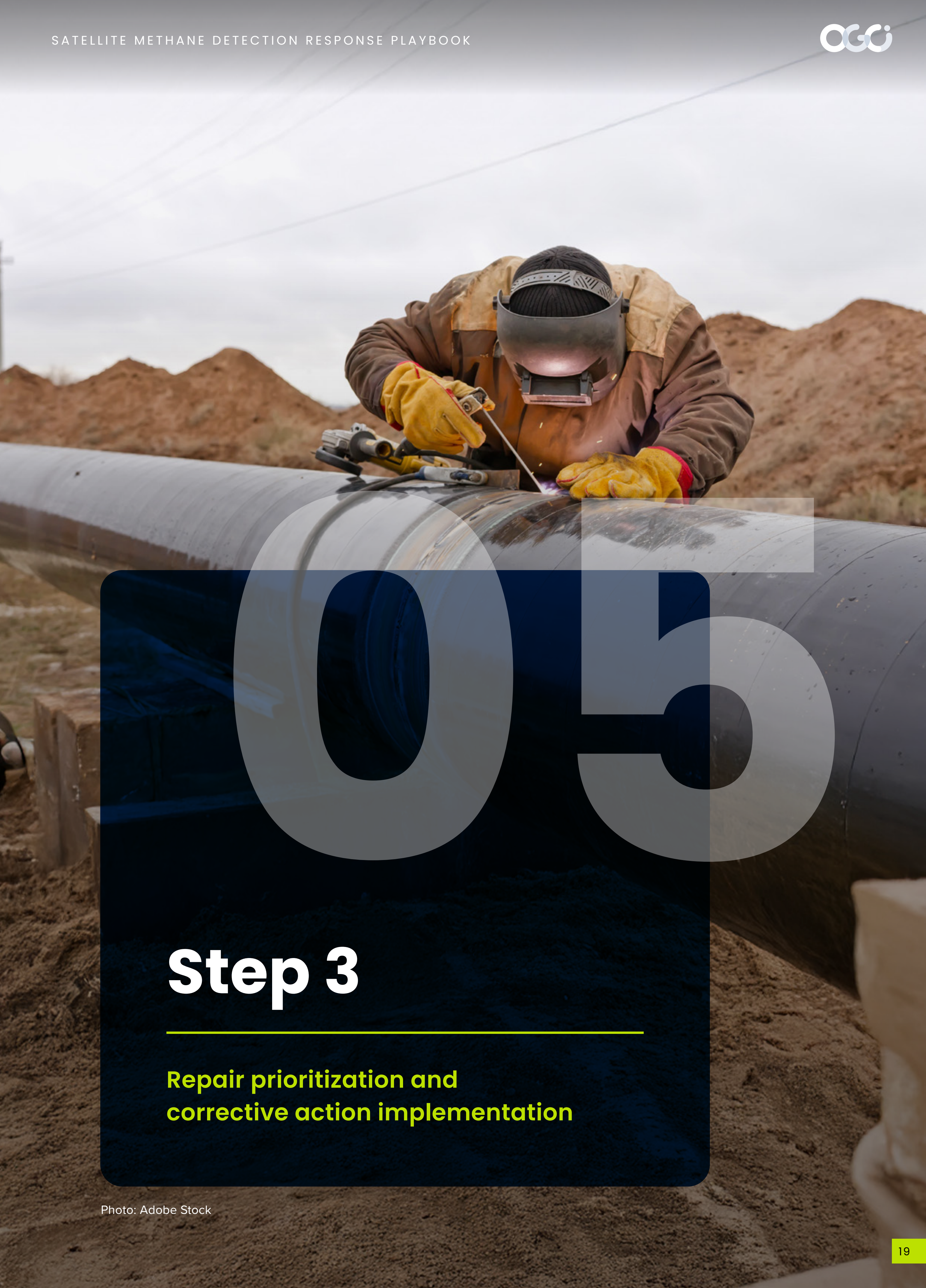
If emissions are ongoing and are due to an upset condition: Document investigation and proceed to Section 3 (prioritize repair) for corrective action. Once the repair is completed continue following this guide including verification of repair (Section 4), preparing a response (Section 5) and embarking on a learning journey (Section 6).

If no emission source is identified despite comprehensive field investigation:

- **Prepare investigation report** documenting methodology, equipment examined, and findings.
- **Consider implementation of additional monitoring** for future emission events, particularly for sites with recurring detection histories.

Technology resources

There are many technology resources available to operators to assist in the identification of methane emissions and their source location. Audio/olfactory/visual (AVO) inspections require no specialized equipment and are the default minimum standard available to operators globally. Additional field investigation capabilities include Optical Gas Imaging (OGI) cameras utilizing specialized infrared sensors, handheld methane detection instruments, continuous methane monitors and fixed cameras. Remote technologies such as drones and aircraft are available in some locations. Additionally, commercially available satellite methane products and visible imagery may be available to your company. A list of possible resources can be found here along with an ability to filter technologies by desired application.



05

Step 3

Repair prioritization and corrective action implementation

Photo: Adobe Stock

Step 3
Repair prioritization and corrective action implementation

When equipment malfunction is identified as the source of methane emissions, implement repair prioritization protocols based on the emission rate, your company risk assessment criteria, regulatory requirements and the potential of the release to exceed acceptable safety criteria.

Record repair information including specific work performed, parts replaced or repaired, operational adjustments, personnel involved, and completion timestamps.

Upon completion of corrective actions, proceed to Section 4 for post-mitigation validation.

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Step 4

Post-mitigation validation

Photo: Adobe Stock

Step 4
Post-mitigation validation

Verify repair

I. FIELD VERIFICATION PROCEDURES:

- **Return to original emission source location** and verify that no emissions are occurring and that the repair was successful.
- **Document repair completion verification.** Consider including photographic evidence, measurement data, verification methods employed, and personnel involved in verification activities.

II. OPERATIONAL PERFORMANCE VERIFICATION:

- **Monitor relevant process parameters** including pressures, temperatures, flow rates, and control system responses to confirm normal operation.
- **Review system performance data** over a sufficient time-period to establish stable operation.
- **Document verification** approach including the data and criteria used to verify secession of emissions.

If validation procedures confirm successful repair and emission cessation, proceed to Section 5 for response preparation.

If emissions continue despite repair efforts, return to implementation of corrective action (Section 3) and work with operations to develop a revised repair plan.

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07

Step 5

Investigation summary and reporting for internal use

Photo: Adobe Stock

Step 5
Response preparation and documentation

Investigation summary and reporting for internal use

Prepare a summary of important aspects of the emission notification, investigation process and findings. Consider the development of an internal reporting template or checklist that collects uniform information for all events across your company to facilitate learning over time.

I. FACILITY LOCATION AND PRODUCTION CHARACTERISTICS:

- **Clearly identify facility ownership** including legal entity, operational responsibility, and management authority.
- **Document operational capability** including equipment inventory, process description, and methane-handling potential under various operational scenarios.

II. COMPREHENSIVE SOURCE IDENTIFICATION AND ANALYSIS:

- **Provide specific source identification** including equipment type, location, and operational circumstances if successfully identified.
- **Detail investigation methodology** including desktop analysis, field investigation techniques, measurement equipment used, and personnel involved.
- **Explain technical basis** for source attribution including supporting evidence, measurement data, and engineering analysis.

III. EVENT CLASSIFICATION, CHARACTERIZATION AND INVESTIGATIVE ANALYSIS:

- **Categorize emission type** as equipment malfunction, normal process emission, planned operational activity, or unplanned event.
- **Identify operational context** including startup/shutdown procedures, maintenance activities, completion operations, or routine process operations.
- **Provide process description** explaining normal operational parameters and how the emission event deviated from expected operation.
- **Document possible mitigation options** to reduce the likelihood of recurrence.

IV. TEMPORAL ANALYSIS AND TIMELINE DEVELOPMENT:

- **Document event initiation** including estimated start time and methodology used for determination.
- **Identify date when the event concluded** including estimated end time and supporting evidence for end.
- **If no source is identified,** provide a clear statement with an explanation of investigation efforts and limitations.

Regulatory compliance and reporting assessment

Conduct a review of applicable regulatory requirements and reporting obligations. Review:

- **Regulatory requirements** include air quality standards, emission reporting obligations, noting thresholds and applicable filing timelines, oil and gas regulations, pipeline safety standards, and other compliance obligations.
- **Corporate reporting obligations** including internal policies, stakeholder commitments, and voluntary reporting programs,

If identified emissions are not currently captured in your greenhouse gas inventory or emissions reporting:

- **Develop emission estimation methodologies** using appropriate engineering calculation methods, measurement data, and emission factor databases. Examples of some existing methods for emissions calculations can be found in the API Compendium, within US EPA Subpart W reporting methodologies, and GTI Veritas.
- **Consider the implications to reporting frameworks your company participates in** such as the Oil & Gas Methane Partnership (OGMP) 2.0, US EPA Subpart W reporting, and API Environmental Partnership emission reporting.
- **Update inventory methodologies** to capture similar future events and improve overall emission quantification accuracy and completeness.

Response to emission event notifier (optional)

Consider preparing a response to the notifier of the emission event including a high-level summary of your investigation. It is important that your response to the notifier follows your company protocols and is reviewed by the appropriate stakeholders within your organization prior to sharing externally. For example, if you were able to determine that the emission event was a short duration event due to maintenance, communicating that the event was planned and completed quickly may avoid notifiers assuming that the event occurred over a long period of time.

08

Step 6

Continuous improvement and learning integration

Photo: Adobe Stock

Step 6
Continuous improvement and learning integration

Transform emission investigations into a valuable opportunity for operational excellence, environmental stewardship, and organizational learning that benefits improvements in operational efficiency, environmental performance and industry-wide best practices. Many resources are available, such as the OGCI Methane Library that offer source specific suggestions on emissions management.

Mitigation planning and prioritization of actions

I. EQUIPMENT MALFUNCTION PREVENTION AND MITIGATION STRATEGIES:

Proactive prevention strategy development:

- **Establish visual flare inspection protocols** during all site visits including presence or absence of flame and presence or absence of visible smoke. Consider including pilot ignition verification (if applicable)
- **Consider implementing enhanced inspection frequency** for equipment that has the potential to emit above thresholds visible by satellite technology. Prioritize equipment and facilities that your operations team considers 'high risk' for issues and equipment previously identified as the driver of other events across your operations.
- **Prioritize proactive equipment repairs/maintenance** identified during routine inspection programs before minor issues escalate to significant emission events and use information to adjust maintenance schedules.
- **Optimize operating parameter control** to maintain equipment operation within design specifications.

II. PROCESS EMISSION OPTIMIZATION AND REDUCTION OPPORTUNITIES:

Engineering solutions for emission reduction:

- **Evaluate routing options** for vented gas streams to existing or new control devices including flares, thermal oxidizers, or beneficial use applications.
- **Implement process modifications** to minimize routine emissions through design optimization, equipment upgrades, or operational procedure improvements.
- **Assess equipment upgrade opportunities** including higher-efficiency equipment, improved sealing technologies, retrofit kids and advanced control systems.

III. OPERATIONAL ACTIVITY OPTIMIZATION AND BEST PRACTICE DEVELOPMENT:

Work practice enhancement and procedure improvement:

- **Optimize startup/shutdown procedures** to minimize emissions through improved sequencing, temporary control measures, and enhanced planning.
- **Implement portable emission control** during maintenance activities including portable flares, vapor recovery systems, or temporary containment.
- **Enhance activity planning** for high-emission activities including scheduling coordination, resource preparation, and environmental impact minimization. For example, reducing the pressure of pipelines prior to a planned maintenance event can reduce the volume of gas that must be vented prior to work.
- **Evaluate beneficial use opportunities** for gas that would otherwise be flared or vented, including power generation or sales to third parties.

Knowledge sharing and industry collaboration

I. INTERNAL COMMUNICATION AND ORGANIZATIONAL LEARNING:

Share comprehensive learnings and best practices across organizational functions:

- **Operations teams** including field personnel, supervisors, and management to improve day-to-day practices and operational awareness.
- **Engineering departments** encompassing design, maintenance, and project teams to influence future equipment selection, modification options and process design.
- **Health, Safety and Environment departments** to integrate lessons learned into training programs, policies, and compliance strategies.
- **Geographic regions and business units** to leverage learnings across diverse operational environments and regulatory frameworks.
- **Communications and external affairs teams** to support stakeholder engagement, regulatory relationships, and corporate transparency efforts.
- **Leadership and executive management** to inform strategic decision-making, resource allocation, and corporate sustainability initiatives.

II. EXTERNAL COLLABORATION AND INDUSTRY LEADERSHIP:

Consider sharing valuable learnings through established industry channels:

- **Industry working groups** including Oil and Gas Climate Initiative (OGCI), The International Association of Oil & Gas Producers (IOGP), The Oil & Gas Decarbonization Charter (OGDC), The Environmental Partnership (TEP), ONE Future, & American Exploration and Production Council (AXPC) collaborative programs.
- **Regional consortiums** including low carbon energy working groups, state industry associations, and regional environmental partnerships.
- **Technology vendor feedback programs** to drive equipment improvement, measurement accuracy, and detection capability enhancement.
- **Equipment manufacturer partnerships** to influence design improvements, maintenance best practices, and reliability enhancement initiatives.

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Conclusion and commitment to excellence

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Conclusion and commitment to excellence

Effective response to satellite-based methane emission notifications requires systematic investigation methodologies, appropriate technical resources, organizational commitment, and dedication to continuous improvement that extends beyond regulatory compliance to environmental stewardship. This process framework helps ensure evaluation of emission events and potential emission sources while simultaneously reducing operational risk, collecting more product, building organizational capability for advanced emission management, environmental responsibility, and operational excellence.

Key terms and definitions:

- **Desktop analysis:** An investigative process using available operational records, historical data, process information, and digital resources without requiring physical field visits to the facility. Desktop analysis may provide enough information to complete investigation or may provide context for staff conducting Field Investigations.

- **Field investigation:** Is a systematic, on-site physical examination and assessment process conducted at operational facilities to identify, verify, and characterize methane emission sources that cannot be definitively determined through desktop analysis alone. The hands-on investigative approach outlined here relies primarily on trained personnel using their senses and basic detection equipment to conduct thorough, methodical inspections at the actual facility location where satellite monitoring detected methane emissions.

- **Notifier:** The specialized organization, governmental agency, or advanced monitoring system that detected and reported the methane emission using satellite or aerial surveillance technology.

- **Order of magnitude analysis:** A systematic categorization methodology for organizing potential emission sources by their magnitude ranges, allowing companies to focus on equipment capable of producing detected emission rates.

- **Plume:** The distinctive, measurable methane emission cloud or signature detected in satellite imagery, representing the spatial distribution of higher methane concentrations in the atmosphere.

- **PTE (potential to emit):** The maximum theoretical capacity of equipment, systems, or processes to release emissions under normal operating conditions and during upset scenarios, typically expressed in kilograms per hour.

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Case studies

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Case study 1
Unlit flare methane emission investigation

Receipt of notification

The operations team received a notification from Carbon Mapper, a third-party emissions monitoring organization. The notification provided important data: NASA's EMIT satellite detected a methane emission event at one of their facilities three weeks prior. The emission rate was estimated at 2,500 kg/hr with an uncertainty of ±800 kg/hr.

The notification included GPS coordinates and a detailed plume image overlain on visual satellite imagery, showing a methane signature from an onshore production facility.

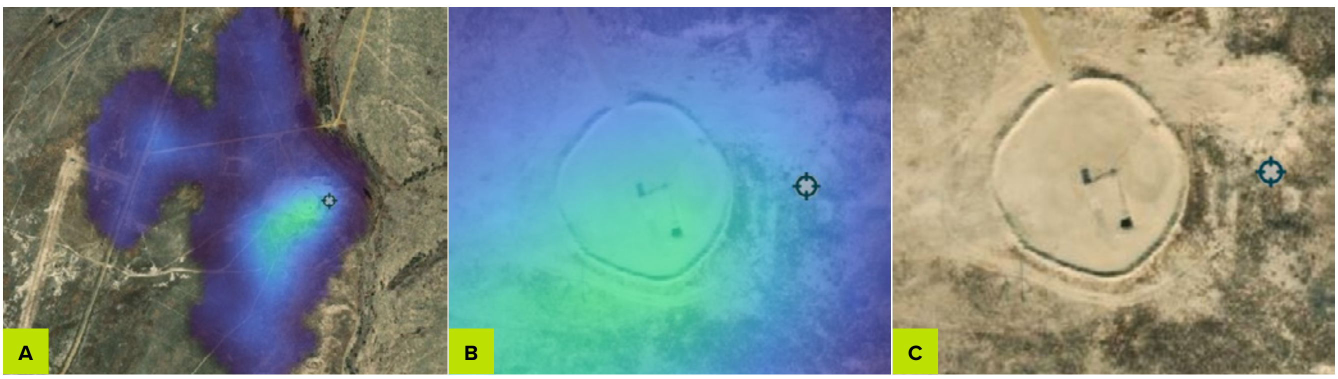

FIGURE 1. Plume image overlain on visual imagery provided by Carbon Mapper to the operator. Panel A shows the entire plume extent. Panel B zooms in on the area of the plume enhanced in methane and near the identified source of the plume (turquoise marker). Panel B shows only the visible imagery the possible source location (turquoise marker) without the plume overlay. Here the flare is clearly visible and is the closest piece of equipment near the facility. Visual imagery data from ESRI. Plume images and data points from Carbon Mapper.

Initial assessment and preliminary evaluation

The operator examined imagery available in a free online mapping platform and saw that the plume was roughly correlated with an area where the company actively operated several facilities. The operator was able to confirm with operations teams that Facility #7 was the closest facility to the emission point of origin.

Visual analysis of the plume image and aerial photography showed that the methane plume appeared to originate directly from the facility's flare stack. This observation significantly narrowed the potential source, as the flare represented a single point of emission rather than multiple possible equipment sources across the facility.

Source investigation and identification

Given clear visual evidence pointing to the flare, the team isolated their order of magnitude (OOM) analysis to only the flare system and confirmed that the emission rate observed was plausible given the anticipated gas flow rate to the flare. They examined additional third-party detection data that had been associated with the site and found that 5 previous emission events had been detected near this same flare over the past six months, providing useful context for their investigation and indicating that this detection should be prioritized.

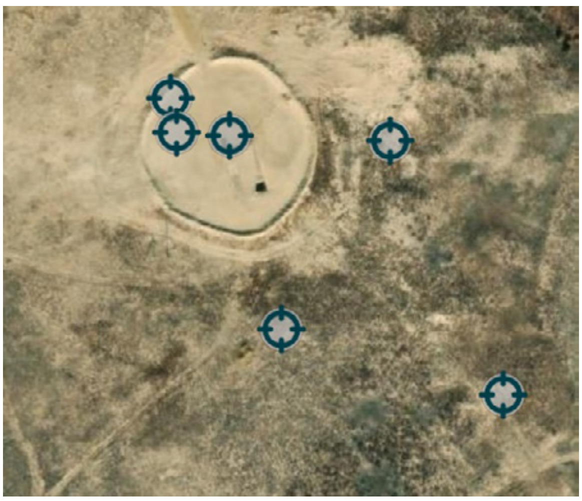

FIGURE 2. Third party methane detections at the facility in question over the past two years. Turquoise markers indicate locations identified by the third party as near the source of the emission events. Visual imagery data from ESRI. Data points from Carbon Mapper and UNEP.

The desktop analysis revealed that Facility #7 did not have continuous flare monitoring equipment installed, which meant the team would need to conduct a field investigation to determine the flare's operational status during the emission period.

The operations team promptly dispatched personnel to the flare site with specific guidance about the satellite detection. The field investigation team confirmed that the flare was receiving gas flow but was not lit, explaining the satellite observation.

Corrective action and verification

Once the source was identified, the team took immediate corrective action. The operations team successfully relit the flare, restoring proper combustion. After several hours, personnel returned to visually confirm the flare remained lit and was operating as designed.

Response and documentation

The incident was thoroughly documented in the company's environmental database, with all satellite data, field reports, and corrective actions recorded for compliance purposes. The operator also responded to Carbon Mapper, confirming that the emission event had been resolved.

Continuous improvement and learning integration

The team conducted a thorough investigation to understand the underlying cause of the flare extinction. They determined that the flare's liquids knockout vessel had become filled with liquids, which disrupted gas flow and caused the flame to extinguish.

Working proactively, the facilities design team evaluated similar equipment across the company's portfolio to identify potential improvements. They established enhanced maintenance protocols for regular knockout vessel unloading by field teams. Additionally, the operator added a visual flare inspection to the checklist that the local operations team completes each time they visit a site. The local team logs their findings at each visit (flare is lit/not lit), initiates corrective action if a problem is found, and provides them with a record of flare status for future use.

The experience and lessons learned were shared with industry partners through regional operator working groups, contributing valuable insights about flare system operations and the benefits of satellite-based emissions monitoring as a complement to existing monitoring programs.

Case study 2: Elevated pipeline rupture investigation

Receipt of notification

An operator received a notification from their national regulator based on Tanager-1 satellite detection data. The detection indicated a methane emission event at one of their facilities three days prior, with an estimated emission rate of 735 kg/hr ± 515 kg/hr. The notification included precise GPS coordinates and satellite imagery of the methane plume overlain on visible imagery.

Initial assessment and preliminary evaluation

The environmental team cross-referenced the provided coordinates with their asset database and confirmed based on this and the wind direction at the time of detection that the emission originated at one of their large processing facilities. While the location matched their asset inventory, the satellite imagery resolution wasn't sufficient to identify specific equipment groups or facility areas responsible for the emission, requiring a more comprehensive investigation approach.

FIGURE 1. Plume image overlain on visual imagery provided by the national regulator to the operator. Panel A shows the entire plume extent. Panel B zooms in on the area of the plume enhanced in methane and near the identified source of the plume (turquoise marker). Panel C shows only the visible imagery the possible source location (turquoise marker) without the plume overlay.
Visual imagery data from ESRI. Plume images and data points from Carbon Mapper.

Source investigation and identification

The environmental team collaborated with operations to conduct an order-of-magnitude analysis, developing a list of potential sources capable of emitting methane at rates between 200 and 1,300 kg/hr (accounting for detection uncertainty). They focused on sources that could produce emissions in this range even during brief events such as depressurization, since satellite measurements represent nearly instantaneous observations. Sources with expected emission rates below 200 kg/hr, such as engine exhaust, valve leaks, and low-volume vent stacks, were eliminated from consideration.

Review of historical emission data showed no additional detections at this facility in public archives, suggesting this was an isolated event rather than a recurring issue. Desktop analysis of process monitoring data and operational logs didn't reveal information that could explain the emission source or timing.

The environmental team briefed operations on their findings, explaining that their analysis had eliminated smaller potential sources and providing the plume imagery overlaid on visual satellite data. Operations dispatched a field team to conduct a comprehensive Audio-visual-olfactory inspection, followed by a ground-based optical gas imaging camera survey. Initially, no issues were identified.

After discussions with their management team, the environmental team contracted with a third-party satellite vendor to conduct an additional methane survey over the facility.

The independent survey confirmed a second methane detection with imagery similar to the emission event shared by the national regulator. This prompted operations to conduct a more thorough optical gas imaging inspection, during which the team discovered emissions originating from an elevated pipeline that was difficult to access from the ground during routine inspections.

Corrective action and verification

Once the source was identified, the operator immediately initiated repair procedures and replaced the ruptured pipeline section. The company used optical gas imaging technology after completing the repair to verify that the work was successful and emissions had ceased.

Response and documentation

The investigation and repair were thoroughly documented according to company procedures. The operator provided a comprehensive response to the national regulator, demonstrating the successful identification and repair of the pipeline rupture.

Continuous improvement and learning integration

The investigation highlighted the importance of increasing company knowledge of pipeline integrity management for methane emissions. The company enhanced their tracking system to monitor pipeline properties including pipeline material, construction date, lining type, diameter, and service application along with any logged integrity issue. The goal of this data management project is to develop predictive analytics that will help prioritize monitoring and maintenance. Additionally the operator modified their leak detection and repair plan to include safe operating procedures for regularly including difficult to reach elevated sources in their leak detection monitoring program.

The operator shared their experience with midstream industry working groups, discussing best practices for tracking pipeline integrity issues correlated with identified risk factors. This knowledge sharing helps the industry develop more effective pipeline monitoring strategies and demonstrates how satellite detection capabilities can complement traditional inspection methods for hard-to-access infrastructure.

Case study 3
Pipeline blowdown investigation

Receipt of notification

An operator received a notification from the Methane Alert and Response System (MARS), managed by United Nations Environment Programme's International Methane Emissions Observatory (UNEP's IMEO) based on NASA EMIT satellite data. It reported a methane emission event six months prior with an emission rate of 2,400 ± 300 kg/hr at a specific GPS location. The notification included satellite imagery of the plume detection overlain on visible imagery.

Initial assessment and preliminary evaluation

The environmental team cross-referenced the provided coordinates with their asset database and discovered they did not operate a facility at the detection location. However, they identified that one of their natural gas pipelines ran through the area, with a pig launching and retrieval station located near the coordinates. This finding focused their investigation on pipeline-related activities.

Examination of the satellite imagery revealed what appeared to be a pipeline right-of-way near the detection point. While the imagery resolution wasn't sufficient to identify specific equipment details such as meters or pigging facilities, it was consistent with their asset records showing pipeline infrastructure in the area.

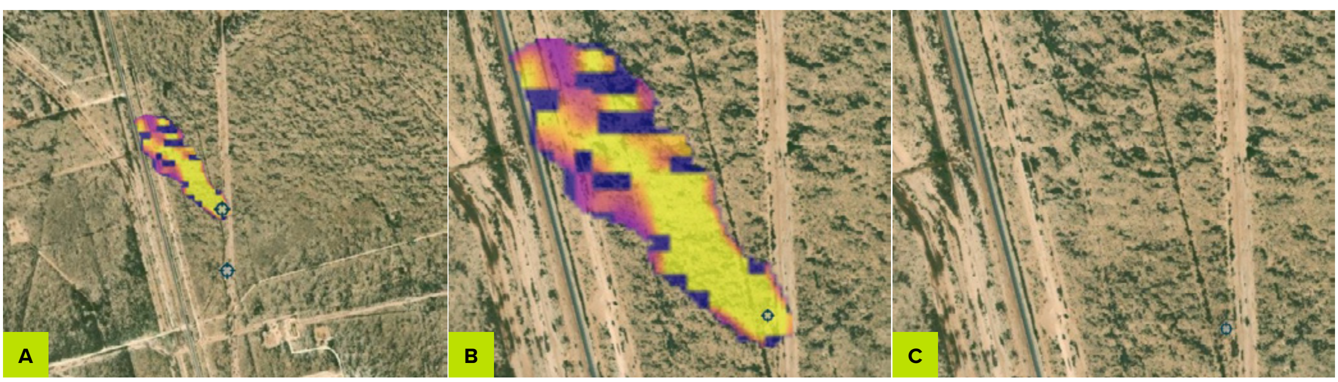

FIGURE 1 Plume image overlain on visual imagery provided by UNEP to the operator. Panel A shows the entire plume extent. Panel B zooms in on the area of the plume enhanced in methane and near the identified source of the plume (turquoise marker). Panel C shows only the visible imagery the possible source location (turquoise marker) without the plume overlay. Here the pipeline right-of-way is visible. Visual imagery data from ESRI. Plume images and data points from UNEP.

Source investigation and identification

The environmental team conducted an order-of-magnitude analysis and determined that the observed emission rate could be explained by either a pipeline rupture or a planned blowdown event during maintenance operations. To better understand the situation, they examined all available third-party detection data for the area and found 13 separate emission events over a four-year period. The recurring pattern in this region elevated the importance of the investigation of this individual event because it appeared to be a recurrent issue.

FIGURE 2. Third party methane detections near the area of interest over the past four years. Turquoise markers indicate locations identified by the third parties as the source of the emission events. Visual imagery data from [ESRI]. Data points from [Carbon Mapper] and [UNEP].

Desktop analysis of operational logs revealed pigging activities had occurred around the same timeframe as the satellite detection. The team contacted operations personnel to discuss their findings and request field verification. Operations visited the pipeline location and found no evidence of continuing emissions, confirming there was no ongoing pipeline rupture. They verified that regular pigging operations do occur at this location for liquids removal and pipeline maintenance.

The correlation between operational records and satellite detections, combined with the absence of visible emissions during the field inspection, led the team to conclude that routine pigging operations were the most likely explanation for the satellite observations.

Corrective action and verification

Since the emission resulted from planned maintenance operations rather than equipment malfunction, no repairs were necessary. The field inspection confirmed the pipeline system was operating normally with no ongoing emissions.

Response and documentation

The investigation was thoroughly documented according to company procedures. The operator prepared a response to UNEP's IMEO explaining that the detection corresponded to normal operational activities of short duration, with emissions ceasing shortly after the event.

Continuous improvement and learning integration

The investigation highlighted that routine pigging operations can generate emissions detectable by satellite monitoring systems. While these operations are essential for pipeline safety and integrity, the team recognized an opportunity to explore emission reduction strategies. Since the operator didn't have existing technologies to mitigate emissions from pigging operations, they engaged with voluntary industry working groups to explore alternative approaches and emerging technologies.

The company shared their experience with industry peers through professional associations, contributing to broader discussions about operational practices and satellite monitoring. This collaborative approach helps the industry develop best practices for managing routine maintenance activities while minimizing environmental impact and addressing the growing capabilities of satellite-based emissions detection systems.

Case study 4
Tank battery emission investigation

Receipt of notification

An operator received a notification from the United Nations Environment Programme's International Methane Emissions Observatory (UNEP IMEO) based on Sentinel-2 satellite data. The detection indicated a methane emission event at one of their facilities four months prior, with an estimated emission rate of 3750 kg/hr ± 1125 kg/hr. The notification included precise GPS coordinates and a plume outline overlain on visual imagery.

FIGURE 1. Plume image overlain on visual imagery provided by UNEP to the operator. Panel A shows the entire plume extent. Panel B zooms in on the area of the plume enhanced in methane and near the identified source of the plume (turquoise marker). Panel C shows only the visible imagery the possible source location (turquoise marker) without the plume overlay. Here the tanks are clearly visible and are the closest equipment to the detection. Visual imagery data from ESRI. Data points and plume images from UNEP.

Initial assessment and preliminary evaluation

The environmental team cross-referenced the provided coordinates with their asset database, transforming the coordinates to match their company's coordinate reference system for accurate comparison. The analysis confirmed the emission originated near their Facility #23. Visual examination of the satellite imagery revealed that the methane plume was likely originating from the tank battery on site, allowing the team to focus their investigation on this specific equipment group.

Source investigation and identification

Given the clear visual evidence from the imagery, the team focused their order of magnitude analysis on the tank system. They found that the methane emission rate was higher than anticipated given the expected methane gas produced from flashing during normal operations, but that other activities on site do occur where excess flow is routed through the tanks to capture any liquids. They reviewed historical third-party detection data and found no previous emission events at this location, suggesting this was an isolated occurrence.

The desktop analysis proved particularly valuable. The environmental team identified that the tank battery was a controlled system with continuous pressure monitoring. Initially, they found a significant pressure drop lasting approximately three hours on the detection date, followed by pressure recovery. Operations logs revealed that the local team had been routing excess gas from a well pressure release during maintenance activities. However, the timing didn't initially match the satellite detection.

After internal discussion, the team realized they needed to convert their process monitoring data from local time to UTC to match the detection timestamp. Once properly aligned, the operational data correlated with the satellite observation, providing a clear explanation for the emission event.

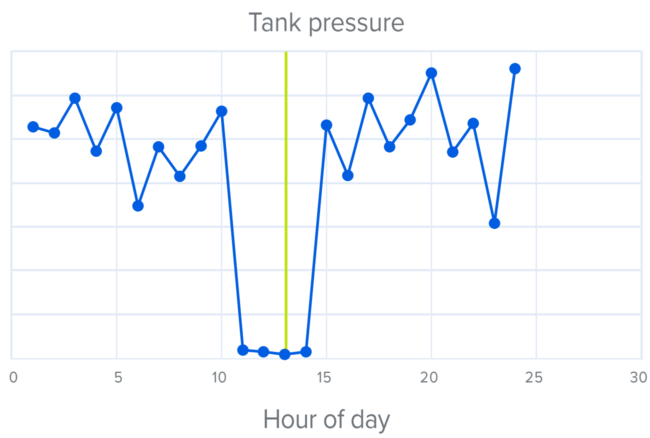

FIGURE 2. Time series of tank pressure measurements (blue) showing the period of depressurization due to a maintenance event. The green line represents the time of the satellite detection, which occurred during the maintenance event.

The environmental team contacted operations and reviewed the notification and desktop analysis results. Operations personnel verified that the desktop analysis was feasible, and noted that they typically open tank thief hatches to manage excess gas from well unloading operations, then closed them afterward.

Corrective action and verification

Since the emission resulted from planned operational activities rather than equipment malfunction, no repairs were required. However, operations conducted a visual inspection of the tank system to confirm all hatches and pressure relief devices were properly sealed.

Response and documentation

The investigation was documented following company procedures for internal records and regulatory compliance. The operator responded to UNEP IMEO, explaining that the emission was a short-duration event related to routine maintenance activities.

Continuous improvement and learning integration

The team conducted an evaluation of their operational practices. While the emission resulted from legitimate maintenance activities, they identified opportunities for improvement. The challenge arose when routing excess gas from well unloading into the tank system, which, combined with opening the thief hatch, led excess emissions.

Working collaboratively, the operations and environmental teams developed alternative work practices using a portable truck-based capture system for high-volume, short-duration releases. This solution allows them to manage similar maintenance events without exceeding local system capacity, effectively eliminating future emissions that might be detected by satellite monitoring.

The new approach is in testing within a business unit for similar maintenance activities and will be rolled out to the broader company if successful. The operator shared this experience with industry peers at environmental professional meetings, contributing valuable insights about operational best practices and the integration of satellite monitoring data into routine operations management.

Case study 5
Compressor engine exhaust

Receipt of notification

A natural gas operator received notification from a commercial satellite provider regarding a methane emission event detected at one of their facilities. The satellite data indicated an emission rate of 136 kg/hr ± 35 kg/hr occurring three weeks prior to the notification and contained latitude/longitude coordinates. The provider included plume imagery overlain on visible imagery showing concentrated emissions over the facility area.

Initial assessment and preliminary evaluation

The operator's environmental team compared the emission location coordinates against their asset inventory, confirming the detection corresponded to an active compressor station. Analysis of the satellite imagery revealed the methane plume was concentrated over the site but lacked a distinct point source, suggesting the emissions were not obviously originating from a single source.

FIGURE 1. Plume image overlain on visual imagery provided by the commercial satellite provider to the operator. Panel A shows the entire plume extent. Panel B zooms in on the area of the plume enhanced in methane and near the identified source of the plume (turquoise marker). Panel C shows only the visible imagery the possible source location (turquoise marker) without the plume overlay. Here no specific source is the obvious origin of the plume. Visual imagery data from ESRI. Plume images and data points from Carbon Mapper.

Source investigation and identification

The environmental team conducted an order of magnitude analysis to evaluate possible sources. They systematically evaluated potential emission sources capable of producing methane at rates between 100-170 kg/hr, accounting for measurement uncertainty. Sources expected to emit below 100 kg/hr, such as valve leaks and low-volume vent stacks, were eliminated from consideration. The analysis showed that combined expected methane emissions from the natural gas engines driving the compressors could account for the observed emission rate.

The team verified that the station was operational at the time of the observation. Maintenance records indicated the engines were operating normally during the detection period.

Additionally, the team examined historical satellite data for the facility and found four additional emission events at the same location with similar emission rates. This pattern was consistent with the emissions originating from engine exhaust, which is a persistent and relatively stable source.

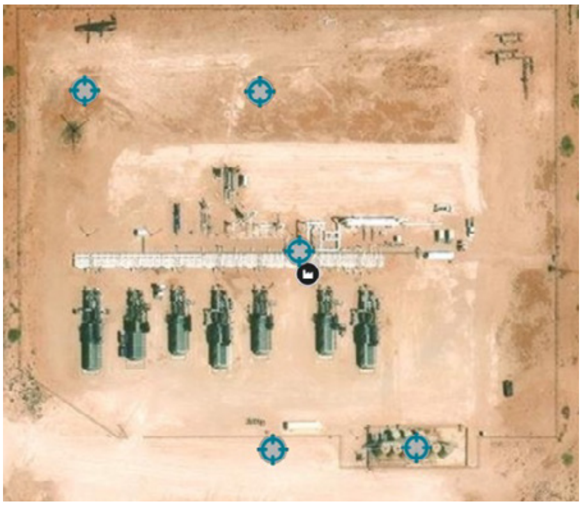

FIGURE 2. Third party methane detections at the facility in question over the past 6-months. Turquoise markers indicate locations identified by the third party as near the source of the emission events. Visual imagery data from ESRI. Data points from Carbon Mapper and UNEP.

Corrective action and verification

Since the investigation determined that emissions resulted from routine operation of natural gas engines within manufacturer specifications, no immediate corrective actions or repairs were required. The engines were functioning as designed, and emission rates were consistent with normal operational parameters.

Given the source identification and normal operating status, no repair verification activities were deemed necessary.

Response and documentation

The operator prepared comprehensive internal documentation summarizing the investigation process and findings in accordance with company requirements. This documentation provided a detailed record for future reference and regulatory compliance purposes.

The company also responded to the commercial satellite provider, communicating that the detected emissions represented normal operating conditions at the facility.

Continuous improvement and learning integration

This investigation highlighted the significance of compressor engine exhaust emissions in the company's overall methane emissions profile. The company actively participated in an industry work group focused on compressor-driver emissions, contributing their operational experience while learning about emerging technologies. The work group facilitated knowledge sharing about new driver technologies and retrofit solutions designed to reduce methane slip from natural gas engines.

Through industry collaboration, the operator identified potential retrofit kits that could be installed during routine engine rebuilds, demonstrating their commitment to continuous improvement and emission reduction where technically and economically feasible.

Appendix

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Appendix
Example field investigation protocol

Safety is the highest priority

- **Strictly follow all site-specific safety procedures** including permit requirements, gas monitoring, and emergency response protocols.
- **Ensure proper personal protective equipment** appropriate for potential gas exposure and concentration levels (paying particular attention to hazardous compounds such as H2S, benzene, etc…)
- **Maintain constant awareness** of gas concentration limits, explosion hazards, ignition sources, and emergency evacuation procedures.

Investigation suggestions

I. AUDIO, VISUAL AND OLFACTORY ASSESSMENT

- **Listen carefully** for characteristic sounds of high-pressure gas release including hissing or whistling sounds that may indicate leakage. Keep in mind the release rate reported for this event and focus on equipment that may have rates of similar magnitude.
- **Conduct visual inspection** at each suspected atmospheric vent, pipe outlet, and potential emission point focusing on:
  - **Atmospheric disturbance indicators** such as shimmering air or heat waves that indicate gas flow.
  - **Temperature-related evidence** including frost formation on valves indicating expansion of cooling from gas leakage.
  - **Liquid accumulation patterns** including mist, condensation, or hydrocarbon liquids near outlet points.
  - **Environmental impact indicators** such as disturbed soil, dead or stressed vegetation, soot deposits, or unusual ground conditions
- **Document any smells** that indicate abnormal emissions.

II. TEMPERATURE DIFFERENTIAL MEASUREMENTS

For each atmospheric outlet pipe and potential emission point:

- **Trace piping systems** back to identify the first upstream isolation or control valve.
- **Measure temperatures** upstream and downstream of valves and look for any ice buildup. Downstream temperatures that are significantly lower indicate gas expansion and potential leakage through valves.
- **Document temperature readings** with location, time, and equipment identification for future reference.

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Gas leak detection and verification (if equipment is available)

- **If safe access exists,** begin testing at safe distance using calibrated lower explosive limit (LEL) meter or equivalent gas detection equipment if available.
- **Approach systematically** moving progressively closer (one-foot intervals, then six-inch intervals) only if no gas concentration alarms occur.
- **If no alarm activation occurs at six-inch distance,** conclude that no leak contributing to satellite detection exists at that specific location.

Equipment-specific investigation suggestions

- **Flare systems:** Verify whether flares are lit. Verify pilot light status. If flare is assisted, evaluate the air fuel ratio is appropriate given flow and expected BTU content.
- **Storage tank systems:** Examine pressure relief devices for proper operation, inspect thief hatches and atmospheric vents, evaluate liquid level management systems, and check tank pressure conditions. Examine overall tank integrity.
- **Compressor systems:** Listen for engine misfiring or irregular operation, inspect spark plug and ignition systems, examine exhaust systems for proper operation, and evaluate overall mechanical condition. Investigate all seals for signs of wear or degradation.
- **Valve systems:** Inspect bypass, pressure safety, control and isolation valves.

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