



# ROMEEO

- Romanian Methane Emissions from Oil and gas -

## Campaign Implementation Plan

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### Project Identification

Budget line: M1-32SLP-000009/32SLP/M99/14AC001/ SB-009157.10.02.16

Reference number: DTIE18-EN0XX Amount: \$653,000

BP number: 1500002770 POW 2017-2018

Sub-programme: Climate Change Expected Accomplishment: EA (b)

Title of the approved PRC project: **Project 1-b/c (01554): Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants**

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**ROMEO** – **RO**manian **M**ethane **E**missions from **O**il and **g**as

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## Purpose of document

The scope of this document - the Campaign Implementation Plan (CIP) - is to present the planning of the foreseen campaign that will be executed in the project “ROMEEO - ROmanian Methane Emissions from Oil & gas”. The CIP is a compilation of the contractual requirements and the campaign experimental planning.

The document provides information about the campaign objectives, execution and contractual requirements.

General information given in this CIP is also available on the campaign dedicated wiki websites, which were accessible for all participants and partly for the public.

## Acronyms and abbreviations

AGH	University of Science and Technology, Poland
Cal / Val	Calibration/ Validation
CH <sub>4</sub>	Methane
CIP	Campaign Implementation Plan
DTU	Technical University of Denmark
EDF	Environmental Defense Fund
EMPA	Swiss Federal Laboratories for Materials Science and Technology
HC	HydroCarbon
INCAS	National Institute of Aerospace Research “ELIE CARAFOLI”
INOE	National Institute of Research and Development for Optoelectronics
<b>MEMO<sup>2</sup></b>	<b>M</b> ethane goes <b>M</b> obile - <b>M</b> Easurements and <b>M</b> odelling
OTM 33A	Other Test Method nr. 33A
RHUL	Royal Holloway of London
ROMEEO	ROmanian Methane Emissions from Oil & gas
SA	Scientific Aviation
TNO	Netherlands Organisation for applied scientific research
UBB	Babes-Bolyai University, Romania
UG	University of Groningen
UHEI	University of Heidelberg, Germany
UNFCCC	United Nations Framework Convention on Climate Change
UU	Utrecht University
UVSQ	Université de Versailles Saint-Quentin-en-Yvelines
WUR	Wageningen University and Reseach



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# 1. Introduction

## 1.1 Scientific Background and Executive Summary

Mitigation of climate change is a key societal challenge. The 2015 United Nations Climate Change Conference in Paris (COP21) agreed to limit global warming "well below" 2 °C and, if possible, below 1.5 °C. Reaching this target requires massive reductions of greenhouse gas emissions, far beyond the Intended Nationally Determined Contributions. Methane (CH<sub>4</sub>) is one of Europe's most important sources of energy, and CH<sub>4</sub> emissions are a major contributor to Europe's global warming impact. With a rather short lifetime of 10 years, CH<sub>4</sub> is an attractive target for climate change mitigation. In particular CH<sub>4</sub> emission reductions related to natural gas production, distribution and use are considered "no-regret" solutions, since they have only positive effects and can often be realized in a cost-effective way (McKain et al. 2015, Hopkins et al. 2016).

According to the United Nations Framework Convention on Climate Change (UNFCCC) statistics 2015, Romania is the country in the European Union that reports the highest emissions of CH<sub>4</sub> from the oil and gas sector to the atmosphere, in particular related to methane production and end use. However, the estimates reported by Romania are derived using non-country-specific Tier 1 emission factors, and there are only very few observations which investigate whether the reported emissions are realistic. Such measurements will be provided in the project **ROMEEO (ROmanian Methane Emissions from Oil & gas)**. The measurements will result in experimental quantification of CH<sub>4</sub> emissions from the oil and gas sector in Romania and will help in devising emission mitigation strategies.

The main goal of ROMEEO is a combined bottom-up - top-down quantification of the Romanian CH<sub>4</sub> emissions related to oil and gas production, processing and transport on three different scales, the exploration basin scale, the well scale and the city scale. This approach includes not only inventory statistics but quantification of individual facilities, together with a basin-scale aircraft approach. Two aircrafts (from Scientific Aviation (SA) and from The National Institute of Aerospace Research "ELIE CARAFOLI" – INCAS) will be used for the basin scale quantification, and several vehicles together with drone-based measurements for the facility scale estimates. The campaign is scheduled from the 30<sup>th</sup> of September till the 20<sup>st</sup> of October. Besides this, emissions in the city of Bucharest will be mapped due to logistical reasons already in August. The campaign is executed in close collaboration with the European H2020 project **MEMO<sup>2</sup> (MEthane goes MOBILE - MEasurements and MOdelling)**, <https://h2020-memo2.eu>.

## 1.2 Objectives

ROMEEO aims at an experimental quantification of CH<sub>4</sub> emissions from the oil and gas sector in Romania at different scales, which can help in devising emission mitigation strategies. To reach this goal, ROMEEO has the following objectives:

### 1.2.1 Basin scale emissions

Basin scale emissions will be derived from a top-down mass balance approach using high-precision airborne and ground-based measurements of CH<sub>4</sub> concentration downwind and upwind of large methane production regions. Aircraft-based measurements will be extended down to the ground level using high precision sensors on vehicles. Scientific flights will be planned using meteorological forecasts and mass balance models will be used for evaluation. To support source attribution, air samples will be collected for analysis of isotopic composition and higher hydrocarbon (HC) content.



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### 1.2.2 Well scale emissions

Well scale emissions will be derived using local ground-based and airborne measurements of methane concentration on vehicles and drone platforms (potentially aircraft, depending on permissions). To support source attribution, air samples will be collected for analysis of isotopic composition and higher HC content.

### 1.2.3 City scale emissions

Studies in the US indicated that very localised (and short-term) emissions from the natural gas distribution network can significantly contribute to local CH<sub>4</sub> emissions and offer an (cost-) efficient pathway to emission reductions (McKain et al. 2015, Hopkins et al. 2016), and that in some regions, constant but slow fugitive emissions significantly contribute as well (Wunch et al. 2016). City scale emissions will be derived using vehicle based high-precision measurements of methane concentration at the street level. Emission locations will be categorized into large, medium and small emissions using the formalism suggested in von Fischer et al. (2018). To support source attribution, air samples will be collected for analysis of isotopic composition and higher HC content.

## 2. Logistics

The size of the campaign with approximately 80 participants from more than 10 international institutes require a careful logistical planning, included in the preparations before and the daily planning during the campaign. Particularly the target regions, the distribution of the groups and the collaboration of them is a crucial element in the logistical procedures.

### 2.1 Target regions

The target areas are dedicated to the scientific objectives. The definition of target areas is crucial for ROMEEO and one of the main topics of preparation. It includes information of Romanian authorities, involved oil and gas companies, and open sources such as existing emission inventories and well locations.

According to the aim of ROMEEO, initially five regions based on emission inventory information (Fig. 1a) were identified as possible targets. All areas show characteristic oil and/or gas production activities. Based on additional information from pre-campaign flights and inventory verifications, the locations of the gas basins and gridded information on production sites (Fig. 1b), the target regions were narrowed down to areas in Transylvania and around Bucharest as the largest natural gas fields but also underground storage capacities are located in these regions (Fig. 2).

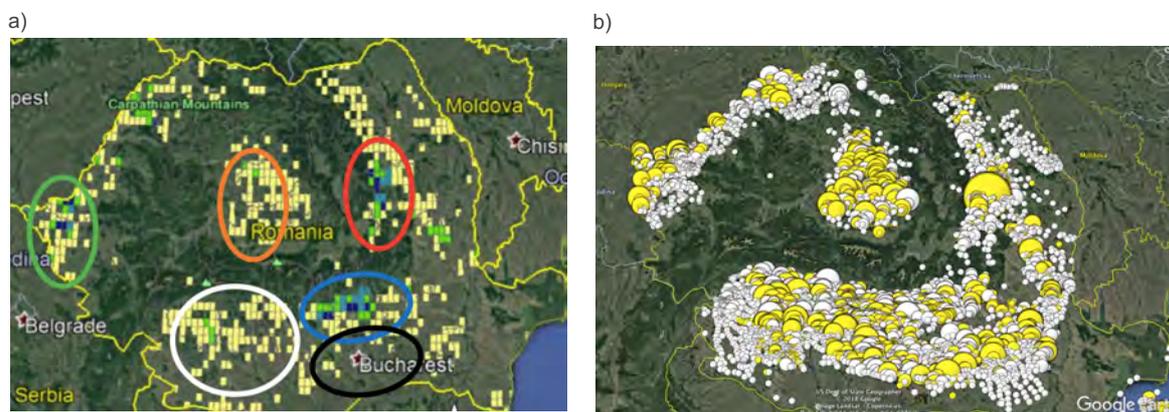
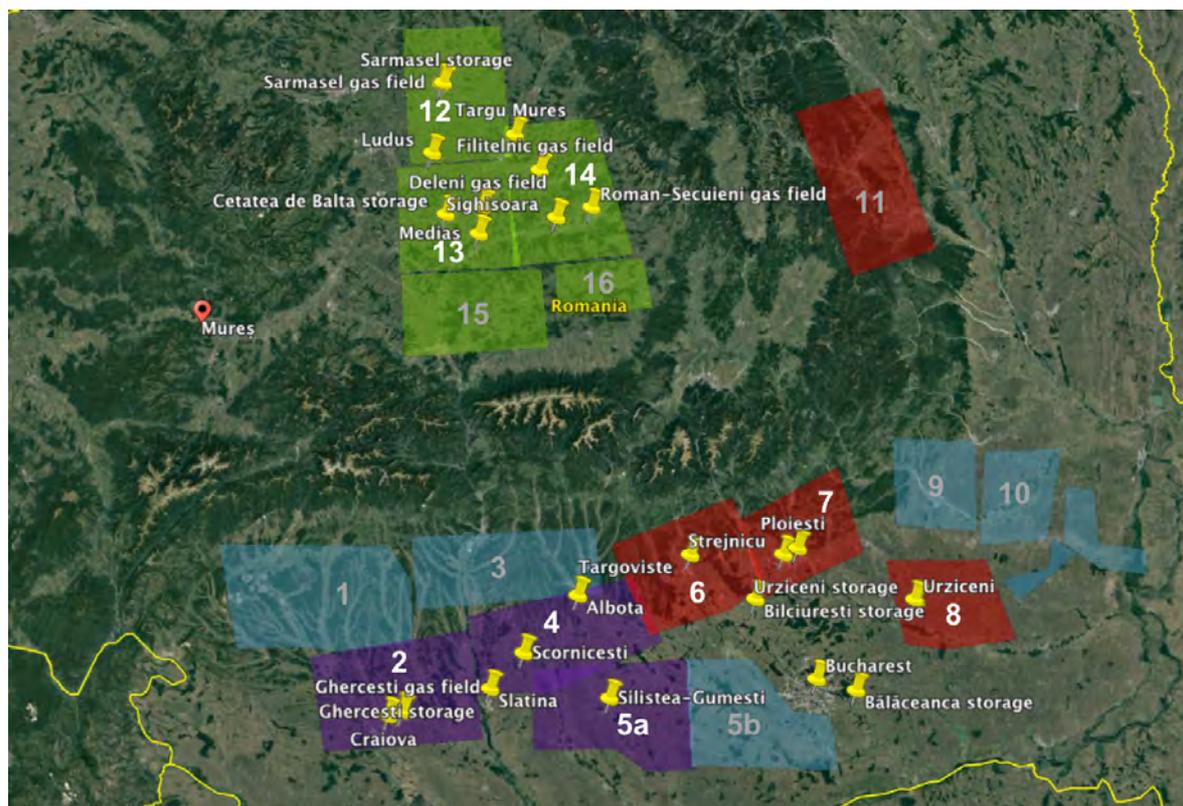


Fig. 1: a) overview of the investigated preliminary target locations, b) overview of active and passive wells in Romania



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**Fig. 2:** Overview of potential areas to be investigated during ROMEEO, including largest gas fields and underground storage facilities in Romania

The selected areas have an average size of 40x60 km, are logistically reachable within the constraints of ROMEEO and suitable for the applied methods during the campaign.

The areas belong to three Romanian regions: Oltenia (western Walachia), Muntenia (eastern Walachia) and Transylvania. Table 1 gives an overview of the selected areas.

**Table 1:** overview of selected areas and their main characteristics

Area nr.	size	Main cities	Geographical characterization	main operator
2	45 x 70 km	Craiova	Hilly, mix forest and agricultural, in the north foothills of the Transylvanian Alps, heights 100 - 300 m	Petrom
4	35 x 70 km	Scornicesti / Albota	Hilly, mix forest and agricultural, in the north foothills of the Transylvanian Alps, heights 200 - 450 m	Petrom
5a	40 x 70 km	Silistea-Gumesti	Agricultural, Hilly, heights 70 - 220 m	Petrom
6	40 x 55 km	Targoviste	Hilly, mix forest and agricultural, foothills of the Transylvanian Alps, heights 800 - 150 m	Petrom
7	40 x 50 km	Ploiesti / Strejnicu	Hilly, mix forest and agricultural, foothills of the Transylvanian Alps, heights 600 - 150 m	Petrom
8	35 x 45 km	Urziceni	Flat, agricultural, heights 30 - 80 m	Petrom
11 (optional)	35 x 70 km	Bacau	Forest, Eastern Carpathian Mountains, heights 400 - 1500 m	Petrom
12	40 x 55 km	Targu Mures / Ludus	Agricultural, Northern Transylvanian Plateau, height 250 - 600 m	Romgaz
13	40 x 50 km	Medias	Agricultural, Transylvanian Plateau, height 250 - 500 m	Romgaz
14	45 x 60 km	Sighisoara	mix forest and agricultural, Eastern Transylvanian Plateau, height 300 - 700 m	Romgaz



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### 2.2 Teams

17 teams are involved, of which 13 research teams are participating in the field to measure CH<sub>4</sub> as well as other atmospheric compounds and meteorological data. Around 80 people from 20 nations are participating, 2/3 of them directly working in the field and the others support the measurement teams by providing modelling data, analyses and forecasts, logistics and administration. Support is also coming from the Romanian ministries and the two main oil and gas companies, OMV Petrom and Romgaz.

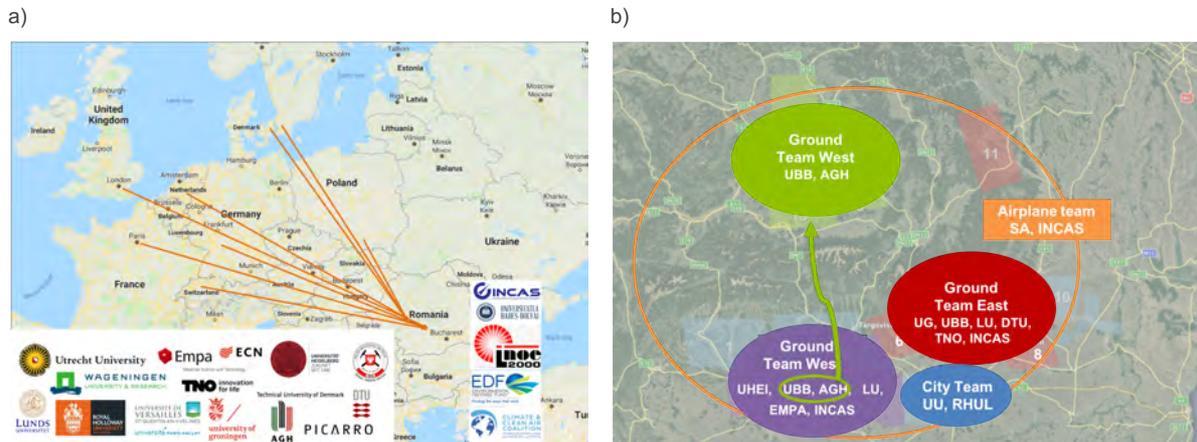


Fig. 3: a) Participating teams (see also Annex I), b) distribution of the teams over the groups and areas

The field teams were distributed over 4 groups (Table 2), each within a dedicated target region. The dedication of teams to the areas, the proposed measurement timelines during the campaign and the selection of driving routes depended on the following criteria:

- Measurement locations are geographically reachable by the mobile platform (geographically and timely)
- Availability of teams
- Minimization of travel time
- Geographical suitability of locations for applied methods
- Logistic requirements (e.g. hotels, re-charging instruments, safety)

Table 2: overview of ROMEEO groups and their target areas.

Group	Team	Area
Aircraft	SA, INCAS	2, 4, 5a, 6, 7, 8, 11
Ground-based East	UG, UU, DTU, TNO/ECN, Sniffers	6, 7, 8, optional 11
Ground based West	UHEI, INCAS, EMPA, AGH, UBB, INOE	2, 4, 5a (for UHEI, INCAS, EMPA, AGH, UBB), 12/13/14 (AGH, UBB)
City	RHUL, UU	Bucharest city
General support	WUR, UVSQ, EMPA, INCAS, Picarro	Scientific, logistic and instrumental support

#### 2.2.1 Aircraft group

The Aircraft group, consisting of the team from SA and INCAS, is operating 2 aircrafts. The aircrafts will cover at least the areas 2, 4, 5a, 6, 7, and 8, which are also measured by the ground-based teams West and East. The areas will be described in more detail in chapter 2.2.2 and 2.2.3. If possible area 11 will be also measured. This depends on flight permissions due to a military base in this region.

#### 2.2.2 Ground-based group EAST

The Ground-based group EAST is planned to investigate 3 areas north and north-east of Bucharest, which all belong to the eastern Walachia or Muntenia. Fig. 4 shows the envisaged measurement areas



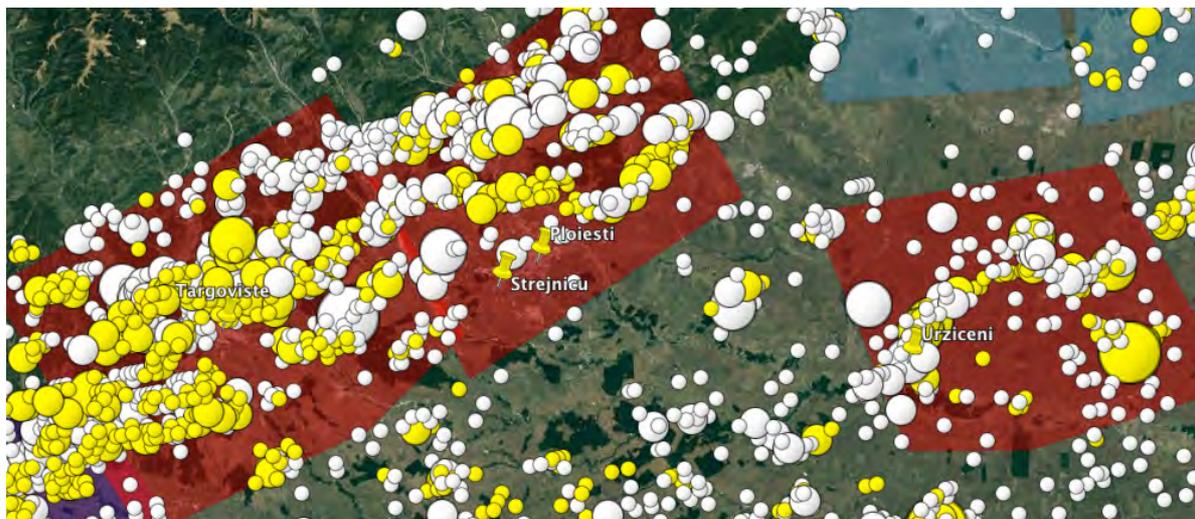
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6 (around Târgoviște), 7 (around Ploiești), and 8 (around Urziceni). Yellow circles indicate active wells, white circles the inactive ones in the region.

**Area 6** is part of Dâmbovița County, the capital city is Târgoviște. The county's landscape has three main forms with mountains from the Southern Carpathians group (the Bucegi Mountains and the Leaotă Mountains) in the north, the sub-Carpathian hills in the middle and parts of the Romanian Plain in the south. In Târgoviște one of the biggest steel factories in Romania is located. Predominant industries are also oil extraction and refinery, textile and chemical industry. Near Cornesti, In the corner south of area 6 and 7, is the Bilciuresti underground storage located, the largest of the 6 Romanian storage facilities (all operated by Romgaz).

**Area 7** is part of the Prahova County, a heavily industrialised area containing the main oil reserves in Romania. The oil industry is the predominant industry in this area, accounting for almost 50% of the county's industrial production. Besides this also chemical industry, rubber, food and textile industry are present. To some extent also agriculture is developed - in the southern part mainly extensive agriculture and the hills area is well suited for wines and fruit orchards. In total it realises about 3% of the country's agricultural production.

**Area 8** belongs to the Ialomița County around the city Urziceni. It is situated in the Bărăgan Plain in south-eastern Romania, a flat and steppe plain area crossed by small rivers with small but deep valleys. The area is mainly agricultural, mostly cereal-growing. Industry, focussed on food and textile industry, is almost entirely concentrated around Slobozia. The region is known for its black soil and a rich humus. In Urziceni underground storage facilities for natural gas are located.



**Fig. 4:** envisaged measurement areas 6 (around Târgoviște), 7 (around Ploiești), and 8 (around Urziceni). Yellow circles indicate active wells, white circles the inactive ones in the region.

Optional also an area in the eastern part of Romania (see **area 11**, Fig. 2) around Comănești will be investigated. The area belongs to the Bacău county, which was one of the most industrialized regions in the communist period. It remained Moldavia's most important industrial center ever since. The predominant industries in the county are the chemical and the oil industry, with two large oil refineries at Onești and Dărmănești. Around Comănești coal and forest industry was the dominating industry until a few years ago. Both are closed and economically this area is dominated by small local businesses. Bacău county is restricted by the Eastern Carpathian Mountains in the west with decreasing heights towards the East. The lowest point can be found on the Siret River valley which crosses the county from North to South in the middle. On the East side there is the Moldavian Plateau crossed by many small rivers.



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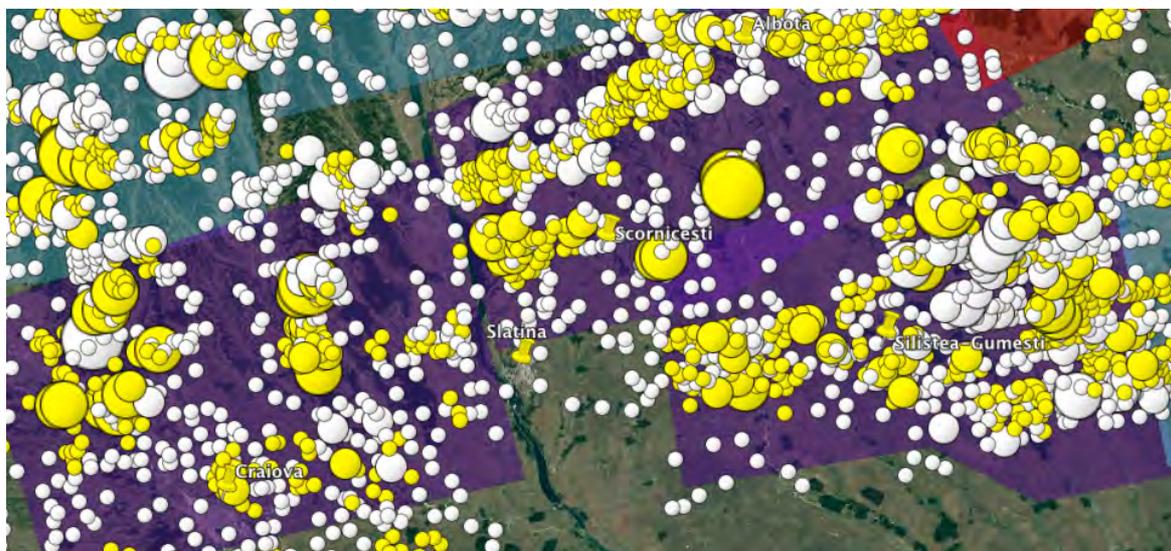
### 2.2.3 Ground-based group WEST

The Ground-based group WEST is planned to investigate 3 areas in the Wallachia north-west and west of Bucharest, and also 3 optional areas in Transylvania. Fig. 5 shows the envisaged measurement areas 2 (around Craiova), 4 (around Scornicesti), and 5a (around Silistea-Gumesti), Fig. 6 shows the ones in Transylvania (area 12 - 14). Yellow circles indicate active wells, white circles the inactive ones in the region.

**Area 2** lays in the triangle of the three counties Dolj, Olt, and Vâlcea, mainly on the Romanian plain. The region is relatively flat and dominated by agriculture, mainly suited for growing cereals and vegetables. Other industries such as automotive, heavy electrical and transport equipment industry are mainly located in the city of Craiova, which is the largest city in southwestern Romania. Area 2 is restricted in the East by the Olt, a river distributing the Wallachia into Muntenia (the eastern part) and Oltenia (western part). In area 2 lays the Chercesti gas field and also underground storage facilities.

**Area 4** covers the north of the Olt and the middle of the Argeş County. As area 2, the area is relatively flat and dominated by agriculture. Oil is being extracted in the eastern part of the area. Also, there are a few coal mines. Area 4 is separated in the north-east from area 6 by the Argeş River.

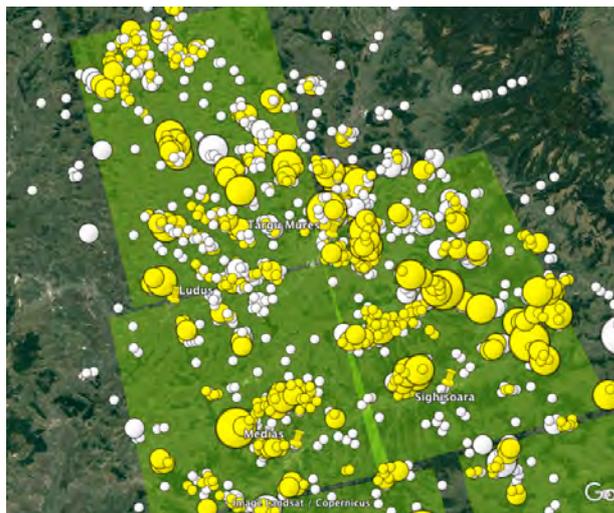
**Area 5a** lays mainly in the counties Teleorman and Argeş on the parts of the Romanian plain. The area is flat and dominated by agriculture. There is some oil extraction in the south of the area.



**Fig. 5:** envisaged measurement areas 2 (around Craiova), 4 (around Scornicesti), and 5a (around Silistea-Gumesti). Yellow circles indicate active wells, white circles the inactive ones in the region.



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**Fig. 6:** envisaged measurement areas in Transylvania 12 (above Ludus / Targu Mures), 13 (around Medias) and 14 (around Sighisoara). Yellow circles indicate active wells, white circles the inactive ones in the region.

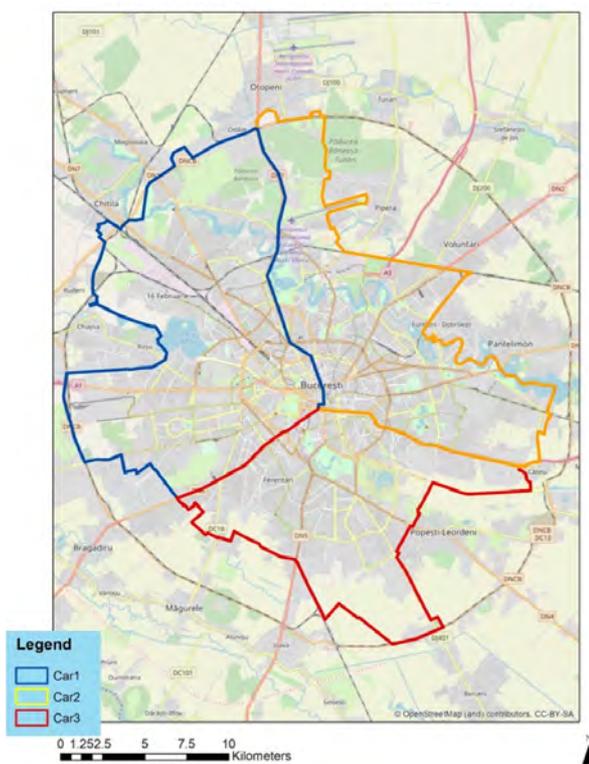
**Area 12** lays, together with the **areas 13 and 14**, mainly on the Transylvanian Plateau which is almost entirely surrounded by the Carpathian Mountains. The region is formed of a network of valleys of various sizes, ravines and canyons, united together by numerous small mountain ranges, which attain a height of 150 - 250 m above the altitude of the valley and a mean elevation of 300 - 500 m. Area 12 is located in the county triangle of Mures, Cluj and Bistrița-Năsăud. Area 13 lays on the county triangle Mures, Alba, and Sibiu, and area 14 covers the south-eastern part of Mures. Within the selected areas 4 of the main gas fields of Romania are located, including the largest one, the Deleni gas field (area 13). Mureș and Sibiu together produce about 50 % of the natural gas developed in Romania.

### 2.2.4 Bucharest CITY group

Urban cities are important targets for greenhouse gas emissions mitigation as they constitute emission hotspots. Important sources are the fugitive emissions from engineered systems such as natural gas pipelines. CH<sub>4</sub> mitigation in cities is beneficial for several reasons. One the one hand it is the reduction of an economic commodity. Besides this, high concentrations of CH<sub>4</sub> are also a safety hazard as it poses an explosion risk and reduce air quality.

Bucharest, with almost 2 million inhabitants (> 10% of the country's population) and more than 200 km<sup>2</sup>, is the biggest city in Romania and has been chosen for investigations of CH<sub>4</sub> missions on city scale. Due to logistical reasons – accessibility of the city, availability of instruments – this part of ROME O had been executed separately from the other ROME O campaign parts already in August by the teams of Utrecht University (UU), Royal Holloway of London (RHUL), and the National Institute of Aerospace Research “ELIE CARAFOLI” (INCAS).

To ensure a representative coverage within the measurement period, the city was sampled by three cars simultaneously (Fig. 7).



**Fig. 7:** Subdivisions of Bucharest, measured by 3 mobile platforms



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## 3. Campaign deployment

### 3.1. Campaign timeline in general

Although officially launched in October 2019, ROMEEO started already in May 2019 the preparation activities and will run until October 2020. The practical part of the campaign is scheduled from 30st of September till 20st of October 2019, with an additional time period of one year afterwards to analyse data and prepare the publication of results. The Gantt Chart in Annex III gives an overview of the project timeline and the contractual deliverables to the funding agency in general, the Gantt Chart in Annex IV shows the preliminary day-to-day planning per team. The day-to-day planning will be kept up-to-date during the campaign, depending on weather conditions and preliminary results which might lead to changes of measurement locations and team constellations. The day-to-day planning will be discussed within the teams and group leaders and is available on the campaign wiki (<http://romeo-memo2.wikidot.com/overview>).

### 3.2 Campaign participants and responsibilities

The campaign is an international and interdisciplinary effort, with around 80 participants from 17 mainly European institutions. ROMEEO is overall coordinated by Thomas Röckmann (UU) for the scientific part and Andreea Calcan (INCAS) for the local logistical operations. As described in Chapter 2.2, the participants will execute the campaign assigned to one out of four groups with dedicated measurement areas and tasks. Each group consists of several teams and has one group leader. Annex II gives a brief overview of all ROMEEO participants, the following chapters describe the groups and teams, and their tasks in more detail.

#### 3.2.1 Aircraft group

The **Aircraft group** consists of the teams of Scientific Aviation (SA) and INCAS as the responsible aircraft owners, and the Environmental Defense Fund (EDF). The group will be led by Stefan Schwietzke from EDF.

**Table 3:** overview of the Aircraft group

Team	Team member	Task
EDF	<b>Stefan Schwietzke</b>	Overall ROMEEO co-coordinator, EDF team leader, contact for general logistics and communication Oil/Gas companies
INCAS	<b>Andreea Calcan</b>	Overall ROMEEO co-coordinator, INCAS team leader, contact for general local logistics, communication with local authorities and air traffic controller
INCAS	Magdalena Ardelean	Contact for general local logistics and communication with local authorities and air traffic controller
INCAS		Pilot
INCAS	Oana Pîrvu	Officer in charge aviation security
SA	<b>Mackenzie Smith</b>	Senior scientist
SA	Niall Armstrong	Pilot

#### 3.2.2 Ground-based group EAST

The ground-based group EAST is overall led by Huilin Chen from the University of Groningen (UG), and Antonio Delre from the Technical University of Denmark. Group EAST includes the teams of the University of Groningen (lead Huilin Chen), Utrecht University (UU, lead Thomas Röckmann), Technical University of Denmark (DTU, lead Charlotte Scheutz), TNO (TNO, lead Arjen Hensen), the Sniffers (lead Indy Vatteroth), and the National Institute of Research and Development for Optoelectronics (INOE, lead Dragos Ene). The teams facilitate several mobile platforms such as 4 cars, a measurement truck,



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and a drone equipped with active AirCore to measure not only CH<sub>4</sub> but also many other trace gases (CO<sub>2</sub>, CO, N<sub>2</sub>O etc.) and meteorological data. TNO and DTU will perform additional tracer release tests using N<sub>2</sub>O and C<sub>2</sub>H<sub>2</sub>, and together with Sniffers the effectiveness and efficiency of leak repairs will be investigated.

**Table 4:** overview of the ground-based group EAST

Team	Team member	Task
<b>UU</b>	<b>Thomas Röckmann</b>	<b>Overall ROMEEO coordinator, UU team leader</b>
	Malika Menoud	Isotope sampling, operating MS
	Hossein Maazallahi	Atmospheric sampling, operating Picarro
	Patryk Lakomic (LU)	Driver, team support
	Sylvia Walter	Coordination support
<b>UG</b>	<b>Huilin Chen</b>	<b>Group leader, UG team leader</b>
	Katarina Vincovic	Operating active AirCore and sample analysis
	Steven van Heuven	Equipment setup and meteorological measurements
	Marcel de Vries	Equipment setup and meteorological measurements/UG drone pilot
<b>DTU</b>	<b>Charlotte Scheutz</b>	<b>DTU team leader</b>
	Antonio Delre	Operating DTU instrumentation
	Konstantinos Kissas	Operating DTU instrumentation
<b>TNO</b>	<b>Arjan Hensen</b>	<b>TNO team leader</b>
	Pim van der Bulk	Operating TNO instrumentation
	Ilona Velzeboer	Operating TNO instrumentation
	Hugo Denier van der Gon	Scientific support
<b>Sniffers</b>	<b>Indy Vatteroth</b>	<b>Sniffers Team leader</b>
	Danut Dimitru	Sniffers team member
<b>INCAS</b>	<b>Andreea Calcan</b>	<b>INCAS team leader</b>
	Aurel Constantin	Student assistant, translator, drone pilot
	Sebastian Iancu	Student assistant, translator
	Alex Nica	Drone pilot
	Sorin Ghemulet	Driver
	Constantin Visoiu	Drone department leader
<b>UBB</b>	Cristian Pop	General operating instrumentation, translator
<b>INOE</b>	<b>Dragos Ene</b>	<b>INOE team leader</b>
	Razvan Doru	INOE team member
	Alexandru Dandosci	INOE team member

### 3.2.3 Ground-based group West

The ground-based group WEST is led by Martina Schmidt from the University of Heidelberg (UHEI), and includes the teams of the University of Heidelberg (UHEI, lead Martina Schmidt), the National Institute of Aerospace Research “ELIE CARAFOLI” (INCAS, lead Andreea Calcan), the Swiss Federal Laboratories for Materials Science and Technology (EMPA, lead Lukas Emmenegger and Randolph Morales), the University of Science and Technology (AGH, lead Jaroslaw Necki), the Babes-Bolyai University (UBB, lead ). Group WEST will focus first on the north-east of Bucharest (area 2, 4) and then split to also investigate areas in Transylvania (area 12/13/14).

**Table 5:** overview of the ground-based group WEST

Team	Team member	Task
<b>INCAS</b>	<b>Andreea Calcan</b>	<b>INCAS team leader</b>
	Alexandru Pana	Drone pilot
	Alexandru Tudor	Student assistant, translator
	Mihai Profir	Drone pilot
	Alin Scarlat	Student assistant, translator



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	Lucian Cusa	Student assistant, translator
	Marius Corbu	Field team leader, general operating instrumentation
	Sorin Vajaiac	Student assistant, translator
	Denisa Moaca	Student assistant, translator
	Vincent Edjabou	Drone pilot
<b>UHEI</b>	<b>Martina Schmidt</b>	Group leader, UHEI team leader
	Piotr Korben	Atmospheric sampling, operating UHEI instrumentation
	Julia Wietzel	Atmospheric sampling, operating UHEI instrumentation
<b>EMPA</b>	<b>Randolph Morales</b>	EMPA co - team leader
	Jonas Ravelid	Atmospheric sampling, operating EMPA instrumentation, drone pilot
	Killian Brennan	Atmospheric sampling, operating EMPA instrumentation, drone pilot
	Bela Tuscon	Atmospheric sampling, operating EMPA instrumentation
	Lukas Emmenegger	Remote Empa team leader
	Dominik Brunner	Remote ROMEO modelling support, wiki maintenance
<b>AGH</b>	<b>Jarek Necki</b>	AGH team leader
	Mila Stanisavljevic	Atmospheric sampling, operating AGH instrumentation
	Pawel Jagoda	Atmospheric sampling, operating AGH instrumentation
	Jakub Baryzel	Atmospheric sampling, operating AGH instrumentation
<b>UBB</b>	<b>Andrei Radovici</b>	UBB team leader, operation UHRI instrumentation
	Horatiu Stefanie	Atmospheric sampling, operating UHEI / AGH I instrumentation
	Alexandru Mereuta	Atmospheric sampling, operating UHEI / AGH I instrumentation
	Artur Ionescu	UBB team member

### 3.2.4 Ground-based group CITY

The ground-based group CITY includes teams of the UU and RHUL and covers the city area of Bucharest. The overall team leader of the CITY group are Dave Lowry and Rebecca Fisher (RHUL).

**Table 6:** overview of the ground-based group CITY

Team	Team member	Task
<b>UU</b>	Hossein Maazallahi	Atmospheric sampling, operating UU instrumentation
<b>RHUL</b>	Julianne Fernandez	Atmospheric sampling, Isotope sampling, operating RHUL instrumentation
	James France	Atmospheric sampling, Isotope sampling, operating RHUL instrumentation
	<b>Rebecca Fisher</b>	<b>RHUL team leader</b>
	<b>Dave Lowry</b>	<b>RHUL team leader</b>
<b>INCAS</b>	<b>Andreea Calcan</b>	<b>INCAS team leader</b>
	Marius Corbu	Operational support
	Student assistants	General support

## 3.3 General campaign facilities, requirements, and instrumentation

### 3.3.1 General facilities and requirements

The campaign headquarter will be located at the INCAS aircraft hangar in Ploiesti. The campaign will start in Ploiesti, with joint measurements for the first days. Afterwards the groups as described in chapter 3.2 will be located at the respective areas where they will execute their part of the campaign. Beside the technical scientific instrumentation and facilities, the campaign depends on general facilities for being operational. This includes e.g. good communication facilities, technical support or opportunities to meet for briefings. Table 7 gives an overview of the team locations and the general facilities at the locations. Each team has its own scientific instrumentation and facilities as described in Table 8 / Chapter 3.3.2.



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**Table 7:** overview team requirements and locations

Group	Group leader	Location	facilities
AIRRAFT	Stefan Schwietzke	Ploiesti	Aircraft hangar, meeting rooms, internet, safe parking, Romanian speaking support
EAST	Huilin Chen	Ploiesti, Urziceni	Meeting rooms, availability to re-charge instruments, safe parking, Romanian speaking support, field measurements
WEST	Martina Schmidt	Ploiesti, Pitesti, Craiova	Meeting rooms, availability to re-charge instruments, safe parking, Romanian speaking support, field measurements
CITY	Dave Lowry / Rebecca Fisher	Bucharest	Meeting rooms, availability to re-charge instruments, safe parking, Romanian speaking support

### 3.3.2 Overview of used scientific instrumentation

Each team will have its own instrumentation, which is available during the whole campaign. The teams are responsible to inform the coordinators in time about special requirements different from general ones regarding charging or handling.

**Table 8:** Scientific instrumentation

Group	Team	Instrument	Instrument Owner	Measured variables	Platform	Platform operator
Aircraft	INCAS	Picarro G2401-m	INCAS	CO, CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> O mole fraction profile, (extend with CH <sub>4</sub> -C <sub>2</sub> H <sub>6</sub> instrument, loaner from Picarro)	BN-2A 27 aircraft	INCAS
Aircraft	SA	Picarro, wind system	SA	CO, CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> O mole fraction profile	aircraft	SA
EAST	UG, INCAS, UBB	AirCore, Picarro G2401-m, 3D wind measurement	UG	CH <sub>4</sub> , CO <sub>2</sub> , CO, u, v	Drone	INCAS
		G2301	UG	CH <sub>4</sub> , CO <sub>2</sub>	Roof INCAS	UG
EAST	UU	Picarro 2301, and Picarro backpack, 2 wind sensors, isotope instrumentation	UU	CH <sub>4</sub>	vehicle (rented)	INCAS
EAST	DTU	tracer release equipment, methane sensor and wind sensor	DTU	CH <sub>4</sub> , CO <sub>2</sub> , C <sub>2</sub> H <sub>2</sub>	Van	DTU
EAST	INOE	FTIR (stationary)	INOE	CH <sub>4</sub> , CO <sub>2</sub> , CO columns	FTIR	INOE
EAST	TNO	Picarro and Aerodyne instrument, sonic, not secured	TNO	CH <sub>4</sub> , CO <sub>2</sub> , CO, N <sub>2</sub> O, u, v	van	TNO
WEST	EMPA	with QCL methane instrument, wind measurement	EMPA	CH <sub>4</sub> , H <sub>2</sub> O	drone	EMPA
WEST	UHEI, INCAS	Picarro 2301, wind sensors,	UHEI	CH <sub>4</sub> , CO <sub>2</sub> , wind	vehicle	INCAS
WEST	AGH	Picarro G2201i with isotopes, wind sensor LGR ultraportable analyser	AGH	CH <sub>4</sub> , CO <sub>2</sub> , <sup>13</sup> CH <sub>4</sub> u, v	Vehicle 1 AGH	AGH
				CH <sub>4</sub>	Vehicle 2 rented	AGH
WEST	UHEI, UBB	Licor 7810 wind measurement	UHEI	CH <sub>4</sub> , CO <sub>2</sub> , wind	Vehicle	UBB



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## 3.4 Campaign implementation

The main framework is planned in preparation to the practical part of the campaign to ensure a smooth execution of the campaign according to the contractual deliverables. However, this framework might be necessarily adjusted according to weather conditions, local geographical and logistical issues which cannot be foreseen in advance. Therefore, ROMEEO will start with 3-4 days of joint measurements to implement procedures, set-up and calibrate the instruments and decide on the final timelines.

### 3.4.1 Aircrafts and drones

For both aircrafts 50 flight hours each are scheduled. The flight activities are scheduled within the timeframe from 30th of September till 20st of October 2019. During this period, 10 flight days with 5 hours each are planned for the aircrafts. The specific days and operational areas depend on local weather conditions and flight permissions. All flight will be under VFR rules.

The drones are operated by EMPA and UG. The operators are responsible in collaboration and agreement with INCAS as the local coordinator for the necessary official Romanian permissions. The drones will fly below 150 m AGL outside cities. In case weather conditions are not suitable for executing all flight hours the timeframe will be adjusted in agreement with the involved teams.

#### 3.4.1.1 Airborne platform types, logistics, and instrumentation:

Two aircrafts and 4 drones are planned to be used within the ROMEEO campaign. The operators are responsible for the maintenance and any technical or legal aspects. The flight plans will be prepared in collaboration and agreement with INCAS as the local coordinator, respectively contact to aviation ministries and flight security.

One aircraft is a single engine Mooney M20 aircraft, operated by Scientific Aviation (SA). The second one is operated by INCAS, a BN-2A Britten Norman Islander aircraft. The aircrafts are i.a. equipped with in situ and remote sensing instrumentation for aerosol and trace gases monitoring (CO, CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>CO, NO<sub>2</sub>, SO<sub>2</sub>, water vapour), horizontal winds, temperature, and humidity.

A technical hangar is required to test on the ground the instruments that are be mounted on board of BN-2A airborne platform (in terms of time management this procedure will take about an hour prior to take-off). Additional requirements on this facility: temperature inside the hangar 20 – 30°C, and electrical alimentation: 230V. Requirements regarding the use of the airborne platform are

-  Fuel: avgas
-  Pilot's schedule: max. 12 hours of work, of which max 10 flight hours (there are no constraints regarding the minimum rest time of the pilots between two consecutive research flights)
-  refuelling stops between 2 consecutive research flights is minimal 1 hour
-  the BN-2A crew consists of two pilots and an operator for the instruments. Before flying the instruments (i.e. NO<sub>2</sub>CAPS, Picarro 1&2, SWING+, APS, Nephelometer) needs to be started at ground by specialised personnel.

The SA aircraft is planned for 10 to 12 flights including regional mass balance and facility-level quantification. A minimum of 2 focus areas will be selected out of 6 pre-defined. The daily flight schedule depends on the weather conditions, it is the pilot's decision to postpone or change a flight if necessary from a safety point of view. An in-person meeting took place in July 2019 for detailed logistical planning, together with INCAS at the INCAS aircraft hangar facility. The INCAS aircraft will perform raster flights in selected focus areas, and also mass balance flights in collaboration with SA. This will include vertical profiles either in support of the SA mass balance or in parallel for a wider spatial coverage. If possible, continuous ethane measurements will be executed to derive high-volume statistics for source attribution, and also single facility flights if wind measurements through the column can be realized. During the flights samples will be collected for isotope analyses, approximately 5-10 per flight, 100 samples in total.



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The drones are from the type INSPIRE 1 (UG), MAVIC (EMPA), and MATRICE 600 (INCAS, EMPA). The UG and the INCAS drone will be equipped with an AirCore. The EMPA drone will carry a QCLS.

### 3.4.1.2 Flight permits

In order to obtain the permits to fly, the procedures were started 3 months in advance. The flights will be performed only if the weather condition will permit. For this reason, a longer period will be targeted if necessary, to meet the required flying hours. The Romanian authorities contacted for obtaining flight permits are the Romanian Civil Aeronautical Authority, ROMATSA – Air Traffic Controller, and the Ministry of National Security. The drones do not need a dedicated flight permit but must be registered.

### 3.4.1.3 Flight pattern

The drones will fly at facility level, suitable facilities will be selected in the field. Further requirements are the downwind accessibility of facilities and a not-hilly terrain.

The aircraft planning for flight pattern assumes 2-hour flights. The 6 boxes in Fig. 8 describe the general spatial boundaries for the research flights, a final decision for probably 2 or 3 boxes will be made during the campaign depending on weather conditions.

Each box represents the largest necessary extent that needs to be covered. The full boxes may not always be accessible because of airspace restrictions, such as military airspaces. Boxes will be adjusted according to the restrictions from the Civil Aviation Authority or other applicable authorities. This includes cutting corners, shrinking boxes, or leaving out restricted areas inside each box. As described below, the orientation of each box in Fig. 8 is illustrative, and will be oriented according to wind direction on each day, but without exceeding the spatial boundaries of each box. Table 9 gives the planned boarder points of the boxes given in Fig. 8.

In each box, we are requesting authorization to perform, if possible, all flight four patterns as:

- 🌐 **Box flights:** Flight pattern along the edges of each box. The exact orientation of the box depends on the wind direction on each day. The box will be oriented perpendicular to the wind direction. The upwind and downwind edges of the box will be flown multiple times at different altitudes. The altitudes range from the minimum legal/safe flight altitude until the top of the boundary layer (usually between 1000 - 3000 m AGL, but weather dependent). The objective is to understand the inflow and outflow of methane for each box.
- 🌐 **Raster flights:** Flight pattern as indicated by the blue lines in Fig. 8. This means parallel transects with approximately 2 to 10 km spacing between each transect. The altitude will be near (but above) the minimum legal / safe flight altitude including an additional safety margin of about 100 m. The objective is to understand the spatial patterns of methane concentrations in each box.
- 🌐 **Vertical profile flights:** Spiralling flight pattern inside each box with a diameter of approximately 3 km. The lowest altitude will be near (but above) the minimum legal / safe flight altitude. The spiral will go up through the top of the boundary layer (see above), but will end approximately 500 m past the top of the boundary layer. The objective is to determine the vertical distribution of methane concentrations and other meteorological parameters.

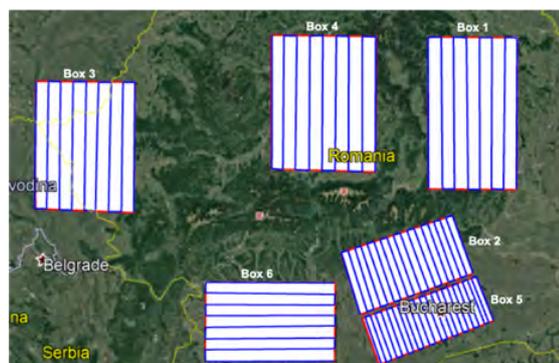


Fig. 8: General overview of the possible spatial extent for the research flights.

Table 9: boarder points of boxes as in Fig. 8

Box	Latitude	Longitude
P1	44°32'36.64"N	25°52'35.55"E
P2	44°34'11.73"N	26°14'43.89"E
P3	44°27'12.12"N	26°21'12.67"E
P4	44°18'2.67"N	26°16'36.61"E
P5	44°16'59.24"N	25°58'45.86"E
P6	44°24'8.02"N	25°49'38.90"E



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- *Facility flights:* Spiralling flight pattern inside each box around potential methane emitting sources. Spirals will have a diameter of approximately 1 - 2 km. The lowest altitude will be near (but above) the minimum legal / safe flight altitude. The spiral will go up at most to the top of the boundary layer (see above). The objective is to understand the inflow and outflow of methane for each facility.

### 3.4.2 Ground based operations

The ground-based operations are executed by the groups WEST, EAST, and CITY.

The CITY group, consisting of teams from the UU, RHUL, and INCAS, already measured CH<sub>4</sub> during August 2019 in the city of Bucharest. In total 3 cars, equipped with Picarro instrumentation executed this part of ROMEEO. Fig. 7 gives an overview of the targeted area. On request of the Romanian Ministry for Environment the city of Ploiesti is scheduled optional, too.

Group WEST and EAST consist of teams operating 3 to 4 cars and 1 to 2 drones.

#### 3.4.2.1 Used methods

Within ROMEEO we will use several methods and instrumentations to measure CH<sub>4</sub> and its emissions. More details on the methods and peer-reviewed literature will be available as guidelines on the wiki.

##### 3.4.2.1.1 Emission screening / Mass Balance Approach

The goal of this method is to identify super emitter, to statistically classify the oil and gas wells in “emitter classes” and to prepare the planning for the next day(s). For the emission screening each car should be equipped with a CH<sub>4</sub> analyser, a GPS mouse and a suitable wind sensor on the roof of the car. Cars should drive as slow as possible downwind the emitters, preferably 15 - 30 km/h. However, with traffic and expressways driving speed should be adjusted for safety reasons. During emission screening a first check for suitable OTM 33A locations will be made.

##### 3.4.2.1.2 OTM 33A

OTM 33A (Other Test Method) is a method submitted by the EPA's office of Research and Development (<https://www3.epa.gov/ttn/emc/prelim/otm33a.pdf>). It will be used for the mobile assessment of emissions from point sources of emission heights close to the ground (fugitive and vented emissions from gas and oil wells). Each car should be equipped with a CH<sub>4</sub> analyser, if possible with 1Hz data acquisition, a GPS mouse, and a 3D sonic anemometer, which can be placed close to the car. Measurements can be done in 20 - 60 min, parking the car in the plume downwind of an emitter in a distance of 20 – 200 m. For statistical reasons this method should be repeated. It is also necessary to identify possible interferences with other sources and to ensure stable atmospheric conditions. The data will be analysed using a dedicated OTM 33A code, which will be available.

##### 3.4.2.1.3 Gaussian plume approach

By applying this method, the emission plume is crossed several times while passing by perpendicular. The “identification” of peak and atmospheric stability for OTM33A method can be used. Each car should be equipped with a CH<sub>4</sub> analyser, a GPS mouse, and a 2D or 3D sonic anemometer, which can be placed close to the car. A simple “weather station” can also be used. Concentration mapping should be done downwind as well as upwind of a facility, and interfering emitters should be identified. For statistical reasons surveys should be repeated several times (preferably 10 times). Data analysis can be done by “simple” Gaussian plume approach.

##### 3.4.2.1.4 Tracer gas dispersion method

By applying the tracer gas dispersion method, acetylene as a tracer gas is released at an emission source with a controlled release rate. This will be combined with plume measurements of CH<sub>4</sub>. The ratio between measured CH<sub>4</sub> and tracer will give the emission rates from the source. Each car should be equipped with a CH<sub>4</sub> analyser, a GPS mouse, and a 2D or 3D sonic anemometer, which can be placed close to the car. Interfering emitters should be identified. Preferred distance is 50 – 100 m downwind the source. For statistical reasons surveys should be repeated 10 to 15 times.



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### 3.4.2.1.5 Drone based measurements

All methods mentioned in Chapter 3.4.2.1.1 to 3.4.2.1.3 are also useable for the drones. For the OTM 33A the drone needs to be positioned in the center of the CH<sub>4</sub> plume, ensuring measurements of wind data in parallel for 20 min. Additional investigation is needed about possible affects by the drone itself.

For the drones some joint experiments will be planned, such as

- Comparison of drone-based Mass Balance Approach, OTM 33A, and Gaussian Plume Approach
- Assess the interference of neighbouring facilities plumes, especially in clusters
- Comparison of measurements investigating gas flaring

### 3.4.2.1.6 FTIR

A FTIR spectrometer will be installed at the head quarter at the INCAS airfield in Ploiesti, measuring column concentrations of O<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>O, and CO. The instrument requires constant weather conditions with clear sky and no clouds.

### 3.4.2.2 Planned measurement program

The planned measurement program is ambitious but realistic, considering also un-controllable issues as e.g. weather conditions or bad road conditions. So, we strive for at least 15 full measurement days at 2 to 4 sites per day for the vehicle teams, and end up with approximately 120 vehicle-based facility estimates for group WEST and EAST each. For the drone-based measurement we also strive for 15 full measurement days, with 1 to 2 sites per day and by this approximately 20 drone-based facility estimates per group.

As a general procedure for executed measurements all teams have to

- Ensure proper documentation, as detailed as possible, e.g. including accessibility, obstacles, GPS positions, measurements start and end, distance to the source, source height, ect., also by appropriate photos and videos about the facilities, environment or weather conditions
- Ensure timely upload of data on the wiki
- Select suitable facilities based on the weather forecast
- Briefing within the group about the daily planning before starting in the morning

### 3.4.3 Sampling for isotope analysis:

Within all groups samples for isotope analyses will be collected to investigate CH<sub>4</sub> sources. The aircraft group will sample approximately 5-10 samples per flight, ending up with 100 air samples for isotope analyses. The ground-based groups will sample 3 to 4 samples per facility, planned from 40 facilities and 10 background samples (150 samples in total). The CITY group had been asked to sample in total 100 samples (3 samples at 30 locations, and 10 background samples).

## 3.5 Communication

### 3.5.1 Communication in the field

Communication in the field is crucial for campaigns as ROMEEO, because a high number of teams working at different locations need to be organised on a daily base, depending on accessible locations in combination with local weather conditions. Communication will be organised on four different levels, the

- Coordination level includes the overall coordinators from the UU, INCAS and EDF
- Group level includes the overall coordinators and the group leaders
- Team level includes the team members
- General campaign communication level includes all ROMEEO participants

Communication lines within and between the levels are organised either directly by phone, or via dedicated WhatsApp groups and email. Each team will nominate one responsible contact person. The



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coordination team is also responsible for the communication outside the consortium, including stakeholders, aviation security or organisation of accommodation.

Each day will start with a briefing in the morning, where the group leader will present the program of the day for the vehicle and the drone teams. Those programs will give the framework and can be adjusted during the day.

A similar procedure will be implemented at the end of the day to summarize the activities and discuss if there were any problems encountered.

### **3.5.2 Communication with remote participants**

This includes the communication with e.g. our modelling support at EMPA or technicians in the home labs. The communication lines are in principle similar as those in the field. The remote participants are included in the email communication or WhatsApp groups where necessary and are available directly by phone. For the modelling support a dedicated wiki was set-up by EMPA, which is available for all ROMEEO participants, and partly for the public.

### **3.5.3 Communication with the public**

An objective of ROMEEO is to ensure the visibility of the campaign and publish the results for further use. However, communication with the public is a crucial issue as not only the scientific topic is sensitive but also the location and facility data provided by the partners from the ministries and the oil and gas industries should remain within the consortium. Therefore, all participants will be briefed which data are confidential and how to communicate with social media. This will be done at the beginning of the campaign.

Beside the public available part of the wiki, impressions of the campaign will be published via blogs on the MEMO<sup>2</sup> website, LinkedIn, Instagram and Twitter. Collaboration with the participants' public relation offices will be encouraged. The public relation strategy of MEMO<sup>2</sup> will be adopted, where necessary adjusted.

## **4. Data**

### **4.1 Data handling during the campaign**

#### **4.1.1 Data calibration**

The first days of the campaign will be dedicated for joint measurements, including measurements of several calibration gases which are available for all campaign participants. Data will be shared to ensure intercomparability of results.

#### **4.1.2 Data analysis and storage**

Data will be analysed as fast as possible for the purposes during the field campaign. To assure FAIR data, i.e. data meeting the criteria for further use and by this to fulfil the campaign objectives, the data management of MEMO<sup>2</sup> will be adopted and where necessary adjusted based on the contractual agreements between the coordinator and the UN.

Raw data will preferably be uploaded directly to dedicated folders on the ICOS Carbon Portal (<https://www.icos-cp.eu>), which are password protected and only available for the participants or on request.



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## 4.2 Data handling after the campaign

### 4.2.1 Data analyses and storage

The data analyses will follow the timeline given in the UN contract, see Chapter 5. Data, i.e. raw data and processed data, will be stored in a long-term on the ICOS Carbon Portal (<https://www.icos-cp.eu>) in dedicated folders for the ROMEEO campaign. The folders are password protected and only available for the participants or on request.

### 4.2.2 Data exchange, use, and public availability

Data will be exchanged and used on the purpose of the campaign and scientific collaboration. The data management of MEMO<sup>2</sup> will be adopted, and where necessary adjusted based on the contractual agreements between the coordinator and the UN.

## 5. Deliverables

Deliverables and milestones have been defined for several activities before, during and after the campaign to ensure an efficient and effective implementation and execution of ROMEEO. They are linked to the distribution of the available budget.

In total 43 deliverables, distributed over 5 activities, have been defined. The progress of the deliverables will be described in the Progress Report to the UN in January 2020.

### 5.1 Activity 1 – Campaign preparation and management

Activity 1 describes the preparation and management activities to ensure a smooth and well-targeted execution of the campaign. This includes administrative and scientific activities, such as the preparation of the Campaign Implementation Plan (CIP), the specification of the target regions, facilities to be deployed, measurement protocols and data processing steps that will be followed during ROMEEO. Activity 1 will involve obtaining more detailed activity data by ROMEEO partners, and - if possible - establishing contact with Oil & Gas production companies. It also involves obtaining all required permissions from the local authorities, and preparation of facilities. Activity 1 will also include preparatory meetings in person and remote of participating institutions and a site visit of the team leaders to Romania.

**Table 10:** Deliverables of activity 1

Nr.	Deliverable description	Nature	Due date
D1.1	Local preparatory meeting to discuss the campaign in general and establish contact (UU)	Informal report	30 September 2019
D1.2	In-person preparatory meeting (as a side event to the NCGG8) to update participants and initiate the campaign implementation plan (UU)	Report	30 September 2019
D1.3	Approval of flight permissions for SA (SA, INCAS)	Documentation	30 September 2019
D1.4	Bottom-up inventories for selection of target areas (UU)	Report	30 September 2019
D1.5	1st pre-campaign visit (INCAS, RHUL, UU)	Campaign report	30 September 2019
D1.6	Registration of drones from INCAS, UG, EMPA	Documentation	30 September 2019
D1.7	Measurement protocol for well-scale quantification (UG, UHEI)	Protocol	30 September 2019
D1.8	Approval of flight plans for SA, INCAS (INCAS, SA)	Documentation	30 September 2019
D1.9	Campaign Implementation Plan (CIP) ready (UU, UG, UHEI)	Delivery of CIP	30 September 2019
D1.10	2nd pre-campaign visit executed (UU, UG, UHEI)	Campaign report	30 September 2019
D1.11	Management (UU)	Report	31 October 2020



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### 5.2 Activity 2 - Basin-scale campaign part

The basin-scale part of ROMEEO includes aircraft-based measurements which will be extended down to the ground level using high precision sensors on vehicles. Scientific flights will be planned using meteorological forecasts and mass balance models will be used for evaluation.

Two aircrafts will be deployed, one from INCAS and a second one hired from Scientific Aviation (SA). The aircraft of SA is planned for 10-12 upwind and downwind flights as indicated in Chapter 3.4.1 including regional mass balance and facility-level quantification (choice depending on daily weather situation) over a minimum of two focus areas. The INCAS aircraft will fly low-altitude raster flights in the envisaged focus areas to investigate the spatial distribution of CH<sub>4</sub> plumes. If possible, continuous ethane measurements will be implemented on the INCAS aircraft for source attribution. Additional single facility flights will be executed if wind measurements through the column can be realized. If required, ground teams of the well-scale campaign part (Activity 3) may measure below the aircraft tracks. To ensure the intercomparability of results, all analysers (aircraft and vehicles) will be intercalibrated.

During the campaign raw data will be uploaded to the ICOS Carbon Portal (<https://www.icos-cp.eu>). The coordinator will facilitate the data upload via the wiki.

**Table 11:** Deliverables of Activity 2

Nr.	Deliverable description	Nature	Due date
D2.1	Scientific flights executed according to the CIP (SA)	Flight records	31 October 2019
D2.2	Scientific flights executed according to the CIP (INCAS)	Flight records	31 October 2019
D2.3	Raw data uploaded to ROMEEO data repository (SA, INCAS)	Data	31 October 2019
D2.4	Calibrated data uploaded to ROMEEO data repository (SA, INCAS)	Data	30 November 2019
D2.5	Aircraft-based basin scale mass balance calculations available (SA, UU)	Report	31 March 2020
D2.6	Identification of methane sources from raster flights (INCAS, UU)	Report	31 March 2020
D2.7	Collection of 100 air samples for isotope analysis (UU)	Samples	30 October 2019
D2.8	Isotope measurements on 100 air samples for source attribution (UU)	Report	31 January 2020
D2.9	FTIR measurements carried out, data provided and evaluated (INOE)	Data on server	31 January 2020

### 5.3 Activity 3 – Well-scale campaign

The well-scale emission quantification of ROMEEO aims to deliver mobile surface mapping of CH<sub>4</sub> mole fraction around wells and emission quantifications. Measurements be recorded using two teams that perform local ground-based and airborne measurements of CH<sub>4</sub> concentration on vehicles and drone platforms. Using drones simultaneously to the mobile vehicle platforms will deliver 3-D mapping of plumes from individual sources. Each ground team consists of three vehicle platforms and 1 drone platforms. The vehicle platforms are planned to measure on average 2-4 locations per day, each drone team to measures on average 1-2 locations per day. Facility selection will be based on available information from bottom-up inventories and meteorological conditions. Depending on flight permissions, emission quantification of individual wells by low-flying aircraft (in addition to drones) will be performed. If required, ultra-mobile analysers can be used by pedestrians and / or cyclists to provide high resolution mapping, e.g. in order to distinguish natural emissions from emissions associated with industrial activity.

During the campaign raw data will be uploaded to the ICOS Carbon Portal (<https://www.icos-cp.eu>).

**Table 12:** Deliverables of Activity 3

Nr.	Description	Nature	Due date
D3.1	Vehicles, drones, and drivers prepared for measurement (INCAS, UBB, Empa, AGH, DTU)	Report	30 September 2019
D3.2	Vehicle measurements executed according to the CIP	Data	31 October 2019
D3.3	Drone measurements executed according to the CIP	data	31 October 2019
D3.4	Raw data on ROMEEO data repository	data	31 October 2019



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D3.5	Calibrated data on ROMEEO data repository	data	30 November 2019
D3.6	Measurements evaluated with Gaussian plume model	Report	31 December 2019
D3.7	Intercalibration of instruments during the campaign (UHEI, UG)	Report	30 November 2019
D3.8	Selected measurements evaluated with particle dispersion model (Empa)	Report	31 December 2019
D3.9	Collection of 130 air samples for isotope analysis (UU)	Samples	31 October 2019
D3.10	Isotope measurements on 130 air samples for source attribution (UU)	Report	31 January 2020
D3.11	Leak detection and quantification on 3-7 selected facilities (SNIF)	Report	31 October 2019

### 5.4 Activity 4 – City-scale campaign

Bucharest as the largest city of Romania with a population greater than 2 million (> 10% of the country's population) has been chosen for investigations of CH<sub>4</sub> emissions on city scale. Studies in the US indicated that very localised (and short-term) emissions from the natural gas distribution network and constant but slow fugitive emissions can significantly contribute to local CH<sub>4</sub> emissions and offer an (cost-) efficient pathway to emission reductions. City scale emissions will be derived using vehicle based high-precision measurements of methane concentration at the street level. Emission locations will be categorized into large, medium and small emissions. The city-scale campaign is scheduled for 7-10 days with 3 vehicles, including initial untargeted surveys and two days of targeted survey to confirm persistence at locations with significant CH<sub>4</sub> elevations, and for collecting samples for source attribution using isotope measurements. Depending on flight permissions 1-2 days will be scheduled to investigate the CH<sub>4</sub> mass balance by aircraft.

During the campaign raw data will be uploaded to the ICOS Carbon Portal (<https://www.icos-cp.eu>).

**Table 13:** Deliverables of Activity 13

Nr.	Description	Nature	Due date
D4.1	Vehicles prepared for measurement (INCAS)	Report	30 September 2019
D4.2	Vehicle measurements executed according to the CIP (INCAS, RHUL, UU)	Data	30 September 2019
D4.3	Preliminary evaluation and upload of data (RHUL, UU)	Data	30 September 2019
D4.4	Calibrated data on ROMEEO data repository (RHUL, UU)	Data	30 September 2019
D4.5	Collection of 75 air samples for isotope analysis (UU, RHUL)	Samples	30 September 2019
D4.6	Isotope measurements on 75 air samples for source attribution (UU, RHUL)	Report	30 September 2019

### 5.5 Activity 5 – Analysis and evaluation

The analyses and evaluation of samples and data will last beyond the ROMEEO campaign. This activity includes the analyses of taken samples in the home labs, quality control, final calibration, and mass balance analysis of aircraft data. The results will deliver plume quantifications from individual wells by using ground-based and local airborne (drone) data, high-resolution emission maps for the city of Bucharest and detailed source information due to high precision analyses of  $\delta^{13}\text{C}$  and  $\delta\text{D}$  of CH<sub>4</sub>. It is aimed on scientific publications of results at the three scales (basin, well, city).

During and after the campaign raw data and processed data will be uploaded to the ICOS Carbon Portal (<https://www.icos-cp.eu>).

**Table 14:** Deliverables of Activity 5 – Analysis and evaluation

Nr.	Description	Nature	Due date
D5.1	Integration of available inventory data (UU, TNO)	Report incl. data	31 March 2020
D5.2	City scale data fully evaluated and uploaded (RHUL, UU)	Report incl. data	31 March 2020
D5.3	Publication on city data prepared (RHUL, UU)	Manuscript	30 June 2020
D5.4	Facility scale data integrated, harmonised, and uploaded (UHEI, UG)	Report incl. data	30 April 2020
D5.5	Publication on facility data prepared (UHEI, UG)	Manuscript	31 August 2020
D5.6	Top-down - bottom-up constraints on emissions - manuscript prepared (UU)	Manuscript	31 October 2020



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## Annex I: overview of campaign participants

First name	Surname	Institution
Jaroslav	Necki	AGH
Pawel	Jagoda	AGH
Jakub	Baryzel	AGH
Charlotte	Scheutz	DTU
Antonio	Delre	DTU
Konstantinos	Kissas	DTU
Daniel	Zavala-Araiza	EDF
Stefan	Schwietzke	EDF
Bela	Tuzson	EMPA
Dominik	Brunner *	EMPA
Jonas	Ravelid	EMPA
Lukas	Emmenegger *	EMPA
Randolph	Morales	EMPA
Killian	Brennan	EMPA
Andreea	Calcan	INCAS
Magdalena	Ardelean	INCAS
Marius	Corbu	INCAS
Oana	Pirvu	INCAS
Aurel	Constantin	INCAS
Denisa	Moaca	INCAS
Sebastian	Iancu	INCAS
Alex	Nica	INCAS
Vincent	Edjabou	INCAS
Sorin	Ghemulet	INCAS
Constantin	Visoiu	INCAS
Alexandru	Pana	INCAS
Alexandru	Tudor	INCAS
Mihai	Profir	INCAS
Alin	Scarlat	INCAS
Lucian	Cusa	INCAS
Sorin	Vajaiac	INCAS
Alexandru	Dandocsi	INOE
Doina	Nicolae *	INOE
Dragos	Ene	INOE
Razvan	Doru	INOE
Barbara	Szenasi *	LSCE
Sara	Defratyka *	LSCE
Jutta	Holst *	LU
Patryk	Łakomic	LU
David	Lowry *	RHUL
Julianne	Fernandez	RHUL

\* remote

First name	Surname	Institution
Rebecca	Fisher *	RHUL
Semra	Bakkaloglu *	RHUL
James	France	RHUL
Chelsea	Thompson *	SA
Stephen	Conley *	SA
Mackenzie	Smith	SA
Niall	Armstrong	SA
Indy	Vatteroth	Sniffers
Danut	Dimitru	Sniffers
Arjan	Hensen	TNO
Hugo	Denier van der Gon	TNO
Pim	van den Bulk	TNO
Ilona	Velzeboer	TNO
Calin	Baciu *	UBB
Giuseppe	Etiopie	UBB
Cristian	Pop	UBB
Andrei	Radovici	UBB
Horatiu	Stefanie	UBB
Alexandru	Mereuta	UBB
Artur	Ionescu	UBB
Huilin	Chen	UG
Katarina	Vinkovic	UG
Steven	van Heuven	UG
Marcel	de Vries	UG
Martina	Schmidt	UHei
Piotr	Korbeń	UHei
Julia	Wietzel	UHei
Carina	Van der Veen *	UU
Hossein	Maazallahi	UU
Malika	Menoud	UU
Pieter	Thijssen *	UU
Sylvia	Walter	UU
Thomas	Röckmann	UU
Camille	Yver-Kwok *	UVSQ
Gregoire	Broquet *	UVSQ
Isabelle	Pison *	UVSQ
Philippe	Bousquet *	UVSQ
Anja	Raznjevic *	WU
Chiel	van Heerwaarden *	WU
Maarten	Krol *	WU



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## Annex II - Gantt chart of ROMEEO timeline in general

Activities and tasks	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	Jul 20	Aug 20	Sep 20	Oct 20
<b>1 - campaign preparation and management</b>															
preparatory meetings	D1.1														
	D1.2														
pre-campaigns	D1.5	D1.10													
approval of flight permissions and flight plans	D1.3	D1.8													
Bottom-up inventories for selection of target areas	D1.4														
registration of drones		D1.6													
measurement protocol for well-scale quantification		D1.7													
CIP (Campaign Implementatin Plan) ready		D1.9													
Management															D1.11
<b>2 - Basin-scale campaign part</b>															
Flights executed according to CIP			D2.1												
			D2.2												
Raw data uploaded to ROMEEO repository			D2.3												
Calibrated data uploaded to ROMEEO repository				D2.4											
Aircraft-based basin scale mass balance calculations available								D2.5							
Identification of methane sources from raster flights								D2.6							
Collection and measurements of 100 air samples for isotope analysis			D2.7			D2.8									
FTIR measurements carried out, data provided and evaluated						D2.9									
<b>3 - Well-scale campaign part</b>															
measurement platforms prepared		D3.1													
measurements executed according to CIP			D3.2												
			D3.3												
Raw data uploaded to ROMEEO repository			D3.4												
Calibrated data uploaded to ROMEEO repository				D3.5											
Measurements evaluated with Gaussian plume model / particle dispersion model						D3.6									
						D3.8									
Intercalibration of instruments				D3.7											
Collection and measurements of 130 air samples for isotope analysis			D3.9			D3.10									
Leak detection and quantification on 3-7 selected facilities (SNIF)			D3.11												
<b>4 - City-scale campaign part</b>															
measurement platforms prepared	D4.1														
measurements executed according to CIP	D4.2														
preliminary evaluation of data and uploaded to ROMEEO repository	D4.3														
Calibrated data uploaded to ROMEEO repository	D4.4														
Collection and measurements of 75 air samples for isotope analysis	D4.5														
Isotope measurements on 75 air samples for source attribution (UU, RHUL)		D4.6													
<b>5 - Analysis and evaluation</b>															
Integration of available inventory data								D5.1							
City scale data fully evaluated and uploaded								D5.2							
publications prepared										D5.3		D5.5		D5.6	
Facility scale data integrdated, harmonized, and uploaded								D5.4							

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