EARSC
European Association of Remote Sensing Companies

EARTH OBSERVATION FOR METHANE MONITORING

Earth Observation Technological Feasibility Assessment

Proposal for a Regulation on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942

Article	Comment on Technological Feasibility
Context of the proposal (page 2) Reasons for and objectives of the proposal ● *Improve the accuracy of information on the main sources of methane emissions associated with energy produced and consumed within the EU.* ● *Improve the availability of information*	● Satellites are a cost-effective and proven system for observing emissions, providing accurate, reliable and frequently updated data to support decarbonization strategies[1] ● Satellite data is the only technology that can provide daily European-wide monitoring capabilities for monitoring methane, which is necessary for policy enforcement[2]. ● Satellite-derived data can provide regular detection and quantification of methane, especially in hard-to-reach areas or instances where extensive geographic coverage is required *(broad spatial coverage and repeat coverage datasets)*[3] ● Satellites provide a cost-effective and ready-to-go solution[4] to the provision of verifiable, incorruptible, standardised data sources ideal for policy enforcing.

[1] A recent paper documented the cost-effectiveness and efficacy of a tiered monitoring approach using GHGSat's satellite constellation and aircraft-based instruments in the oil and gas sector [Esparza et al., 2023]. Similarly, a recent modelling study concluded that tiered monitoring using satellites and aircraft will increase emissions reductions when compared to OGI surveys alone [Cardoso-Saldaña, 2023]. https://www.sciencedirect.com/science/article/pii/S1364032123001211 and https://pubs.acs.org/doi/10.1021/acs.est.2c08582

[2] Current areas where satellites are being used operationally are the Common Agricultural Policy, European Ground Motion Service, CleanSeaNet (by European Maritime Safety Agency)

[3] As stated in the "Estimating methane emissions" section of the "Global methane Tracker 2022 report" of the International Energy Agency, the "Satellites and better data will play a key role in improving policy"
"...Nevertheless the limitation due to cloud cover, reducing the number of days when detections can be made.. They can struggle to provide readings in many environments such as offshore areas, mountain ranges, and snowy or ice-covered regions, and at high latitudes....."

[4] A cheaper alternative to other technologies especially when large geographic coverage is required, by using an existing infrastructure. Even using commercial methane detecting satellites (in addition to free-public sources such as Sentinel 5P), the cost reduction is 55%.

(page 10) *…Methane emissions are increasingly subject to public attention, including scientific and stakeholder campaigns to detect and quantify emissions. Supported by increasing spatial and temporal resolution of satellite data, such public scrutiny is a valuable resource in monitoring the impact of the proposal and identifying shortcomings in implementation….* *The International Methane Emission Observatory will provide additional scrutiny of submitted methane emissions data, including the possibility to cross-reference them with other sources such as satellite imaging and products*	• New satellite missions are working to increase their spatial and spectral resolution in order to detect and accurately provide the location of every smaller emission - there are multiple methane monitoring satellites currently working at GSD (ground sample distance) of less than 25 m, which enables the detection and quantification of emissions at "facility" or even in the case of gas network operators at "asset scale", thus enabling effective leak detection, law enforcement and mitigation[5]. • Environmental agreements and targets are hard to enforce without independently verified data, but satellites alongside advances in computing can help monitor methane emissions (and other pollutants) helping to measure whether governments, methane emission generating sectors and even individual organisations and facilities are hitting their targets. There are increasing examples of scientists using satellite data to locate and quantify intentional (also known as venting), and unintentional methane releases all over the globe.[6]
(56) (page 22) *…It would provide methane emission data from different sources of fossil energy from around the globe - including from source-level estimations and measurements as well as from aerial/satellite monitoring…*	• Satellite-derived data and services complement and can be used alongside existing and future technologies to measure and map GHG emissions on a local, regional and global scale and can also identify specific emitting sources and provide almost real time data on GHG emissions sources (e g power plants) leakages or hotspots (e.g. emission anomalies such as methane leaks)
Article 2 - Definitions (page 25) *'site-level measurement' means a top-down measurement and typically involves the use of sensors mounted on a mobile platform, such as vehicles, drones, aircrafts, boats and satellites or other means to capture a complete overview of emissions across an entire site;*	• We recommend that co-legislators examine the possibility of a kind of top-down and tiered methane emissions monitoring approach,[7] In a tiered approach, a wide range of advanced technologies can be included.[8] Satellites which already have a detection threshold down to 100 kg/hr could monitor sites and networks (even those underground) at scale on a monthly basis, ensuring the quick detection of larger emissions. Airborne instruments with a detection threshold down to 10 kg/hr could be dispatched on a bimonthly basis with an emphasis on the high-risk areas identified by satellites. Finally, optical gas imaging (OGI) surveys could be performed on a yearly or year-and-a-half basis to detect and quantify the remaining much smaller emissions, again with an emphasis on the high-risk areas identified by airborne

[5] Private missions allows better resolutions to identify who exactly is causing the emission
[6] https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/Monitoring_methane_emissions_from_gas_pipelines
[7] I.e., Proposal by the US Environmental Protection Agency's (EPA) proposed rulemaking for Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources (EPA-HQ-OAR-2021-0317).https://www.regulations.gov/document/EPA-HQ-OAR-2021-0317-1460
[8] As referenced in IOGP, Gas Naturally Letter: Methane emissions reduction: call for a proportionate, efficient and implementable EU Regulation, https://iogpeurope.org/news/letter-methane-emissions-reduction-call-for-a-proportionate-efficient-and-implementable-eu-regulation/

	instruments. Such a tiered approach, coupled with timescale implementation, would detect and prioritise fixing of the biggest leaks quickly yet still allow for small leaks to be detected and fixed. There are a number of interesting papers on the cost and detection efficiency of such a tiered approach.[9] • Such a top-down and tired methane emissions monitoring approach could be easily tailored to allow for different monitoring and leak detection requirements for assets in different locations (above ground, below ground, above water, underwater etc.), made from different materials, installed at different times and carrying methane at different pressures.
Article 14 - Leak detection and repair (page 35) • *In carrying out the surveys, operators shall use devices that allow detection of loss of methane from components of 500 parts per million or more.* • *Operators shall repair or replace all components found to be emitting 500 parts per million or more of methane.*	**Units of measurement** • The use of parts per million as a detection unit is relevant mostly to terrestrial instrumentation and is hugely impacted by the distance of the sensor from the emission source and the environmental conditions at the time of measurement (windy, rainy). It is a scientific unit indicating the concentration at a single point, it says nothing about the total mass of methane being emitted. The use of ppm derives from a time when methane was only a safety issue when concentration levels became high enough for there to be a risk of explosion. Ideally, the proposal should reference parts per million column concentration with regard to satellite-derived methane monitoring data, or in a more advanced case kg/h. • For all types of satellite and non-satellite methane monitoring sensors conversion to kg/h will require modelling [10] (knowing wind speed and direction) **Satellite-based operational solutions** A list of all the current missions is available in the GEO booklet for GHG Monitoring from Space, and a generic table has been added as Annex 1 to illustrate on some of the ongoing and planned missions. Two examples of open source satellite data from the Copernicus programme: Sentinel 5p: (i) detection of methane emissions across very large areas (spatial resolution of 5.5 km by 7 km) (ii) minimum detection threshold is 5 tons of methane/h (iii) helps identify super-emitters with near daily readings of methane concentration globally over land and sea. Sentinel 2: (i) finer spatial resolution than Sentinel 5p (spatial resolution of 20 meters by 20 meters) (ii) minimum detection threshold is 0.5 tons of methane/h (iii) finer resolution helps to

[9] Analysis of a tiered top-down approach using satellite and aircraft platforms to monitor oil and gas facilities in the Permian basin [Esparza et al., 2023] . Tiered Leak Detection and Repair Programs at Oil and Gas Production Facilities [Cardoso-Saldaña, 2023].
[10] Here is an example where data is taken from ppm and given in kg/h: https://acp.copernicus.org/articles/22/9617/2022/

	pinpoint problem areas within a site or gas network with readings every week globally over land, limited offshore coverage. One operational commercial example: GHG-sat[11]: (i) spatial resolution of 25 m (ii) 100 kg h−1 for nominal conditions (iii) capture frequencies that can be tailored to the client's needs (iv) growing constellation that is providing increasing amounts of high-fidelity, actionable data to industrial operators worldwide. **<u>Satellite monitoring technology potential</u>**: ● Existing and new open source and commercial providers offering a range of spatial (pixel size) and temporal (revisit frequency) resolutions are looking at providing methane detection thresholds below the current 100 kg/hr detection thresholds.. ● There are already academic papers[12] which demonstrate the potential of the technology to continue to provide global coverage and high revisit frequencies with increasing detection accuracies.
Article 20 - Monitoring and reporting (page 39) Article 25 - Monitoring and reporting (page 41)	● Satellite-derived data and services can improve the deployment efficiency of other more sensitive monitoring methods by scanning large areas and automatically highlighting: ○ the super-emitters ○ the emitters of 100 kg/hr plus ○ specific areas with elevated emissions risks. This can drive a more effective use of the limited resources available to detect very small emitters, ● Satellite-derived data is globally consistent offering harmonised and comparable information facilitating the monitoring, verification and reporting process for ANY sector be that Energy, Agriculture, Oil & Gas, Industry etc. ● Cloud computing is effective in activating and mining large-scale heterogeneous data and has been widely applied to Remote Sensing Big Data (RSBD) over the past years[13]. As cloud platforms advance in technology, the sharing, processing and usage of satellite data has become increasingly efficient.
Article 29 - Methane emitters global monitoring tool (page 44) ● *By … [two years after the date of entry into force of the Regulation], the Commission shall establish a*	● As this field is rapidly evolving through technology and data processing innovations, EO satellites are increasingly capable of monitoring GHG emissions with precision at scale, and the EO sector is already offering data and services in an operational manner. It

[11] https://amt.copernicus.org/articles/14/2127/2021/amt-14-2127-2021.pdf
[12] Sentinel 2 SWIR bands paper: https://amt.copernicus.org/articles/14/2771/2021/
Worldview 3 SWIR bands paper:
https://www.researchgate.net/publication/354732769_Mapping_methane_plumes_at_very_high_spatial_resolution_with_the_WorldView-3_satellite
[13] https://www.tandfonline.com/doi/full/10.1080/17538947.2022.2115567

global methane monitoring tool based on satellite data and input from several certified data providers and services, including the Copernicus component of the EU Space Programme.	is important that the regulation explicitly allows current and upcoming open source and commercial satellite missions to: ○ be taken into consideration as independent verifiers ○ be included by Copernicus for the verification component of the Methane Strategy
Regulation on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942 (starts page 13) (36) flaring & venting "on-site"	● Flaring and venting release varying quantities of carbon dioxide and methane into the atmosphere, contributing to global warming and making it essential for regulators to keep close tabs on these activities. Tracking venting and flaring is essential and satellite-derived data can pinpoint the location and scale of these events. There are already operational services offering satellite-derived flaring activity tracking worldwide[14].

- The Earth Observation (EO) industry is indeed speedily **bringing additional, affordable, high resolution, accurate and frequent emissions monitoring**
- Linking EO with **cloud computing platforms** leading to a big data system which enables complex computing of current emission data and forecast modelling.
- Numerous **public, private sector and hybrid missions are currently in development**, which will further drive innovation and new findings in the field (see a generic state of the art provided below)
- Wide range of applications and services to rapidly detect methane emissions and leaks in a variety of gas **extraction, processing, storage, transmission and distribution settings**, covering large areas in a short time and therefore significantly **reducing the cost of the emissions monitoring and leak detection.**

[14] Wolrd Bank GGFR example https://www.worldbank.org/en/programs/gasflaringreduction/global-flaring-data

Annex 1
Non-exhaustive table of Satellite missions provided by Carles Debart from GHGSat Inc

Area Flux Mappers – Already In Orbit

Instrument	Organisation	Public Data	Launch Date	Pixel size (km)	Coverage	Revisit time (day)	Smallest rate detectable (kg/h)	Note	Reference
SCIAMACHY	ESA	Yes	2003	30x60	Global	~6	**70,000**	Global coverage. Mission was ended in 2012	Noel et al. 1999
GOSAT	JAXA, MOE, NIES	Yes	2009	10x10	Global	~3	**7,100**	Long-term record of high-quality data	Parker et al. 2020; Noel et al. 2022
TROPOMI - Sentinel-5P	ESA	Yes	2017	7x7	Global	~1	**4,000**	Global continuous daily coverage	Lorente et al. 2021

Area Flux Mappers – Future Instruments

Instrument	Organisation	Public Data	Launch Date	Pixel size (km)	Coverage	Revisit time (day)	Smallest rate detectable (kg/h)	Note	Reference
GO SAT-GW	JAXA, MOE, NIES	Yes	2023	1 x 1 & 10 x 10	Global + targets	3	**-**	High-resolution mapping of urban areas	NIES (2021)
MethaneSAT	EDF	Yes	2023	0.13 x 0.4	200x200 km2 targets	~1	**~500-1000**	High-resolution mapping, imaging of large point sources	Rohrscneider et al. 2021
Sentinel-5	ESA	Yes	2024	7.5 x 7.5	global	1	**4000**	Global continuous	ESA (2020)
GeoCarb	NASA	Yes	2025	6 x 3	North & South America	0.5	**4000**	Continuous coverage for CH4,CO2, CO	Moore et al 2018
CO2M	ESA	Yes	2025	2 x 2	global	5	**1000**	High-resolution global continuous coverage	Sierk et al 2019

Point Source Imagers – Already in orbit

Instrument	Organisation	Public Data	Launch Date	Pixel size (km)	Coverage	Revisit time (day)	Smallest rate detectable (kg/h)	Note	Reference

Landsat-8	USGS	Yes	2013	0.03 x 0.03	global	16	**1800-25000**	Global continuous data acquisition, long-term records	Ehret et al 2022; Irakulis et al 2022
WorldView-3	Digital Globe	No	2014	0.0037 x 0.0037	66.5x112 km2 targets	<1	**<100 for bright homogeneous surface**	Very high spatial resolution	Sanchez-Garcia et al 2022
Sentinel-2	ESA	Yes	2015	0.02 x 0.02	global	2-5	**1000-2500 depending on area**	Global continuous data acquisition, long-term records	Varon et al 2021
GHGSat C1-C11	GHGSat Inc	No	2016	0.025 x 0.025	12x12 km2 targets	~ 1	**100**	High sensitivity and revisit, established constellation, operational	Jervis et al 2021
PRISMA	ASI	Yes	2019	0.03 x 0.03	30x30 km2 targets	4	**500-2000 depending on area**	Medium sensitivity, extensive coverage	Guanter et al 2021

Point Source Imagers – Future Missions

Instrument	**Organisation**	**Public Data**	**Launch Date**	**Pixel size (km)**	**Coverage**	**Revisit time (day)**	**Smallest rate detectable (kg/h)**	**Note**	**Reference**
EnMAP	DLR	Yes	2022	0.03 x 0.03	30x30 km2	4	**100-1000**	Medium sensitivity	Cusworth et al 2019
EMIT	NASA	Yes	2022	0.06 x 0.06	Dust-emitting regions	3	**100-1000**	Surface mineral dust mapper on the ISS, target arid areas	Cusworth et al 2019
Carbon Mapper	Carbon Mapper and Planet	Yes	2023	0.03 x 0.03, 0.03 x 0.06	18 x1000 km2	1-7	**100**	High sensitivity	Duren 2021
GEISAT	SATLANTIS	No	2023	0.025 x 0.025	14 km2	4-7	**150**	In commissioning	