FY 2026 - 2027

Project Number: 26-029

Title: **Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas**

Institution(s) Represented: The University of Texas at Austin (PI: Pawel K Misztal; co-PIs: Lea Hildebrandt Ruiz, Munkhbayar Baasandorj), Texas A&M University (co-PI: Yue Zhang), University of Colorado Boulder / NOAA CSL (co-PI: Nathan Malarich)

Lead PI: Pawel K Misztal

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Awarded Amount: $299,999.00

Abstract

The Houston-Galveston-Brazoria, and Dallas-Fort Worth nonattainment areas face a July 2027 attainment deadline under the 2008 ozone National Ambient Air Quality Standards (NAAQS), with the recently adopted Section 185 penalty fee program contingent on that outcome. San Antonio is in serious nonattainment for the 2015 ozone NAAQS, with an attainment date of September 24, 2027. Accurate volatile organic compound (VOC) emission inventories are essential for the photochemical modeling that underpins the Texas Commission on Environmental Quality (TCEQ) State Implementation Plan (SIP) development. However, everyday consumer and commercial products such as paints, cleaning supplies, personal care products, and adhesives, collectively known as volatile chemical products (VCPs), now constitute approximately half of VOC emissions in cities, yet remain underrepresented in current emission inventories.

Project 26-029 will deploy two all-electric mobile laboratories from the University of Texas at Austin and Texas A&M University to measure a broad range of VOCs and VCP tracers across three Texas regions: Houston-Beaumont-Port Arthur, Dallas-Fort Worth, and Austin-San Antonio. Ground-based measurements will be coordinated with the National Oceanic and Atmospheric Administration (NOAA) Texas Air Quality Study 2026 (TexAQS 2026) airborne campaign. The combined ground and airborne data will be used to compare field-measured emissions against existing inventories through mass-balance approaches. Source apportionment analysis will quantify VCP contributions to total VOC emissions and ozone formation potential across the three regions.

The proposed work directly addresses TCEQ priorities for improved emission inventories in nonattainment areas and will deliver Texas-specific VCP source profiles, inventory comparison reports with improvement recommendations, and ozone formation potential assessments to support air quality management strategies.

Quality Assurance Project Plan

Project 26-029

Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas

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The University of Texas at Austin has prepared this QAPP following the Environmental Protection Agency (EPA) guidelines for a Quality Assurance (QA) Category III Project: Requirement for Measurement and Model Application Projects. It is submitted to the Texas Air Quality Research Program (AQRP) as required in the Work Plan requirements.

QAPP Requirements: This QAPP requires descriptions of project description and objectives; organization and responsibilities; scientific approach; sampling and measurements procedures; emission inventory assessment methodology; quality metrics; data analysis, interpretation, and management; reporting; and references.

QA Requirements:

Technical Systems Audits - Not Required for the Project

Audits of Data Quality - 10% Required

Report of Findings - Required in Final Report

April 8, 2026

Revision: 1

Approvals Sheet

This document is a Category III Quality Assurance Project Plan for the *Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas* project. The Principal Investigator for the project is Pawel K Misztal and Co-PIs are Lea Hildebrandt Ruiz, Munkhbayar Baasandorj, Yue Zhang, and Nathan Malarich.

Electronic Approvals

This QAPP was approved electronically on 2026-05-04 | 14:21:13 CDT

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1. PROJECT DESCRIPTION AND OBJECTIVES

1.1 Process and/or environmental system to be evaluated

Urban volatile organic compound (VOC) emissions have undergone a fundamental transformation over the past two decades. While transportation-related emissions have declined substantially due to regulatory controls, volatile chemical products (VCPs), including personal care products, cleaning agents, paints, coatings, adhesives, and pesticides, now constitute approximately half of VOC emissions in industrialized cities (McDonald et al., 2018). This paradigm shift has profound implications for ozone formation and air quality management in Texas, where current emission inventories inadequately represent VCP sources and their spatial and temporal variability.

The Texas Commission on Environmental Quality (TCEQ) relies on accurate, spatially-resolved emission inventories for ozone attainment demonstration modeling using the Comprehensive Air Quality Model with Extensions (CAMx), permit reviews, rulemaking, and reporting to the U.S. Environmental Protection Agency (EPA). TCEQ uses the emissions inventory to plan pollution control programs, promote compliance with laws and regulations, conduct permit reviews, develop airshed modeling and rulemaking activities, and supply required data to EPA. Persistent discrepancies between measured and inventoried VOC emissions have been documented across two decades of Texas Air Quality Studies (TexAQS). TexAQS 2000 first revealed that industrial highly reactive VOC (HRVOC) emissions were underestimated by one to two orders of magnitude, and TexAQS 2006 confirmed that significant underestimates persisted despite inventory improvements.

With the Houston-Galveston-Brazoria (HGB) and Dallas-Fort Worth (DFW) nonattainment areas classified as severe under the 2008 ozone National Ambient Air Quality Standards (NAAQS), with a July 2027 attainment deadline, and with the recently adopted Section 185 penalty fee program contingent on that outcome, the accuracy of emission inventories used in TCEQ's photochemical modeling carries direct regulatory and financial consequences. For area sources such as VCPs, TCEQ currently employs a top-down approach that distributes county-level emission totals spatially using surrogates such as population density, with estimates relying heavily on product sales data and assumed emission factors rather than direct atmospheric measurements.

Additionally, nontraditional sources such as asphalt-related emissions have emerged as significant contributors to secondary organic aerosol (SOA) precursors, with annual emissions potentially exceeding those from motor vehicles on urban scales (Khare et al., 2020). Understanding these diverse VOC sources is essential for developing effective ozone control strategies, particularly given the spatial heterogeneity of photochemical regimes across Texas urban areas.

1.2 Purpose of the project and objectives

The overarching goal of this project is to provide TCEQ with measurement-based constraints on VOC emission inventories and to quantify VCP contributions to total VOC emissions across major Texas urban areas. The project deploys two state-of-the-art electric mobile laboratories from UT Austin and Texas A&M University, coordinated with the planned National Oceanic and Atmospheric Administration (NOAA) TexAQS 2026 airborne campaign, to characterize VOC and VCP emissions in three Texas regions: the Houston-Galveston-Beaumont-Port Arthur industrial corridor, the Dallas-Fort Worth metroplex, and the Austin-San Antonio corridor.

The following research areas guide the execution of the proposed work:

R1: Quantify VCP contributions to total VOC emissions across Texas urban environments and assess spatial/temporal variability using molecular tracers measured by mobile Vocus Chemical Ionization Mass Spectrometry (Vocus CIMS) platforms.

R2: Develop comprehensive emission source profiles for VCP categories specific to Texas conditions, accounting for the enhanced volatilization expected in warmer climates.

R3: Assess VCP impacts on ozone formation potential across VOC-limited and NOx-limited regimes characteristic of Texas urban and suburban areas.

R4: Systematically compare field-measured emissions with existing emission inventories to identify gaps and inform inventory improvements for VCP sources.

1.3 Task Descriptions

Task 1: Campaign Planning and Coordination.

Meetings will be held with TCEQ staff and the NOAA TexAQS 2026 planning team to develop detailed measurement protocols. Coordination activities will include establishing data sharing agreements with airborne campaign investigators, finalizing target site selection based on current inventory data and preliminary receptor modeling, and identifying optimal stationary measurement locations within each target region. The UT and Texas A&M teams have experience in collaborative field measurements in SE Texas as part of an Inter-Integrated Field Laboratories campaign in Fall 2025. This task also includes coordinating with collaborators at UT Arlington and UT Dallas for stationary site access near Dallas, and Texas A&M University in San Antonio. We plan to conduct mobile sampling jointly 4-5 days in each city (depending on aircraft schedule), including Dallas, San Antonio, and Houston, with one mobile lab driving from upwind to downwind, and another mobile lab driving in the opposite direction to capture the full upwind-downwind profile. During the evening of the mobile sampling days, the mobile lab will be parked overnight for stationary sampling. The other 2-3 days of each week will be used for routine instrument calibrations, cross comparisons of other Airborne and Remote sensing Multi

Air Pollutant Surveys (AiRMAPS) sampling tasks, additional make-up days, and commute between each city.

Task 2: Emission Inventory Compilation and Assessment Framework.

Spatially-resolved emission inventories for target regions will be compiled from the EPA National Emissions Inventory (NEI), TCEQ's point source database (STARS) and Texas Air Emissions Repository (TexAER), and sector-specific sources including NOAA's Greenhouse gas And Air Pollutant Emissions System (GRA^2PES) inventory, which provides aggregated emissions of over 100 species at 4 x 4 km resolution. A mass-balance methodology framework will be developed for comparing measured and inventoried emissions. Protocols for integrating Doppler lidar wind profiles with surface and airborne concentration measurements will be established to enable flux quantification from individual source sectors. Co-PI Malarich will lead this task.

Task 3: Intensive Measurement Campaigns across Three Texas Regions.

Two independent mobile laboratories (UT Austin and Texas A&M) will be deployed for intensive observation periods in the three target regions for approximately one week in each region. Measurements will include systematic transects across urban-suburban gradients, targeted sampling near identified VCP source areas, and coordinated measurements with available airborne platforms during overflight periods. Both mobile laboratories will sample in the same city during the same period but from two opposite directions, maximizing sampling efficiency while providing upwind/downwind chemical evolution data.

Task 4: Source Apportionment Analysis.

Positive matrix factorization (PMF) and chemical mass balance (CMB) techniques will be applied to apportion measured VOCs to source categories. Texas-specific VCP source profiles will be developed using tracer ratios and temporal patterns. Positive matrix factorization was selected as the primary apportionment method because it is well established for high-dimensional real-time mass spectrometry datasets, has been successfully applied to mobile Vocus CIMS measurements of VCP emissions in prior Texas and U.S. campaigns (Dodero et al., 2025; Coggon et al., 2021; Gkatzelis et al., 2021), and supports constrained solutions (ME-2) that allow integration of independent tracer information to anchor poorly resolved factors. Chemical mass balance will serve as a complementary cross-check for source categories with well-defined emission profiles. Texas-specific VCP source profiles will be developed using tracer ratios and temporal patterns. VCP molecular tracers including D5-siloxane, para-dichlorobenzene, p-chlorobenzotrifluoride (PCBTF), Texanol, and glycol ethers will be used to identify and quantify VCP source contributions.

Task 5: Ozone Formation Potential Assessment and Inventory Comparison.

Incremental reactivity-weighted ozone formation potential will be calculated for measured VOC mixtures using maximum incremental reactivity (MIR) values. A systematic comparison of field-measured emissions with existing inventory estimates will be completed using Doppler lidar-derived wind profiles and mixing heights combined with concentration measurements to constrain emission fluxes through mass-balance approaches.

Task 6: Synthesis and Reporting.

Findings will be synthesized into comprehensive reports for TCEQ with recommendations for emission inventory improvements and control strategy development. Results will be prepared for peer-reviewed publications and presented at scientific conferences and stakeholder meetings.

2. ORGANIZATION AND RESPONSIBILITIES

2.1 Project Personnel

This project is being conducted by UT Austin in collaboration with Texas A&M University and the University of Colorado Boulder / NOAA Chemical Sciences Laboratory, under a grant from the Texas Air Quality Research Program. The project Principal Investigator is Dr. Pawel Misztal and the Co-Principal Investigators are Drs. Lea Hildebrandt Ruiz and Munkhbayar Baasandorj (UT Austin), Dr. Yue Zhang (Texas A&M), and Dr. Nathan Malarich (CU Boulder/NOAA CSL). The project will be overseen by AQRP Project Manager and TCEQ Project Liaisons.

Dr. Pawel K Misztal is an Associate Professor (Cockrell Family Fellow) at UT Austin and will be the Principal Investigator. He has more than 15 years of experience studying chemical composition of air using advanced mass spectrometry techniques. He will oversee project coordination, UT Austin mobile measurements in the Houston-BPA, San Antonio-Austin, and Dallas-Fort Worth regions, and data synthesis.

Dr. Lea Hildebrandt Ruiz is an Associate Professor at UT Austin (Professor effective August 15) and will be a Co-Principal Investigator. Her research expertise lies in air quality and atmospheric chemistry with extensive experience in PMF-based source apportionment. She and her group will contribute to mobile measurements and chemical analysis.

Dr. Yue Zhang is an Assistant Professor at Texas A&M University and NSF CAREER Award recipient. He leads the Rapid Onsite Atmospheric Measurement Van (ROAM-V) mobile laboratory equipped with Vocus 2R CIMS. He will lead the Texas A&M mobile laboratory deployment and associated VOC measurements in the Houston-BPA, San Antonio-Austin, and Dallas-Fort Worth regions.

Dr. Nathan Malarich is a Research Scientist in the Atmospheric Remote Sensing group at NOAA Chemical Sciences Laboratory, affiliated with CU Boulder CIRES. He specializes in Doppler lidar aircraft measurements for wind profiling and airborne mass-balance methods. He will lead emission inventory comparison and assessment, coordinate airborne measurement integration, and develop mass-balance emission quantification methodologies.

Dr. Munkhbayar Baasandorj is a Research Associate at UT Austin with expertise in VOC measurements, source apportionment, and air quality studies. As a lead QAPP person in possible consultation with QAPP managers David Sullivan and Mark Muldoon, she will contribute to data quality assurance and integration, in-depth data analysis including trending and ozone formation potential calculations.

2.2 Project Schedule including main milestones

The project start date is assumed to be May 1, 2026. Technical work will not begin until authorization is received from TCEQ and AQRP. The entire project will be completed by August 31, 2027. The intensive measurement campaigns (Task 3) are planned for May and June 2026, coordinated with the NOAA TexAQS 2026 airborne campaign. The Draft Final Report will be submitted by April 30, 2027 and the Final Report by May 31, 2027, allowing approximately three months for AQRP and TCEQ review prior to project close.

UT Austin will prepare and submit monthly technical progress reports on the 10th of the month (or following business day) as well as quarterly reports. Deliverables for this project include a draft final report and final project report documenting all work from Tasks 1 through 6, and a project summary presentation to AQRP. AQRP will receive an electronic copy of all data generated for this project. Further timeline is included in the Scope of Work document.

3. SCIENTIFIC APPROACH

3.1 Experimental Design

The project deploys two complementary electric mobile laboratories to conduct intensive field campaigns across three Texas urban regions, coordinated with the NOAA TexAQS 2026 airborne campaign. The measurement strategy combines survey drives to identify emission hotspots with focused transects to characterize specific source areas. Both mobile laboratories operate simultaneously in the same region, driving from opposite directions to maximize spatial coverage and provide upwind/downwind chemical evolution data.

3.2 Measurement Approach

UT Austin Mobile Laboratory: The UT electric Ford E-Transit mobile lab van has a substantial battery-based power supply allowing approximately 6-8 hours of uninterrupted mobile measurements per charge. It is equipped with a Vocus 2R CIMS capable of measuring hundreds of VOC species at sub-second time resolution with detection limits in the low parts-per-trillion range, and supporting instruments for criteria pollutants and meteorological parameters. The electric vehicle platform eliminates self-sampling artifacts from exhaust emissions.

Texas A&M ROAM-V Mobile Laboratory: The ROAM-V electrical-powered mobile laboratory is equipped with Vocus 2R CIMS providing complementary chemical ionization capabilities for oxygenated and functionalized compounds. The laboratory includes a NOx/O3 analyzers, a scanning electric mobility particle sizer (SMPS), and a LI-840 CO2 analyzer. The Texas A&M University (TAMU) Vocus CIMS will be used in NO+ ionization mode to capture both oxygenated VOCs and alkane/alkene species.

Survey drives will be conducted by two laboratories within a 50-mile radius of each base target area. We will avoid the major highways and use service roads and residential roads. We will repeat the same route in each city 20 times to provide averaged concentration along the route. Focused tracks around identified hotspots, near major pollution sources, and community receptor sites will be performed in synchronization with TexAQS 2026 flights. During no-flight days, mobile labs will complement focused tracks at times of shallow PBL in early morning, during well-mixed conditions, and nocturnally.

Stationary measurement: The two mobile laboratories will also park overnight at one upwind and one downwind location to provide overnight stationary data. The HR-TOF-AMS instruments will be deployed at stationary sites in Houston to provide continuous aerosol composition at two different locations. The NOAA aircraft will perform up and down spiral at the Houston stationary site to complement the stationary ground measurements. The data used in both stationary and mobile sampling can be served as input for hybrid PMF.

3.3 Emission Inventory Assessment Approach

The emission inventory assessment will be led by Co-PI Malarich (CU Boulder/NOAA CSL) and will use Doppler lidar-derived wind profiles and mixing heights combined with mobile and airborne concentration measurements to constrain emission fluxes through mass-balance approaches. Measured emissions will be compared against the GRA^{2}PES inventory and TCEQ's existing databases (STARS and TexAER) through forward and inverse modeling techniques or direct flux estimation comparisons. The assessment will draw on previous NOAA TexAQS campaigns from 2000 and 2006 for cross-comparison with newly measured emissions. Results will be structured to integrate with TCEQ's existing inventory tools and photochemical modeling workflow.

4. MEASUREMENT PROCEDURES

4.1 Methods Used

Table 4.1 summarizes the instruments used for gas- and particle-phase measurements deployed across both mobile laboratories.

Table 4.1. Instrument payloads of the UT Austin and Texas A&M electric mobile laboratories. Some instruments will be deployed at a stationary site (S).

Instrument	Compounds/Parameters	Resolution	UT	A&M
Vocus 2R CIMS (Aerodyne)	Broad range of VOCs, oxygenated VOCs (<1 ppt to 1 ppm)	1 s	X	X
HR-TOF-AMS (Aerodyne)	Non-refractory PM1 (UT) and PM2.5 (A&M)	5-60 s	S	S
Picarro G2307	CH4, HCHO, H2O	1 s	X/S	
Modulair GAS+PM (QuantAQ)	NO2/NO/NOx, CO, O3	5 s	X	X
Thermo 49i	Ozone (O3)	1 s	X	
Thermo 450i	H2S, SO2	80 s	X	
Thermo 42iQ	NO-NO2-NOx	5 s		X
TSI Scanning Mobility Particle Sizer (SMPS)	Particle size distribution	15 s		X
LICOR LI-840	CO2, H2O	1 s	X	X
MAGEE AE33 Aethalometer	Black Carbon	1 s	X	
Davis sonic anemometer	Temperature, wind direction, wind speed	5 s	X	X
Range finder	Distance and height of sources	manual	X	
HOBO(R) MX1101	Relative humidity, temperature	1 s	X	
GPS and dashcam	lat/lon/velocity	1 s	X	X

X- mobile; S – Stationary deployment.

4.2 Detailed Instrument Descriptions

Vocus 2R Chemical Ionization Time of Flight Mass Spectrometer (Vocus CIMS-TOF-MS or Vocus CIMS): The state-of-the-art Vocus 2R CIMS is used to monitor the real-time composition of the full VOC spectrum detectable by H_3O^+ or NO^+ ionization. The Vocus 2R is ultrasensitive to volatile and semivolatile compounds, owing to a highly

efficient design of the ion-molecule resistive glass drift-tube reactor which can be heated up to 150 °C. With sub-ppt (<10^{-12}) detection limits, Vocus can detect and quantify thousands of individual VOC and semivolatile VOC (SVOC) ions in the ambient air at high mass and time resolution (mass resolution >15,000 m/dm, time resolution <1 s). At these detection limits, the Vocus CIMS can quantify about 100 times more chemicals in the air than previous generation PTR-ToF and conventional gas chromatography instruments. The high absolute humidity in the reaction cell (>15% H_2O by volume) for both the NO^+ and H_3O^+ reagent ions means that changes in sample air humidity lead to comparatively small humidity changes in the reactor, greatly simplifying quantification. Both the UT Austin and Texas A&M laboratories are equipped with Vocus 2R instruments. The Texas A&M instrument will operate in NO^+ ionization modes each for approximately 4-5 days per region to capture many of the same VOCs measured by H_3O^+ but complement certain alkane/alkene and PFAS species that cannot be easily detected in the H_3O^+ mode. This way a large fraction of VOCs measured by the two modes and independently calibrated can be directly compared while the complementary value of both modes will expand the detectable set of compounds.

High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS): The HR-AMS, manufactured by Aerodyne, Inc., quantitatively measures the size-resolved chemical composition of fine particles at high mass and time resolution. After entering the inlet, particles are focused on an aerodynamic lens, pass through the particle time-of-flight region for sizing, and are vaporized by a heated oven (at 600 °C) for detection of non-refractory components. The vaporized components are ionized by electron ionization and detected by the time-of-flight mass spectrometer. The instrument measures bulk composition including organics, sulfate, ammonium, nitrate, and chloride, and provides mass spectra from which O:C and H:C ratios can be calculated.

Other Instruments: In addition, we also install QuantAQ Modulair multipollutant monitors and Davis sonic anemometers for wind measurements on the mobile lab. All instruments are mounted in the electric mobile lab platforms with GPS and dashcam for continuous position tracking. Other supporting instrumentation includes Picarro cavity ring-down spectroscopy analyzers for CH4 and HCHO, Thermo chemiluminescence analyzers for NOx and SO2, Thermo UV photometric ozone analyzers. We will also have access to the data collected from the stationary sites in Houston during the TexAQS campaign, including the LI-COR non-dispersive infrared CO2 analyzers, Magee Scientific AE33 aethalometers for black carbon, TSI scanning mobility particle sizers (SMPS), QuantAQ Modulair multipollutant monitors, and Davis sonic anemometers for wind measurements.

4.3 Calibration Procedures

Vocus CIMS Calibration: The UT Austin and TAMU Vocus CIMS instruments will use consistent calibration methods. These state-of-the-science mass spectrometers directly measure analyte concentrations in counts per second (CPS), which are translated into concentration values (ppbv) through calibration and the knowledge of the ion collisional kinetics. The primary methods used are explicit calibration with gas-phase standards in a calibration cylinder and estimated calibration with proton transfer rate coefficients for remaining compounds. In the case of NO^+ ionization, explicit calibration can be complemented by the fits with respective coefficients for charge transfer, hydride abstraction and associate complex mechanisms. These different mechanisms complement H3O+ ionization in ability to separate certain isomers such as ketones from aldehydes. Calibration gas cylinders cover VOCs with a range of chemical structures. A plot of calibrant proton transfer rate versus Vocus sensitivity is constructed for each calibrant analyzed from the gas calibration cylinder, and the slope value is used to estimate concentrations of other analytes based on their proton transfer reaction rate constant (*k_ptr*). Small VOCs in the mass-to-charge (*m/z*) range below 60 Thompson (Th) are additionally corrected for the sigmoidal transmission attenuation of the big segmented quadrupole (BSQ) which acts as a low mass pass filter. The Vocus instruments will be calibrated before and after each mobile measurement drive or at least daily during stationary periods. Compounds of interest will be explicitly calibrated; remaining compounds will use proton transfer reaction theory or in the case of NO+, the ionization theory for respective ionization mechanisms (electron transfer, hydride abstraction and association complex).

HR-TOF-AMS Calibration: The ionization efficiency (IE) of nitrate and the relative ionization efficiencies (RIE) of sulfate and ammonium will be calibrated every 1-2 weeks, and at minimum at the beginning and end of each measurement campaign. Ammonium sulfate and ammonium nitrate particles are generated using an aerosol generation system; a differential mobility analyzer (DMA) size-selects 300 nm particles supplied to the HR-AMS and a condensation particle counter (CPC). For organics, an RIE of 1.4 is used as recommended by the manufacturer.

Other Instrument Calibrations: SMPS particle sizing will be confirmed using polystyrene latex spheres per manufacturer procedures. The Thermo NOx analyzers and ozone analyzers will be calibrated using certified reference gases before and during each campaign period. The Picarro will be calibrated using certified CH4 and HCHO standards. Other instruments will be regularly calibrated according to Standard Operating Procedures (SOPs) established in the Misztal, Hildebrandt Ruiz, and Zhang laboratories.

5. EMISSION INVENTORY ASSESSMENT PROCEDURES

5.1 Inventory Data Sources

The emission inventory assessment will compile and compare data from multiple sources to evaluate the accuracy of current inventories for the target regions. Primary data sources include: the EPA National Emissions Inventory (NEI), TCEQ's point source database (State of Texas Air Reporting System, STARS), the Texas Air Emissions Repository (TexAER) for area and non-point sources, and NOAA's Greenhouse gas And Air Pollutant Emissions System (GRA^2PES) inventory providing aggregated emissions of over 100 species at 4x4 km spatial resolution.

5.2 Mass-Balance Emission Quantification Methodology

Co-PI Malarich (CU Boulder / NOAA CSL) will lead the mass-balance emission quantification, which will follow two complementary approaches: an airborne mass-balance approach using NOAA TexAQS 2026 aircraft transects, and a ground-based upwind/downwind approach using the two mobile laboratories.

Airborne mass-balance approach. When NOAA aircraft are deployed during the campaign window, mass-balance fluxes will be derived from east-west aircraft transects spaced approximately 20 km apart. For specific industrial sources, the aircraft will provide background concentration measurements on the upwind transect as well as on either side of the downwind transect, allowing isolation of the plume contribution from the regional background. An airborne Vocus CIMS will provide concentration measurements of VCPs and other VOCs at 1-10 Hz time resolution. An airborne Doppler wind lidar will provide horizontal wind speed and mixing height profiles, which together with the airborne concentration data are used to calculate emission fluxes. Alkene emissions from specific industrial sources will be estimated from Whole Air Sampler measurements collected downwind of the source, using cavity ring-down measurements of NOx and formaldehyde as plume tracers, following the methodology of Wert et al. (2003).

Ground-based mass-balance approach. During and outside aircraft deployment days, the two mobile laboratories will collect concurrent upwind and downwind measurements along driving transects designed to bracket urban source areas. Concentration enhancements between the upwind and downwind tracks, combined with wind and boundary-layer information, will be used to estimate emission fluxes. When upper-air data are available from aircraft profiles or from the planned ozone lidar at the University of Houston site, vertical concentration structure will be incorporated directly into the flux calculation. When upper-air data are not available, the analysis will assume that emitted plumes are vertically well mixed within the boundary layer, and the uncertainty associated with this assumption will be propagated through the flux calculation. This assumption is reasonable when the drive track is located approximately 15 minutes of air-parcel time

downwind of the source, which is sufficient time for vertical mixing within a convective boundary layer.

Supplementary meteorological data. Boundary-layer height will be measured continuously by a micropulsed lidar at the University of Houston. The University of Houston site will also host an ozone lidar and a Doppler wind lidar to support both upper-air ozone profiling and horizontal wind characterization, in coordination with the NOAA TexAQS 2026 campaign. On NOAA flight days, an airborne Doppler wind lidar will provide horizontal wind and mixing height profiles across the entire metropolitan area following a raster pattern. When no airborne data are available, urban winds and boundary-layer heights will be drawn from High-Resolution Rapid Refresh HRRR reanalysis, which assimilates publicly available National Weather Service surface stations. Surface meteorology will be measured continuously on each mobile laboratory using Davis sonic anemometers.

5.3 Inventory Comparison Framework

Measured emissions will be compared against the GRA^{2}PES inventory and TCEQ databases (STARS and TexAER) through forward and inverse modeling techniques or direct flux estimation comparisons. Particular attention will be given to two inventory domains: (1) area sources including VCPs, where TCEQ employs top-down county-level estimates distributed using spatial surrogates such as population density, and (2) industrial point sources, where the mass-balance framework allows assessment of reported emissions against measured fluxes.

Industrial point sources at refineries and chemical manufacturing facilities are spatially distributed across multiple emission release points within each facility, rather than co-located at a single stack. For the Houston-Galveston-Beaumont-Port Arthur corridor, the spatial extent of these distributed source areas is well within the 20 km spacing of the planned aircraft transects, so each facility complex can be enclosed within a single mass-balance domain and treated as an integrated area source. The Houston Ship Channel will be treated as a wider linearly extended source, and aircraft upwind and downwind transects will be oriented parallel to the channel to provide proper spatial coverage of the integrated emission flux.

The primary inventory baseline for the comparison will be the most recent gridded inventories used in TCEQ's photochemical modeling, including the EPA National Emissions Inventory (NEI 2017 and NEI 2020) and the gridded inventory inputs supporting TCEQ's State Implementation Plan modeling. Observational datasets from TexAQS 2000 and TexAQS 2006 will be retained as historical context for evaluating multi-decadal trends in measured-to-inventoried emission ratios but will not serve as the primary baseline. The resulting datasets and assessment methodology will be structured to integrate with TCEQ's existing inventory tools and photochemical modeling workflow,

providing actionable information for future SIP revisions and emissions processing updates.

5.4 Quality Assurance for Inventory Assessment

At least 10% of inventory data extracted from EPA and TCEQ databases, as well as the mass-balance calculations and emission flux derivations, will be independently reviewed as part of the Audits of Data Quality. Co-PI Malarich and PI Misztal will independently verify a subset of the emission quantification calculations. The resulting datasets and assessment methodology will be structured to integrate with TCEQ's existing inventory tools and photochemical modeling workflow, providing actionable information for future SIP revisions and emissions processing updates.

6. QUALITY METRICS

6.1 QC Checks for Measurements

Vocus 2R CIMS (UT Austin and Texas A&M): The UT Austin and TAMU Vocus CIMS instruments will be optimized and calibrated daily with common VOCs spanning a wide range of atmospherically relevant concentrations. The instruments will be run in two different ionizations (UT Austin in H_3O^+, and TAMU in NO^+) which are overlapping and complementary background checks will be performed regularly. Specifically, we will deploy both mobile laboratories at the TCEQ Clinton site to cross compare the VOC derived from the Auto-GC and ozone. We plan to park the mobile lab for about 3-5 hours during daytime at the Clinton site before May 26, the official campaign start date, to first validate the VOC and ozone concentration between the two mobile laboratories as well as the TCEQ site. During the mobile campaign in Houston, we will also design the mobile laboratory route to pass by the TCEQ Clinton site, and stay there for an hour for 1-2 times to co-sample VOC and ozone as an internal reference. At the end of the field sampling (June 15), the mobile laboratories will park at the Clinton site to sample jointly for 3-5 hours for cross comparison of Auto-GC and ozone data.

Quality control is performed at all stages of data acquisition and analysis. During mobile measurements, an embarkation checklist is used to verify SOPs and instrument functionality. Apart from calibrations before and after each drive, response time is derived at the inlet by an acetone spike test where a ppb-level acetone standard is introduced and the time to observe signal response is recorded. Leak tests are performed to ensure instruments are sampling ambient air. During measurements, signals are previewed in real time to immediately recognize potential issues.

The accuracy of measurements is reported at 10% for explicitly calibrated compounds and 30% for those derived from the fit of calibrated compounds and reaction rate coefficient. These uncertainties will be included in the reporting compound tables or in the associated text. The precision is generally better than 15% at 1s and can be further improved with averaging. We are aiming for more than 90% of data completeness. We will reduce downtime by closely monitoring the signal and instrument parameters along with the regular checks described above during the campaign.

HR-TOF-AMS: The instrument will be calibrated as described in Section 4.3. Quality of HR-AMS data will be assured by conducting regular IE and RIE calibrations and co-located measurements with complementary instrumentation (SMPS). Particle volume measurements from the SMPS will be compared to particle volume measurements from the HR-AMS (converted to volume using particle density). Operation of the instrument will be monitored for abnormalities to take immediate corrective action.

SMPS: Particle sizing will be confirmed using polystyrene latex spheres per manufacturer procedures. The plumbing delay between the DMA and CPC will be measured before

experiments begin. Sizing checks will be performed before and after each campaign period.

Other Instruments: Thermo analyzers, Picarro, LI-840, and Modulair will be calibrated per manufacturer specifications. Regular zero and span checks will be performed during the campaigns. All other instruments will be calibrated before the start of the field study and weekly thereafter.

6.2 Audits of Data Quality

The Quality Control Checks described above are part of the Audits of Data Quality that will be performed at the frequency indicated. At least 10% of all measurement data, emission inventory data extracted from databases, and mass-balance calculations will be independently reviewed. For the UT Austin measurements, Co-PI Hildebrandt Ruiz will independently review a subset of Vocus and AMS data. For the Texas A&M measurements, Co-PI Zhang will independently verify data quality. For the inventory assessment, Co-PI Malarich and PI Misztal will independently verify emission quantification calculations. Findings from all Audits of Data Quality will be included in the draft and final reports.

6.3 QC for Source Apportionment

PMF analysis will follow a structured calibration, verification, and evaluation workflow consistent with established practice for atmospheric mass spectrometry datasets.

Model calibration. The PMF input matrix will be calibrated by constructing an associated uncertainty matrix that combines instrument-specific Poisson counting error, calibration uncertainty, and a minimum uncertainty floor. Species with signal-to-noise ratios below 0.5 will be excluded as bad, and species with ratios between 0.5 and 2.0 will be downweighted as weak following standard practice. Below-detection-limit values will be replaced with one half of the detection limit and assigned an uncertainty equal to five sixths of the detection limit. The base PMF runs will target a Q/Qexpected ratio close to unity, indicating that the model residuals are consistent with the assigned uncertainties.

Model verification. Verification will confirm that the selected solution is mathematically valid and reproducible. Residual distributions will be examined for each species and time point to confirm they are approximately normal with mean near zero. Multiple PMF runs from random starting seeds will be performed to confirm convergence to the same solution. For each target region, at least 10 percent of the PMF input data matrix will be independently verified against the original instrument time series by a co-PI not involved in the initial data processing. Bootstrap analysis with at least 100 resampled runs will assess the statistical stability of the factor solutions.

Model evaluation. Solutions will be evaluated across a range of factor numbers, and rotational ambiguity will be examined using the Rotational Forcing Parameter (FPEAK).

Factor profiles will be compared against published reference spectra and known tracer ratios for VCP categories (Gkatzelis et al., 2021; Stockwell et al., 2021; Dodero et al., 2025). Where constrained PMF (ME-2) is applied, the sensitivity of results to the constraint strength (a-value) will be tested systematically. Source apportionment results from the UT Austin and Texas A&M datasets will be cross-compared for consistency during overlapping measurement periods. The diurnal profile of the PMF factors will be plotted, and the uncertainty range of these factors will be calculated based on the standard deviation of data from multiple days.

Model documentation. The PMF analyses in this project will follow the procedures and conventions described in the EPA PMF 5.0 User Guide (Norris et al., 2014) for unconstrained runs and in Paatero (1999) and Canonaco et al. (2013) for constrained ME-2 runs implemented through the SoFi Pro toolkit. Software versions and exact parameter settings used for each analysis will be reported in the corresponding monthly Technical Reports and the Final Report.

6.4 Collocation and Inter-Comparison Protocol

To support quality assurance of the mobile measurements and provide traceability to TCEQ regulatory monitoring, a structured collocation protocol will be implemented at the TCEQ Clinton Drive monitoring station in Houston. The Clinton site provides continuous Auto-GC speciated VOC measurements and ozone monitoring under TCEQ's existing quality system, making it the appropriate reference location for inter-comparison of the two mobile laboratories.

Pre-campaign collocation. Before the official campaign start date of May 26, 2026, both the UT Austin and Texas A&M mobile laboratories will be parked together at the Clinton site for an extended daytime period of approximately 3 to 5 hours. VOC speciation and ozone concentrations measured by the two Vocus CIMS instruments and supporting analyzers will be cross-validated against the Clinton Auto-GC and the Clinton ozone monitor during this period. This pre-campaign collocation establishes the reference baseline for instrument response and inter-platform agreement at the start of the campaign.

In-campaign collocation. During the Houston intensive observation period, mobile sampling routes will be designed to pass through the Clinton site on multiple occasions. The mobile laboratories will dwell at Clinton for approximately one hour on at least one to two occasions during the Houston deployment, providing periodic in-campaign reference comparisons of VOC speciation and ozone against the TCEQ Auto-GC.

Post-campaign collocation. At the conclusion of the Houston field sampling on June 15, 2026, both mobile laboratories will return to the Clinton site for a joint stationary deployment of approximately 3 to 5 hours. This post-campaign collocation closes the

Houston measurement record with a final inter-comparison against the TCEQ reference monitor and will be used to assess any calibration drift over the course of the campaign.

Data handling. All collocation data, including time-aligned VOC concentrations, ozone measurements, and instrument metadata, will be summarized in a dedicated collocation report and shared with TCEQ. The data will be used to validate instrument stability and sensitivity across the campaign, identify any calibration drift, and support uncertainty quantification for the source apportionment and inventory comparison analyses described in Sections 5 and 6 of this QAPP.

7. REPORTING

7.1 Deliverables from each Project Participant

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. PI Dr. Misztal will submit the reports but will be assisted by co-PIs and other project participants. All reports will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website will be followed.

Abstract: At the beginning of the project, an Abstract will be submitted to the Project Manager for use on the AQRP website. The Abstract will provide a brief description of planned project activities written for a non-technical audience. Due Date: Ten (10) business days after notice of intent to fund.

Quarterly Reports: The Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Word doc file, not exceeding 2 pages, text only. Due Dates: To be determined based on project start date.

Technical Reports: Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison as a Word doc using the AQRP MTR Template. Due Dates: Monthly, on the 10th of each month (or following business day).

Financial Status Reports: Financial Status Reports will be submitted monthly to the AQRP Grant Manager by each institution using the AQRP FSR Template. Due Dates: Monthly, on the 10th of each month (or following business day).

Draft Final Report: A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary and follow State of Texas accessibility requirements. Due Date: One month before project end.

Final Report: A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted. Due Date: Project end date.

Project Data: All project data including QA/QC measurement data, databases, source profiles, inventory comparison results, etc., will be submitted to the AQRP Project Manager within 30 days of project completion in a format allowing AQRP, TCEQ, or other outside parties to utilize the information.

AQRP Workshop: A representative from the project will present at the AQRP Workshop. The selected date will be updated.

Presentations and Publications: All data and other information developed under this project included in published papers, symposia, presentations, press releases, websites and/or other publications shall be submitted to the AQRP Project Manager and the TCEQ Liaison per the Publication/Publicity Guidelines included in the Subaward.

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Appendix A. Volatile Chemical Product Species Measured in this Project for Inventory Assessments

This appendix specifies the preliminary 21 individual volatile chemical product species that will be quantitatively measured by the two project Vocus CIMS instruments and identifies their representation in the GRA^{2}PES emission inventory used for the inventory comparison described in Section 5.3. The GRA^{2}PES inventory (NOAA CSL, version 1.1, October 2025; Lyu et al. 2025) provides gridded emissions of 67 speciated hydrocarbon classes at 4 km by 4 km resolution across the contiguous United States. The VCP component of GRA^{2}PES is built on the VCPy bottom-up framework (Seltzer et al. 2021) and the FIVE-VCP inventory (McDonald et al. 2018; Coggon et al. 2021). The species list below combines those explicitly tagged as VCP, OVCP, or siloxane in the GRA^{2}PES output table (rows 1 to 9), additional GRA^{2}PES species with substantial VCP attribution per the underlying VCPy speciation (rows 10 to 14), and individual VCP species lumped into broader GRA^{2}PES categories that will be measured at species-specific resolution by the project instruments to refine those lumped categories (rows 15 to 21). All species are within the calibrated detection range of the UT Austin Vocus CIMS operating in H_3O^+ ionization mode, with the Texas A&M Vocus CIMS operating in NO^+ ionization mode providing complementary coverage of alkanes and alkenes that include important VCP-derived solvents and ozone precursors not efficiently ionized in H_3O^+ mode. Calibrations will be performed before and after each mobile drive or at least daily during stationary periods, in accordance with the procedures specified in Section 6 of this QAPP.

Appendix Table A1. *Preliminary list of VCP species measured by Vocus CIMS for enhancements of TCEQ and GRA2PES inventories.*

#	Species	Formula	Primary VCP category	Source documentation
1	D5-siloxane (decamethylcyclopentasiloxane)	C10H30O5Si5	Personal care products	GRA2PES ReadMe; Gkatzelis et al. 2021
2	D4-siloxane (octamethylcyclotetrasiloxane)	C8H24O4Si4	Adhesives, personal care	GRA2PES ReadMe; Gkatzelis et al. 2021
3	Other siloxane (D3, D6, linear siloxanes)	various	Personal care, adhesives	GRA2PES ReadMe
4	PCBTF (parachlorobenzotrifluoride)	C7H4ClF3	Solvent-borne coatings	GRA2PES ReadMe; Stockwell et al. 2021
5	PDCBZ (para-dichlorobenzene)	C6H4Cl2	Insecticides, deodorizers	GRA2PES ReadMe; Gkatzelis et al. 2021

6	Anthropogenic terpenes (monoterpene mixture)	C10H16	Fragrances, cleaning, pesticides	GRA2PES ReadMe; Gkatzelis et al. 2021
7	Isopropyl alcohol (isopropanol)	C3H8O	Cleaning agents, solvents	GRA2PES ReadMe; Coggon et al. 2021
8	Propylene glycol	C3H8O2	Personal care, coatings	GRA2PES ReadMe; Coggon et al. 2021
9	Glycerol	C3H8O3	Personal care, e-cigarette emissions	GRA2PES ReadMe; Coggon et al. 2021
10	Ethanol	C2H6O	Personal care, cleaning, hand sanitizer	GRA2PES ReadMe; Coggon et al. 2021
11	Methanol	CH4O	Coatings, cleaning, printing inks	GRA2PES ReadMe; Coggon et al. 2021
12	Acetone	C3H6O	Personal care, cleaning, coatings	GRA2PES ReadMe; Coggon et al. 2021
13	Methyl ethyl ketone (2-butanone)	C4H8O	Coatings, adhesives, printing inks	GRA2PES ReadMe
14	Ethylene glycol	C2H6O2	Coatings, antifreeze formulations	GRA2PES ReadMe; Coggon et al. 2021
15	Texanol (2,2,4-trimethyl-1,3-pentanediol monoisobutyrate)	C12H24O3	Water-borne coatings	Stockwell et al. 2021; Dodero et al. 2025
16	Diethylene glycol	C4H10O3	Coatings, cleaning, personal care	Gkatzelis et al. 2021; Seltzer et al. 2021
17	Dipropylene glycol	C6H14O3	Personal care, fragrances	Gkatzelis et al. 2021; Seltzer et al. 2021
18	Benzyl alcohol	C7H8O	Coatings, personal care, cleaning	Tan et al. 2023; Seltzer et al. 2021
19	Carbitol (diethylene glycol monoethyl ether)	C6H14O3	Coatings, cleaning agents	Tan et al. 2023; Seltzer et al. 2021
20	Linalool*	C10H18O	Personal care, fragrances	Tan et al. 2023; Coggon et al. 2024
21	alpha-Terpineol*	C10H18O	Personal care, fragrances, cleaning	Tan et al. 2023

**measured as the sum of terpene alcohols (C10H18O)*

AQRP Project 26-029 Work Plan

Scope of Work

Project 26-029

Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas

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Revision: 1
2026/04/26

QA Requirements: Audits of Data Quality: 10% Required
Report of QA Findings: Required in Final Report

Approvals

This Scope of Work was approved electronically on 2026-05-04 | 14:21:13 CDT

Signed by:
David Sullivan
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David Sullivan

Project Manager, Texas Air Quality Research Program

This Scope of Work was approved electronically on 2026-05-04 | 15:34:22 CDT

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Project Liaison, Texas Commission on Environmental Quality

STATEMENT OF WORK

Introduction

This document provides the work plan for the Texas Air Quality Research Program (AQRP) project 26-029 “Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas”. Work will be completed by August 31, 2027. The project Principal Investigator is Dr. Pawel K. Misztal and the Co-Principal Investigators are Drs. Lea Hildebrandt Ruiz and Munkhbayar Baasandorj of the University of Texas at Austin, Dr. Yue Zhang of Texas A&M University, and Dr. Nathan Malarich of the University of Colorado Boulder / NOAA Chemical Sciences Laboratory. The multi-institutional team will conduct novel and spatially resolved air quality measurements using mobile ground-based platforms in coordination with airborne observations to characterize volatile organic compound (VOC) and volatile chemical product (VCP) emissions across major Texas urban areas.

Urban volatile organic compound (VOC) emissions have undergone a fundamental transformation over the past two decades. While transportation-related emissions have declined substantially due to regulatory controls, volatile chemical products (VCPs), including personal care products, cleaning agents, paints, coatings, adhesives, and pesticides, now constitute approximately half of VOC emissions in industrialized cities (McDonald et al., 2018). This paradigm shift has profound implications for ozone formation and air quality management in Texas, where current emission inventories inadequately represent VCP sources and their spatial and temporal variability. Coggon et al. (2021) found that VCP emissions enhance urban ozone by up to 10 ppb and contribute approximately 35% of fossil-derived secondary organic aerosol (SOA). Seltzer et al. (2022) determined that cleaning products, paints and coatings, and personal care products contribute approximately 81% of VCP-derived ozone nationally, with the largest impacts concentrated in urban cores.

Additionally, nontraditional sources such as asphalt-related emissions have emerged as significant contributors to secondary organic aerosol (SOA) precursors, with annual emissions potentially exceeding those from motor vehicles on urban scales (Khare et al., 2020). Understanding these diverse VOC sources is essential for developing effective ozone control strategies, particularly given the spatial heterogeneity of photochemical regimes across Texas urban areas. Wan et al. (2024) analyzed ozone-NOx-VOC sensitivity across Texas urban areas and found significant spatial variability: urban cores typically exhibit VOC-limited or transitional regimes where VOC reductions effectively reduce ozone, while suburban areas tend toward NOx-limited conditions. This spatial heterogeneity, observed in El Paso, Houston, San Antonio, and Dallas, underscores the importance of accurate VOC source attribution for developing effective control strategies.

This project proposes an integrated measurement and inventory assessment approach combining mobile ground-based observations with airborne platform coordination to characterize VOC and VCP emissions across major Texas urban areas. Two state-of-the-art mobile laboratories will be deployed: the University of Texas at Austin (UT Austin) all-electric mobile laboratory and Texas A&M University (TAMU) ROAM-V electrical-powered mobile laboratory, both equipped with Vocus 2R Chemical Ionization Mass Spectrometers (Vocus CIMS) providing complementary ionization capabilities. The

electric vehicle platforms eliminate self-sampling artifacts. Three Texas regions capture the diversity of VOC source environments: the Houston-Galveston-Beaumont-Port Arthur (BPA) industrial corridor, the Dallas-Fort Worth metroplex, and the Austin-San Antonio corridor.

The project leverages coordination opportunities with the planned NOAA TexAQS 2026 campaign, which will deploy aircraft over Texas to survey greenhouse gases and co-emitted pollutants from major urban areas. While aircraft provide spatial coverage and vertical profiles, ground-based mobile laboratories offer detailed chemical speciation, source proximity measurements, and continuous temporal coverage. Should airborne campaign timing change, the ground-based measurements retain full standalone scientific value.

The following research areas will guide the execution of the proposed work and tasks:

R1: Quantify VCP contributions to total VOC emissions across Texas urban environments and assess spatial/temporal variability using molecular tracers measured by mobile Vocus CIMS platforms.

R2: Develop comprehensive emission source profiles for VCP categories specific to Texas conditions, accounting for the enhanced volatilization expected in warmer climates.

R3: Assess VCP impacts on ozone formation potential across VOC-limited and NOx-limited regimes characteristic of Texas urban and suburban areas.

R4: Systematically compare field-measured emissions with existing emission inventories to identify gaps and inform inventory improvements for VCP sources.

Task Descriptions

Task 1: Campaign Planning and Coordination.

Meetings will be held with TCEQ staff and, as appropriate, with the NOAA TexAQS 2026 planning team and other researchers conducting air quality measurements in Texas to develop detailed measurement protocols. Coordination activities will include establishing data sharing agreements with airborne campaign investigators, finalizing target site selection based on current inventory data and preliminary receptor modeling, and identifying optimal stationary measurement locations within each target region. Sites currently operated by TCEQ, UT Austin, or Texas A&M collaborators will be considered for stationary overnight measurements and van charging. The UT and Texas A&M teams have experience in collaborative field measurements in SE Texas as part of an Inter-Integrated Field Laboratories campaign in Fall 2025 where simultaneous, staggered, and complementary drives were performed. This task will also include coordinating with Dr. Yike Shen from the University of Texas at Arlington for stationary site access near Dallas and Mihaela Stefan at the University of Texas at Dallas. The coordination of these mobile routes is being discussed at weekly meetings of co-PIs and NOAA team with TCEQ representatives. These weekly meetings will continue to enhance maximum synergy and the minutes of these meetings are recorded for future reference. The TexAQS 2026 WP-3D aircraft payload includes in-situ measurements of speciated VOCs, NO2, formaldehyde, and other trace gases, along with vertical profiling capabilities that complement the ground-based observations. Details of the TexAQS 2026 instrument

payload, flight schedule, and regional coverage are being finalized during weekly planning meetings with NOAA and TCEQ. Separate meetings are being held between NOAA and NASA. The NASA G3 aircraft will deploy GCAS (GEOstationary Coastal and Air Pollution events Airborne Simulator) for column NO_2, O_3, and formaldehyde measurements during the first two weeks of June 2026 as part of the Student Airborne Research Program (SARP), with 40 flight hours total and coordination with NOAA TexAQS 2026 when schedules overlap. Flight days and geographic focus areas will be communicated to the mobile laboratory teams as they are confirmed to enable real-time coordination of ground transects with aircraft overpasses. The mobile laboratories will be present for approx. a week in each target region with timing that best overlaps with the pre-designed flight schedule which is dependent on weather conditions.

TCEQ is invited to provide comments on areas of interest within each target region, and mobile sampling routes will be refined accordingly during the weekly coordination meetings. The plans will include concentrical drives as exemplified in Figure 1 but further optimized for downwind and upwind tracks performed by each mobile lab simultaneously in each region. Having mobile labs together in each region for most of the time has a unique advantage of evaluating source contributions by comparing upwind and downwind tracks. The tracks will be presented in one of the first monthly technical reports (MTRs) and kml's shared for finetuning suggestions. In addition to weekly coordination meetings, formal progress updates will be provided in conjunction with monthly Technical Reports submitted to the AQRP Project Manager and TCEQ Liaison.

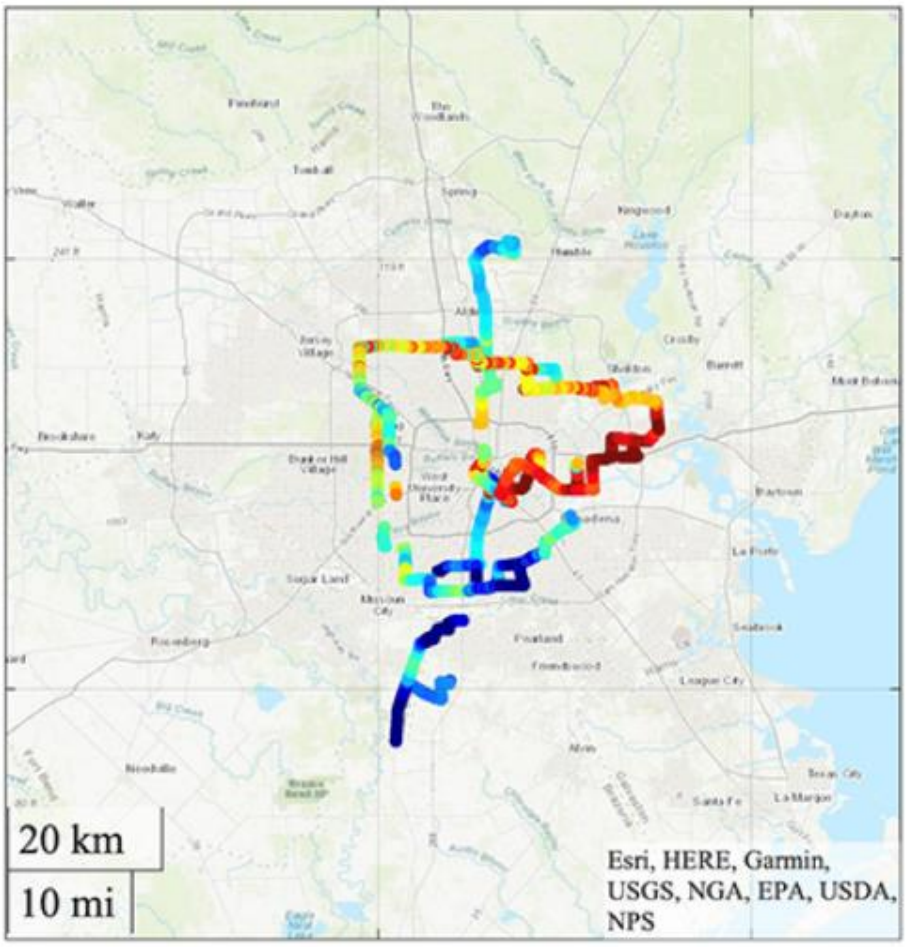

***Figure 1**. Example drive route executed previously in Houston by co-PI Zhang. Similar concentric plans are envisioned to cross-section aircrafts crosswind transects and will be predetermined for Dallas and San Antonio areas as well.*

Task 2: Emission Inventory Compilation and Assessment Framework

The central goal of this task is to provide TCEQ with measurement-based constraints on the VOC emission inventories that underpin the State's photochemical modeling and SIP development. TCEQ relies on accurate, spatially-resolved emission inventories for ozone attainment demonstration modeling (CAMx), permit reviews, rulemaking, and reporting to EPA. Yet persistent discrepancies between measured and inventoried VOC emissions have been documented across two decades of Texas Air Quality Studies: TexAQS 2000 first revealed that industrial HRVOC emissions were underestimated by one to two orders of magnitude, and TexAQS 2006 confirmed that significant underestimates persisted despite inventory improvements. With the Houston-Galveston-Brazoria and Dallas-Fort Worth nonattainment areas facing a July 2027 severe-classification attainment deadline under the 2008 ozone NAAQS, and with the recently adopted Section 185 penalty fee program contingent on that outcome, the accuracy of emission inventories used in TCEQ's photochemical modeling carries direct regulatory and financial consequences.

The primary inventory baseline for measurement-to-inventory comparison will be the most recent gridded inventories used in TCEQ's photochemical modeling, including EPA NEI 2017 and NEI 2020 and the gridded inventory inputs supporting TCEQ's State Implementation Plan modeling. The TexAQS 2000 and TexAQS 2006 datasets are

retained as historical context for evaluating multi-decadal trends in measured-to-inventoried emission ratios but do not serve as the primary baseline.

Spatially-resolved emission inventories for target regions will be compiled from the EPA National Emissions Inventory (NEI), TCEQ's point source database (STARS) and Texas Air Emissions Repository (TexAER), and sector-specific sources including NOAA's Greenhouse gas And Air Pollutant Emissions System (GRA^2PES) inventory, which provides aggregated emissions of over 100 species at 4x4 km resolution.The GRA^2PES gridded inventory includes 21 individual VCP species drawn from the explicitly tagged VCP, oxygenated VCP (OVCP), and siloxane categories and the underlying VCPy framework (Seltzer et al., 2021), all of which fall within the calibrated detection range of the project Vocus CIMS instruments. The full species list, GRA^2PES mapping, and instrument coverage are provided in Appendix A of the project QAPP.

A mass-balance methodology framework will be developed for comparing measured and inventoried emissions. Winds and mixing heights will come from airborne Doppler lidar in a raster pattern over the metro areas during synchronized NOAA flights. Other mobile lab drives in Houston will have a micropulsed lidar at University of Houston for mixing height, and likely an ozone lidar and Doppler lidar also at the site. Barring this data, other drives will use HRRR reanalysis for meteorology and transport variables, which assimilates the permanent, public measurement network (Benjamin et al. (2016)).Protocols for integrating Doppler lidar wind profiles with surface and airborne concentration measurements will be established to enable flux quantification from individual source sectors.

Co-PI Malarich will lead this task, leveraging his expertise in airborne mass-balance methods for emissions quantification. Particular attention will be given to two inventory domains where TCEQ's current inputs carry the greatest uncertainty. First, for area sources, TCEQ currently models emissions from volatile chemical products (VCPs), including coatings, solvents, cleaning products, and personal care products, using a top-down approach that distributes county-level totals with spatial surrogates such as population density. These estimates rely heavily on product sales data and assumed emission factors rather than direct atmospheric measurements, and recent national studies have shown that VCP emissions are a dominant and growing fraction of anthropogenic VOC in urban areas, with substantial implications for both ozone formation and secondary organic aerosol. Our measurements will provide TCEQ with independent, observation-based evaluation of these area-source inventory categories at a level of chemical speciation directly relevant to the CB7 mechanism used in CAMx. Second, for industrial point sources, the mass-balance framework will allow assessment of reported emissions against measured fluxes, extending the legacy of TexAQS-era inventory verification while leveraging improved instrumentation and complementary airborne-ground measurement strategies.

The assessment will draw on previous NOAA TexAQS campaigns from 2000 and 2006, as well as the coordinated TexAQS 2026 measurements, to evaluate long-term trends in the measured-to-inventoried emission ratio across source sectors. The resulting datasets and assessment methodology will be structured to integrate with TCEQ's existing inventory tools and photochemical modeling workflow, providing actionable information for future SIP revisions and emissions processing updates.

Task 3: Intensive Measurement Campaigns across Three Texas Regions.

Two independent mobile laboratories will be deployed for intensive observation periods in the three target regions (Table 1) approximately for 1 week in each region. Measurements will include systematic transects across urban-suburban gradients, targeted sampling near identified VCP source areas (industrial facilities, commercial districts, residential neighborhoods), and coordinated measurements with available airborne platforms during overflight periods. The tracks will be designed so that one mobile lab will perform downwind measurements while the other upwind.

Table 1. *Target regions and scientific rationale.*

Region	***Primary Source Types***	***Scientific Rationale***
Houston-Galveston-Beaumont-Port Arthur (BPA)	Chemical, elastomer, petrochemical, VCPs, mobile, industrial, residential	Largest Texas metro, existing VCP data, complex source mixture, major concentration of industries and TRI top emissions. Ship Channel pollution.
Dallas-Fort Worth	VCPs, mobile, commercial/residential	Major inland metro, less industrial influence, VCP-dominated environment.
Austin-San Antonio	VCPs, mobile, commercial, residential, EV gigafactory, semiconductor, oil and gas	UT Austin/TCEQ reference areas, unique sources and gradient transitioning to less wet gas south of San Antonio.

The UT Austin team (PI Misztal and Co-PI Hildebrandt Ruiz) will operate the UT electric Ford E-Transit mobile lab van, which has a substantial battery-based power supply allowing approximately 6-8 hours of uninterrupted mobile measurements given a full charge. The Vocus CIMS will be operated in the conventional proton transfer reaction (PTR) mode which utilizes H_3O^+ as a protonation agent and is universally suited to a broad range of VOCs including aromatics, heterocycles such as furanoids, carbonyls, alcohols, total terpenoids, acids, hydroxyacids, nitriles, amides, amines, sulfides, multifunctional, and many other including exotic VOCs, embracing most of the well-known and emerging VCPs. Co-PI Zhang's team will deploy the Texas A&M ROAM-V mobile laboratory equipped with the same Vocus CIMS but running in a complementary NO^+ ionization mode which overlaps with PTR mode in detectability of a large fraction of VOCs and complements the PTR mode in certain alkanes and unsaturated PFAS whose detection is challenging under the conventional PTR mode. Although NO^+ is less sensitive to certain VOCs such as aromatics its ionization is softer leading to decreased fragmentation. The complexity arises from the fact that unlike PTR which proceeds via a single well characterized proton transfer mechanism, NO^+ ionization proceeds via several mechanisms (i.e. charge transfer, hydride abstraction, adduct formation, hydroxide abstraction) which can help obtain additional information on structural isomers (e.g. ketone vs aldehyde) which differ in these mechanisms. Overall, calibrated compounds in

both modes allow direct comparisons for a large number of VOCs detectable by both ionization, and resulting in a larger set of measurable compounds than an option if the two labs used exactly the same ionization. Both mobile laboratories will sample at the same city during the same sampling period but from two opposite directions, maximizing sampling efficiency while providing higher time resolution and upwind/downwind chemical evolution of pollutants. The electric vehicle platforms eliminate self-sampling artifacts from exhaust emissions. The instruments will be calibrated regularly, with the Vocus instruments calibrated before and after each mobile drive or at least daily during stationary periods. The payloads of the two mobile laboratories are summarized in Table 2.

Table 2. *Payloads of the electric mobile laboratories. Some payload components such as AMS will be used on the stationary site to help with long-term PMF.*

Instrument	Compounds/Parameters Measured	Resolution	UT	A&M
Vocus 2R PTR-ToF MS	Broad range of VOCs, oxygenated VOCs spanning from <1 ppt to 1 ppm	1 s	X	X
HR-TOF-AMS	Non-refractory PM_1 (UT) and $PM_{2.5}$ or PM_1 (A&M) with soot particle (SP) real-time crude speciation	5 s	S	S
Picarro G2307	CH_4, HCHO, H_2O	1 s	X/S	
Modulair	NO_2/NO/NO_x, CO, O_3	5 s	X	X
Thermo	Ozone (O_3)	1 s	X	
Thermo	H_2S, SO_2	80 s	X	
Thermo	NO-NO_2-NO_x	5 s		X
TSI SMPS	Scanning electric mobility particle sizer	15 s		X
LI-840	CO_2, H_2O	1 s	X	X
AE33 Aethalometer	Black Carbon	1 s	X	
Davis sonic anemometer	T, wind direction, wind speed	5 s	X	X
Range finder	Source distance and height	manual	X	
T, RH HOBO	RH, T	1 s	X	
GPS and dashcam	lat/lon/velocity	1 s	X	X

X – mobile; S- deployed on stationary platforms.

The vans will utilize DC charging networks, 240 V level 2 connectors at stationary sites for overnight charging, and regional networks of RV parks around the focus regions to charge the vans and battery packs and to conduct stationary measurements. A separate rental vehicle will be used to scout routes and shuttle personnel who need breaks from driving. **Survey tracks** are planned to scout for hotspots in O_3, black carbon, $PM_{2.5}$, and a broad range of VOC precursors and source markers. These survey drives are proposed to be conducted within a 50-mile radius of each base target area. Exact times and routes

will be coordinated with TCEQ and the research team in the weekly coordination meetings with the minutes documented for future reference.

The measurement campaigns will allocate approximately equal time across all three regions, with roughly one week per city. While previous AQRP-sponsored measurements in Houston (FY2022-23; Dodero et al., 2025) provide a valuable baseline, those campaigns relied on a single ionization mode and had no coordinated airborne measurements. The current project deploys two mobile laboratories simultaneously, with the UT Austin Vocus operating in H_3O^+ mode and the Texas A&M Vocus in NO^+ mode. This multi-mode approach captures a substantially broader range of VOC species than either mode alone: H3O+ provides high sensitivity to oxygenated VOCs and established VCP tracers, while NO^+ extends coverage to alkenes and alkanes that are important ozone precursors. Coordination with the TexAQS 2026 aircraft over Houston provides the vertical profiles and regional context needed for the mass-balance emission quantification in Task 5, an approach that was not possible with the ground-only FY2022-23 campaign. The Houston revisit therefore yields a more chemically complete and vertically integrated dataset rather than a duplication of prior work, while DFW and Austin-San Antonio will be characterized for the first time with this instrumentation.

On each sampling day, one mobile laboratory will be positioned upwind and the other downwind of the target source area. This paired configuration enables direct quantification of urban emission enhancements by concentration difference, providing the input needed for the mass-balance emission estimates in Task 5. As the mobile labs traverse different road types and surfaces, asphalt-related VOC markers previously identified by PI Misztal (Sreeram et al., 2022) will be monitored in real time, with concentration contrasts between road types used to assess this nontraditional emission source. In the Austin-San Antonio corridor, survey and focused tracks will include transects near other nontraditional sources (e.g. EV factory, semiconductor manufacturing, and data center facilities) to characterize emission profiles from these emerging industrial sources. Co-PI Zhang's NO^+ mode can resolve certain per- and polyfluoroalkyl substances (PFAS) associated with semiconductor manufacturing, while PI Misztal has developed a complementary high-energy (HE) ionization mode (Kienzle et al., 2026) targeting additional PFAS species. The HE mode will potentially be used occasionally near known or suspected PFAS sources for additional confirmation based on the PFAS fragment ions identified by Kienzle et al., 2026 in regular H_3O^+ which were found to scale with the total PFAS.

TCEQ is invited to provide input on additional areas of interest within each target region, and mobile sampling routes will be refined accordingly during the weekly coordination meetings and incorporated in the MTR.

Focused tracks around identified hotspots, near major pollution sources, and community receptor sites will be performed in synchronization with the TexAQS 2026 flights which are coordinated weekly; during no-flight days the mobile labs will either measure at key stationary locations or will complement the focused tracks at times of shallow PBL in early morning, during well-mixed conditions, and nocturnally. The electric vans will also be used as stationary measurement vehicles overnight and between drives, collocated with TCEQ or other strategic monitoring points.

The UT Austin Vocus CIMS will conduct measurements in H_3O^+ mode while Texas A&M Vocus CIMS will conduct measurements in NO^+ ionization mode, which is complementary for alkanes and alkenes and overlaps with compounds detected by H_3O^+. The measurements will be conducted by two vans for approximately one week per region, to capture both oxygenated VOCs and alkane/alkene species. Combining these ionization modes will provide a comprehensive spatial and temporal distribution of organic species from industrial and residential activities. In addition, continuous ground-based monitoring data for criteria pollutants, VOCs, and meteorological parameters collected at nearby TCEQ air quality monitoring stations will be utilized for temporal and spatial context.

Task 4: Source Apportionment Analysis.

With approximately one week per city encompassing both mobile transects and stationary measurement periods across varying meteorological conditions, the sub-second time resolution of the Vocus instruments provides extensive datasets with sufficient chemical variability for robust PMF factor separation. Constrained PMF (ME-2) will be applied to anchor well-characterized factors such as traffic, improving resolution of less constrained sources such as VCPs.

Positive matrix factorization (PMF) and chemical mass balance (CMB) techniques will be applied to apportion measured VOCs to source categories. The collected data will be incorporated into advanced statistical data analysis tools, including hybrid PMF that combines data from multiple measurement platforms (Chan et al., 2011; Crippa et al., 2013; Olin et al., 2022). The results of the hybrid PMF will allow for source apportionment of precursor species (Kong and Pettersson, 2020; Zhang et al., 2011). The use of combined PMF of various gaseous species will accurately quantify source apportionment of different VOC types. Co-PI Zhang's team has experience with hybrid PMF and mobile PMF, with several manuscripts currently in preparation using newly developed methods from other projects.

This project will target the five established VCP tracers from the FY2022-23 Houston campaign (D5-siloxane, para-dichlorobenzene, PCBTF, Texanol, and monoterpenes) to enable inter-annual comparison, along with an additional 16 individual VCP species drawn from the GRA2PES inventory and the underlying VCPy framework, for a total of 21 individual VCP species, to expand emissions characterization and improve source apportionment sensitivity. The full species list, GRA2PES mapping, and Vocus CIMS calibration coverage are provided in Appendix A of the project QAPP. PI Misztal has developed untargeted screening approaches (Neville et al., 2025) that will identify both known and previously unrecognized VCP markers in the H_3O^+ spectra, while Co-PI Zhang's NO^+ ionization mode (Gagan et al., in press) extends tracer coverage to alkenes, alkanes, and other species not efficiently ionized by H_3O^+. The combination of both ionization modes maximizes the chemical dimensionality available for factor separation.

For the Houston region, PMF results from this project will be directly compared with source apportionment from the FY2022-23 AQRP campaign (Dodero et al., 2025; McCary et al., 2025) to assess inter-annual changes in VCP source contributions. The availability of concurrent H_3O^+ and NO^+ datasets from this project, compared against the single-mode data from the earlier campaign, will enable evaluation of how the expanded chemical coverage affects factor resolution and the number of resolvable sources. This comparison

will help distinguish real emission trends from methodological differences, a distinction that is important for informing TCEQ inventory updates.

Texas-specific VCP source profiles will be developed using tracer ratios and temporal patterns. Source contributions will be compared across regions and environmental conditions. Co-PI Hildebrandt Ruiz will lead the aerosol-phase PMF analysis. Co-PI Baasandorj will contribute to data quality assurance and integration, in-depth data analysis including trending and ozone formation potential calculations.

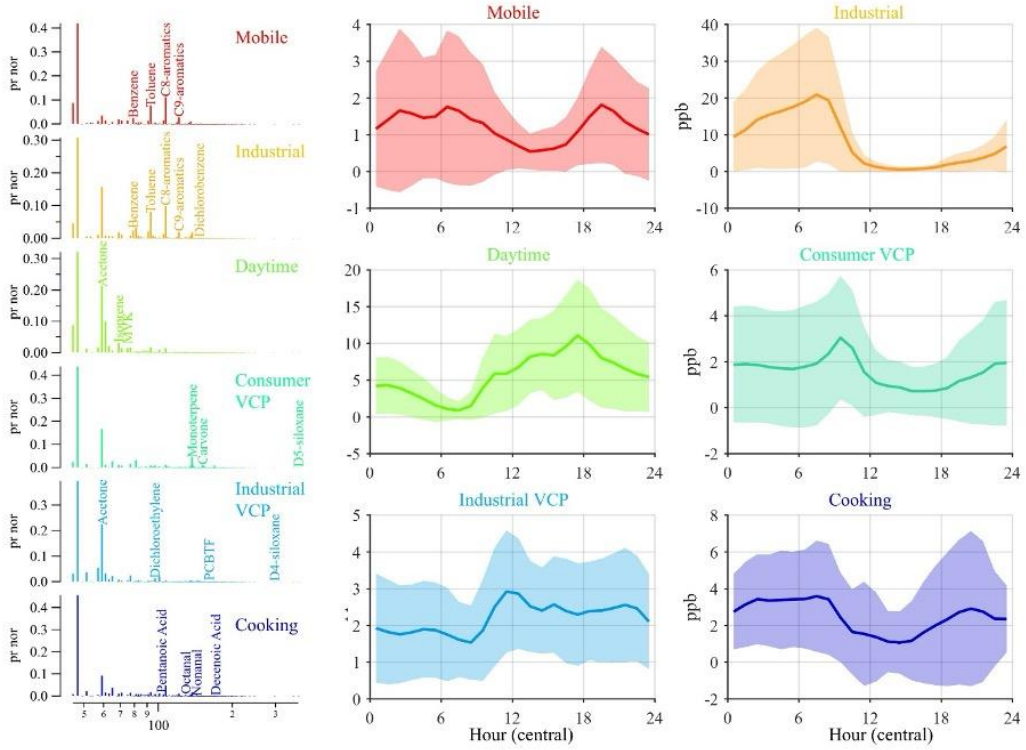

Figure 2. *Examples of a PMF analysis results obtained from a recent Houston Ship Channel deployment by the Vocus CIMS.*

Task 5: Ozone Formation Potential Assessment and Inventory Comparison.

Incremental reactivity-weighted ozone formation potential will be calculated for measured VOC mixtures using maximum incremental reactivity (MIR) values. Ozone formation potential estimates for Houston will be calculated using both the H_3O^+ and NO^+ datasets and compared against OFP values derived from the FY2022-23 AQRP campaign. This comparison will quantify the contribution of reactive species such as alkenes that were not well captured by the earlier single-mode measurements, providing TCEQ with a more chemically complete assessment of VCP contributions to ozone formation in the HGB nonattainment area. VCP contributions to total ozone formation potential will be quantified, with particular attention to spatial variability across VOC-limited and NOx-limited regimes characteristic of Texas urban and suburban areas (Wan et al., 2024).

Co-PI Malarich will lead the inventory comparison component, using two complementary mass-balance approaches detailed in the project QAPP. The first approach uses NOAA

TexAQS 2026 aircraft transects spaced approximately 20 km apart, with airborne Vocus CIMS providing 1 to 10 Hz VOC measurements and airborne Doppler wind lidar providing horizontal wind and mixing height profiles to derive emission fluxes from the major Texas urban areas. For specific industrial sources, both upwind and downwind transects are flown to isolate the plume contribution from regional background, with alkene emissions estimated from Whole Air Sampler measurements following the methodology of Wert et al. (2003). The second approach uses upwind and downwind drive tracks of the two mobile laboratories, combined with surface and upper-air meteorology, to quantify urban emission enhancements directly. When upper-air data are not available, plumes are assumed to be vertically well mixed within the boundary layer, an assumption that is reasonable when the drive track is approximately 15 minutes of air-parcel time downwind of the source.

Supplementary meteorological data will include continuous boundary-layer height measurements from a micropulsed lidar at the University of Houston, planned ozone lidar and Doppler wind lidar deployments at the same University of Houston site, and airborne Doppler wind lidar profiles flown in raster patterns across the metropolitan area on aircraft deployment days. When direct upper-air measurements are unavailable, urban winds and boundary-layer heights will be drawn from HRRR reanalysis, which assimilates publicly available National Weather Service surface stations.

Industrial point sources at refineries and chemical manufacturing complexes are spatially distributed within each facility but fall well within the 20 km aircraft transect spacing, so each complex can be enclosed within a single mass-balance domain. The Houston Ship Channel will be treated as a wider linearly extended source, with aircraft upwind and downwind transects oriented parallel to the channel.

Measured emissions will be compared against the GRA2PES inventory through forward and inverse modeling techniques or direct flux estimation comparisons. Discrepancies will be identified and recommendations for inventory improvements will be developed, with particular attention to VCP categories.

Task 6: Synthesis and Reporting.

Findings from Tasks 2-5 will be synthesized into comprehensive reports for TCEQ. Recommendations will be developed for emission inventory improvements and control strategy development. Results will be prepared for peer-reviewed publications and presented at scientific conferences and stakeholder meetings. The synthesis will address all four research objectives (R1-R4) and provide actionable data for air quality management strategies. All principal investigators will contribute to the final report.

TIMELINE

The project schedule by task is presented below. The project start date is assumed to be May 1, 2026. Technical work will not begin until authorization is received from TCEQ and AQRP. The entire project will be completed by August 31, 2027. The Draft Final Report will be submitted by April 30, 2027 and the Final Report by May 31, 2027, allowing approximately three months for AQRP and TCEQ review prior to project close.

	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 14	M 15	M 16
Task 1 – Campaign Planning & Coordination																
Task 2 – Inventory Compilation & Assessment																
Task 3 – Intensive Measurement Campaigns																
Task 4 – Source Apportionment Analysis																
Task 5 – Ozone Formation & Inventory Comparison																
Task 6 – Synthesis and Reporting																
Task R – Reporting												D F R	F R			

UT Austin will prepare and submit monthly technical progress reports on the 10th of the month (or following business day) as well as quarterly reports. Deliverables for this project also include a draft final report and final project report documenting all work from Tasks 1 through 6, and a project summary presentation to AQRP. AQRP will receive an electronic copy of all data generated for this project. All reports will be in the format requested by AQRP.

PROJECT ORGANIZATION AND RESPONSIBILITIES

This project is being conducted by UT-Austin in collaboration with Texas A&M University and the University of Colorado Boulder / NOAA Chemical Sciences Laboratory, under a grant from the Texas Air Quality Research Program. The project Principal Investigator is Dr. Pawel Misztal and the Co-Principal Investigators are Drs. Lea Hildebrandt Ruiz and Munkhbayar Baasandorj (UT Austin), Dr. Yue Zhang (Texas A&M), and Dr. Nathan Malarich (CU Boulder/NOAA CSL). Dr. Pawel Misztal is responsible for overseeing the project execution and completion and will also lead UT Austin mobile measurements and data synthesis. Dr. Lea Hildebrandt Ruiz will co-lead the study and specifically contribute to chemical analysis and aerosol-VOC interactions. Dr. Yue Zhang will lead the Texas A&M mobile laboratory deployment and associated VOC measurements. Dr. Nathan Malarich will lead emission inventory comparison and assessment, coordinate airborne measurement integration, and develop mass-balance emission quantification methodologies. Dr. Munkhbayar Baasandorj will contribute to data quality assurance and integration, in-depth data analysis including trending and ozone formation potential calculations. All Principal Investigators will contribute to the final report. The project will be overseen by AQRP Project Manager Dr. David Allen (Interim) and TCEQ Project Liaisons Morshad Ahmed and David Westenbarger (Backup).

Internal project communication follows a tiered structure that ensures continuous coordination across institutions, real-time responsiveness during field operations, and formal reporting to the AQRP Project Manager and TCEQ Liaison. Co-PIs hold weekly video conferences to coordinate scientific planning, field logistics, instrument readiness, and data analysis priorities. During the intensive measurement campaigns described in Task 3, the team will conduct daily field briefings to review the previous day's measurements, confirm driving routes and instrument status, and coordinate with the TexAQS 2026 aircraft schedule. Measurement data, calibration records, and field metadata will be shared among team members through a secure cloud-based repository maintained by UT Austin. Weekly co-PI meeting minutes will be archived for future reference. Monthly Technical Reports submitted to the AQRP Project Manager and TCEQ Liaison on the 10th of each month, together with quarterly reports, will provide formal documentation of project progress, preliminary results, and any deviations from the planned scope of work. AQRP and TCEQ representatives are also welcome to participate in the weekly coordination meetings at any point during the project.

The scientists working on this project and their specific responsibilities are listed below.

Dr. Pawel K Misztal is an Associate Professor (Cockrell Family Fellow) at UT Austin and will be the Principal Investigator. He has more than 15 years of experience in atmospheric VOC measurements using CIMS instruments including Vocus CIMS across different spatiotemporal scales, including airborne campaigns in California with the California Air Resources Board. He is a PI or co-PI on multiple federally funded projects including from NOAA, DOE, NSF, ARPA-E, and HEI, and is a recipient of an NSF CAREER award. He will oversee project coordination, UT Austin mobile measurements, and data synthesis.

Dr. Lea Hildebrandt Ruiz is an Associate Professor at UT-Austin and will be a Co-Principal Investigator. Her research expertise lies in air quality and atmospheric chemistry, and she has published extensively in these areas. Dr. Hildebrandt Ruiz has

led several projects focused on atmospheric measurements and detailed analysis of mass spectrometric data including positive matrix factorization.

Dr. Yue Zhang is an Assistant Professor in the Department of Atmospheric Sciences at Texas A&M University and will be a Co-Principal Investigator. Dr. Zhang is an NSF CAREER Award recipient whose research focuses on the physicochemical evolution of VOCs and organic aerosols. He leads the ROAM-V (Rapid Onsite Atmospheric Measurement Van) mobile laboratory equipped with Vocus CIMS. He has recently published the first spatial and temporal VCP measurements in Houston, demonstrating significantly enhanced VCP tracer concentrations in subtropical climate conditions (Dodero et al., 2025). He brings 4 years of VOC concentration data from previous mobile campaigns in the Greater Houston Area, including the NOAA AGES+ campaign.

Dr. Nathan Malarich is a Research Scientist in the Atmospheric Remote Sensing group at NOAA Chemical Sciences Laboratory, affiliated with CU Boulder CIRES. He will be a Co-Principal Investigator. Dr. Malarich specializes in Doppler lidar aircraft measurements for wind profiling and boundary layer characterization and has extensive experience in airborne mass-balance methods for emissions quantification. He will lead the emission inventory comparison and assessment, coordinate airborne measurement integration, and develop mass-balance emission quantification methodologies.

Dr. Munkhbayar Baasandorj is a Research Associate at The University of Texas at Austin and will be a Co-Principal Investigator. She has expertise in VOC measurements, source apportionment, and air quality studies. She will contribute to data quality assurance and integration, in-depth data analysis such as trending and ozone formation potential calculations.

DELIVERABLES

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. A description of the specific reports to be submitted and their due dates are outlined below. One report per project will be submitted. PI Dr. Misztal will submit the reports but will be assisted by co-PIs and other project participants in preparing the reports. All reports will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceesa.utexas.edu/ will be followed.

Abstract

At the beginning of the project, an Abstract will be submitted to the Project Manager for use on the AQRP website. The Abstract will provide a brief description of the planned project activities and will be written for a non-technical audience.

Due Date: Ten (10) business days after notice of intent to fund

Quarterly Reports

The Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Word doc file. It will not exceed 2 pages and will be text only. No cover page is required. This document will be inserted into an AQRP compiled report to the TCEQ.

Due Dates: To be determined based on project start date

Technical Reports

Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison as a Word doc using the AQRP MTR Template found on the AQRP website.

Due Dates: Monthly, on the 10th of each month (or following business day)

Financial Status Reports

Financial Status Reports will be submitted monthly to the AQRP Grant Manager by each institution on the project using the AQRP FSR Template found on the AQRP website.

Due Dates: Monthly, on the 10th of each month (or following business day)

Draft Final Report

A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.

Due Date: April 30, 2027 or one month before project end.

Final Report

A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will be

written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.

Due Date: May 31, 2027 or project end date.

Project Data

All project data including but not limited to QA/QC measurement data, databases, source profiles, inventory comparison results, etc., will be submitted to the AQRP Project Manager within 30 days of project completion. The data will be submitted in a format that will allow AQRP or TCEQ or other outside parties to utilize the information.

AQRP Workshop

A representative from the project will present at the AQRP Workshop. The selected date will be updated.

Presentations and Publications/Posters

All data and other information developed under this project, which is included in published papers, symposia, presentations, press releases, websites and/or other publications shall be submitted to the AQRP Project Manager and the TCEQ Liaison per the Publication/Publicity Guidelines included in the Subaward.

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The University of Texas at Austin

Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas
AQRP Budget

Principal Investigator: Pawel Misztal

Project Dates: 05/01/2026 - 08/31/2027

A. SENIOR PERSONNEL: PI, Co-PI

	FirstName LastName	Title	Monthly Rate	Fringe Rate	FTE / % Effort	Funds Requested
1.	Pawel Misztal	PI	$15,747	32.7%	0.60	$9,448
2.	Lea Hildebrandt Ruiz	coPI	$18,260	32.7%	0.50	$9,130
3.	Munkhbayar Baasandorj	coPI	$16,667	32.7%	0.50	$8,333
4.						
	TOTAL SENIOR PERSONNEL					**$26,911**

B. OTHER PERSONNEL (SHOW NUMBERS IN BOXES)

1	1	Other Professionals / Researchers	$7,179	32.7%	0.50	$3,590
2	1	Other Professionals / Research Coordinator	$6,080	2.7%	1.00	$6,080
3	1	Graduate Student	$3,103	15.0%	12.00	$37,236
		TOTAL OTHER PERSONNEL				**$46,906**
		TOTAL SALARIES AND WAGES (A+B)				**$73,817**

C. FRINGE BENEFITS (AUTOMATICALLY CALCULATED BASED ON ENTERED RATES)

1.	Senior Personnel	**$8,800**
2.	Other Personnel	**$6,923**
	TOTAL FRINGE BENEFITS	**$15,723**
	TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)	**$89,540**

D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5000)

a)		$0
b)		$0
c)		$0
	TOTAL EQUIPMENT	**$0**

E. TRAVEL

		Cost per Trip	# of Trips	
1.	Domestic (Incl. Canada, Mexico and U.S. Possessions)	$1,000	**9**	$9,000
2.	Foreign			
	TOTAL TRAVEL			**$9,000**

F OTHER DIRECT COSTS

1.	Materials and Supplies	$5,776
2.	Professional Services - Idependent Contractors	$0
3.	Subcontracts (contracts will be issued by UT)	
a)	CU Boulder	$50,000
b)	Texas A&M	$109,406
c)		$0
d)		$0
4.	Tuition and Fees	$13,130
5.	Other	$0
	TOTAL OTHER DIRECT COSTS	**$178,312**

G.	**TOTAL DIRECT COSTS (A THROUGH F)**		**$276,852**
H.	**TOTAL INDIRECT COSTS**	**IDC Rate: 15.000%**	**$23,147**
I.	**TOTAL COSTS**		**$299,999**

NOTE: *Please indicate whether you are using Modified Total Direct Costs (MTDC) or Total Direct Costs (TDC) in the calculation of Indirect Costs (IDC).*

You may modify this template as needed to show calculation of direct or indirect costs or other project specific budgetary needs.

University of Texas at Austin
Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas
AQRP Budget Justification

Total Budget: $299,999

A. SALARIES

Dr. Pawel Misztal, Principal Investigator, 0.6 months of 100% effort, will be responsible for overall project coordination, oversight of UT Austin mobile laboratory measurements, data synthesis, and integration with the NOAA TexAQS26 airborne campaign. Dr. Misztal will lead campaign planning, coordinate with collaborators at CU Boulder/NOAA and Texas A&M, supervise data quality assurance, and communicate with AQRP and TCEQ colleagues.

Dr. Lea Hildebrandt Ruiz, Co-Investigator, 0.5 months of 100% effort, will contribute expertise in aerosol chemistry, secondary organic aerosol formation, and source apportionment. She will oversee chemical analysis of VOC-aerosol interactions and contribute to interpretation of ozone formation potential assessments.

Dr. Munkhbayar Baasandorj, Co-Investigator, 0.5 months of 100% effort, will contribute to data quality assurance and integration, in-depth data analysis including trending and ozone formation potential calculations, and VOC source apportionment studies.

TBA, Other Professional/Researcher, 0.5 months of 100% effort, will perform mobile laboratory operation, instrument calibration, field measurements, and preliminary data processing during the intensive measurement campaigns.

Dori Eubank, Research Program Coordinator, 1 month of 100% effort, will help with monthly financial reports, travel arrangements, and other administrative tasks related to the project.

TBA, Graduate Research Assistant (GRA), 12 months of 50% effort, will perform mobile measurements using the Vocus PTR-TOF-MS, assist with instrument calibration, conduct positive matrix factorization and chemical mass balance analyses for source apportionment, and contribute to manuscript preparation.

TBA, Graduate Research Assistant (GRA), 12 months of 50% effort, will perform mobile measurements using the HR-TOF-AMS, assist with instrument calibration, conduct aerosol source apportionment analyses, and contribute to manuscript preparation.

B. FRINGE BENEFITS

Fringe benefits rates are based on University of Texas at Austin federally negotiated rates for the appropriate employee benefits level at the time of proposal submission. Total fringe benefits budget requested: $15,723.

C. EQUIPMENT

none

D. OTHER DIRECT COSTS

MATERIALS AND SUPPLIES

Supplies are calculated at $5,776 for consumables necessary for routine work of the instruments including calibration gas standards, sampling tubing, Swagelok fittings, mass flow controllers, field accessories, compressed gases, and other materials and supplies for the field campaign preparation and execution. Total materials and supplies budget requested: $5,776.

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TRAVEL

Funds are requested for project personnel to travel to conduct mobile measurement campaigns in the three target regions (Houston-Galveston-Beaumont-Port Arthur, Dallas-Fort Worth, and Austin-San Antonio corridors) and to coordinate with the NOAA TexAQS26 airborne campaign. Travel costs are calculated for 9 domestic trips at $1,000 per trip, covering vehicle rental for route scouting and personnel shuttling, lodging at RV parks and stationary measurement sites, per diem, and fuel costs for support vehicles. Total travel budget requested: $9,000.

TUITION

The University requires tuition remission to be budgeted for all GRAs working on sponsored projects. The in-state/resident tuition rate at the University of Texas at Austin for FY 2026-2027 is $625 per semester credit hour. Total tuition budget requested: $13,130.

SUBCONTRACTS

University of Colorado Boulder/NOAA Chemical Sciences Laboratory will be a subcontractor under this project and will be contracted through UT Austin's Subaward Agreement. The costs associated with the subcontract are $50,000 for the period of September 1, 2026 through August 31, 2027. Dr. Nathan Malarich (Co-PI) will lead emission inventory comparison and assessment, coordinate airborne measurement integration with the TexAQS26 campaign, and develop mass-balance emission quantification methodologies using Doppler lidar-derived wind profiles.

Texas A&M University will be a subcontractor under this project and will be contracted through UT Austin's Subaward Agreement. The costs associated with the subcontract are $109,406 for the period of September 1, 2026 through August 31, 2027. Dr. Yue Zhang (Co-PI) will deploy the ROAM-V mobile laboratory equipped with Vocus 2R CIMS to conduct complementary VOC and particle-phase measurements in the Houston-BPA and Dallas-Fort Worth regions, operating in conjunction with the UT Austin mobile laboratory.

Total subaward budget requested: $159,406.

INDIRECT COSTS

The indirect cost rate of 15% of modified/total direct costs (MTDC/TDC) is used as instructed by the AQRP's published proposal preparation instructions. MTDC is calculated as the total of direct costs, less equipment in excess of $5,000 and less tuition remission applied to GRA salary. Total indirect cost budget requested: $23,147.