Latest Developments and Case Studies on Methane Measurement Technologies with Satellites and Aircrafts

Enhancing **planetary health**

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Agenda

1. Overview of Methane Emission Management
2. HiGHGuard® GHG Quantification Service by JGC
3. Technical Overview of Satellite/Aircraft Measurements
4. Organization Deploying Satellite Measurements
5. Measurement Examples by Satellites
6. Measurement Company List
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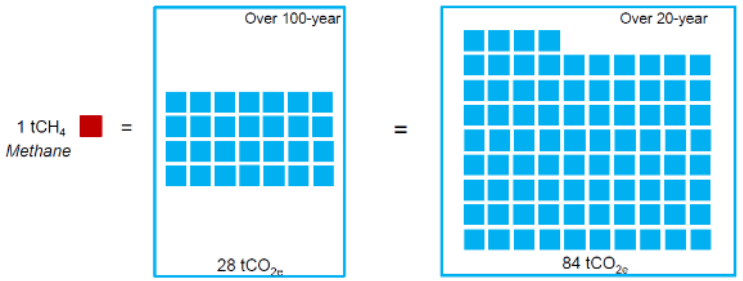
1. Overview of Methane Emission Management

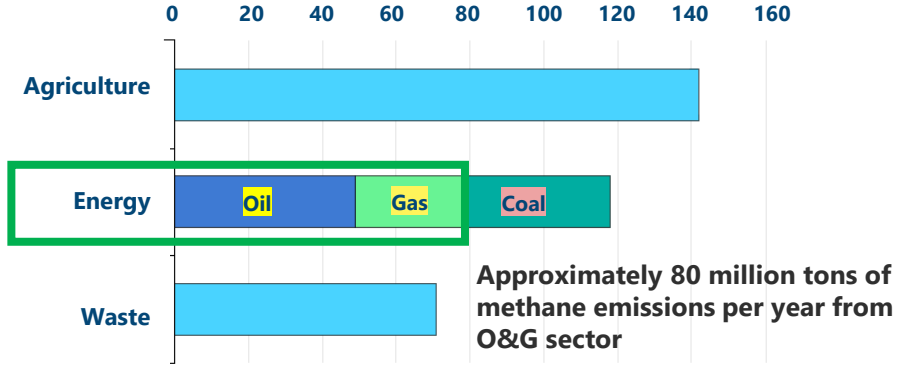
Why Methane is so Focused?

- Methane has global waring potential (GWP) approx. **28 times*1** greater than CO2 (IPCC Fifth Assessment Report)
- **Large amounts of methane are emitted from oil and gas sector.**
- Approximately half of the methane emitted from the plant can be **economically recoverable**.



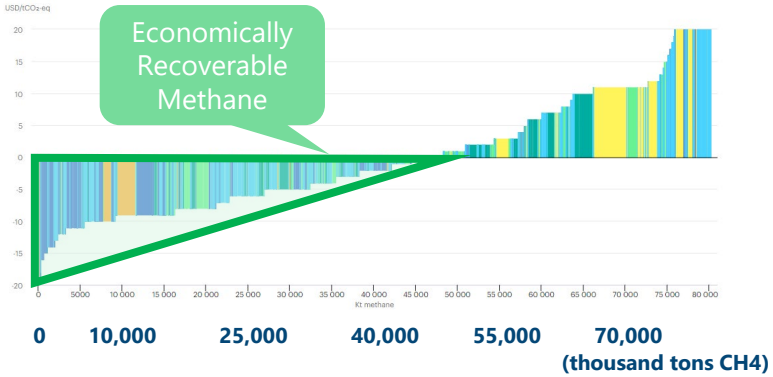
(※1) Approximately 28 times higher than the 100-year basis and 84 times higher than the 20-year basis.

Methane has high GWP



IEA Methane Tracker 2024

Methane Emission from O&G Sector



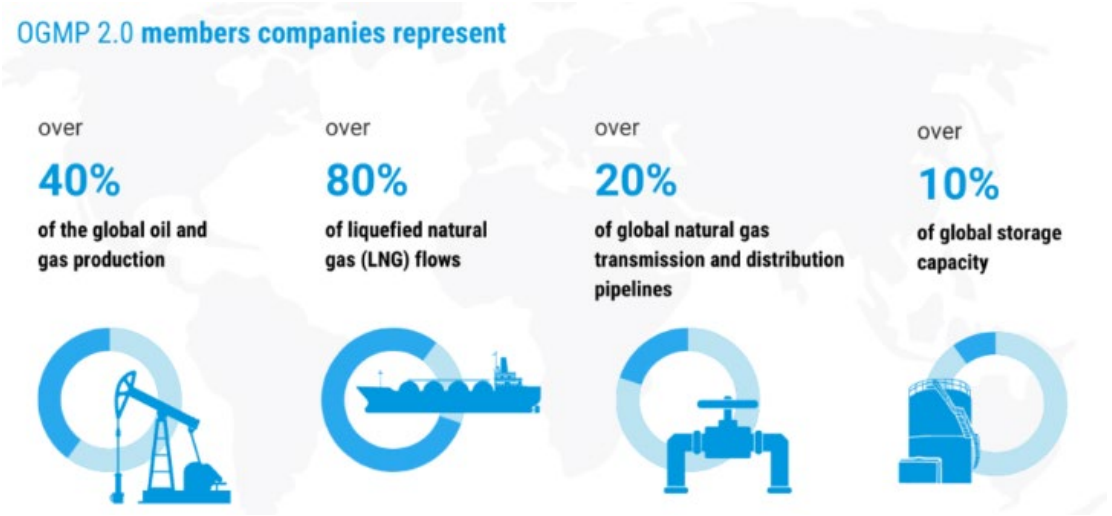
IEA Methane Tracker 2024

Methane emission reduction cost curve for O&G facilities

1. Overview of Methane Emission Management

Situation for Methane Abatement

EU Methane Regulation was adopted in April 2024, making **MRV(*) mandatory within the EU**, including actual measurements of methane emissions in accordance with **OGMP 2.0** requirements. Not only within the EU, but also for **imported energy**, MRV requirements and methane intensity requirements are imposed.



OGMP 2.0 is an initiative leading the methane MRV reporting framework, with over 150 member companies including the IOC, other NOCs such as PETRONAS, PERTAMINA, and INPEX. In total, these member companies account for 40% of global O&G production and over 80% of LNG flows.

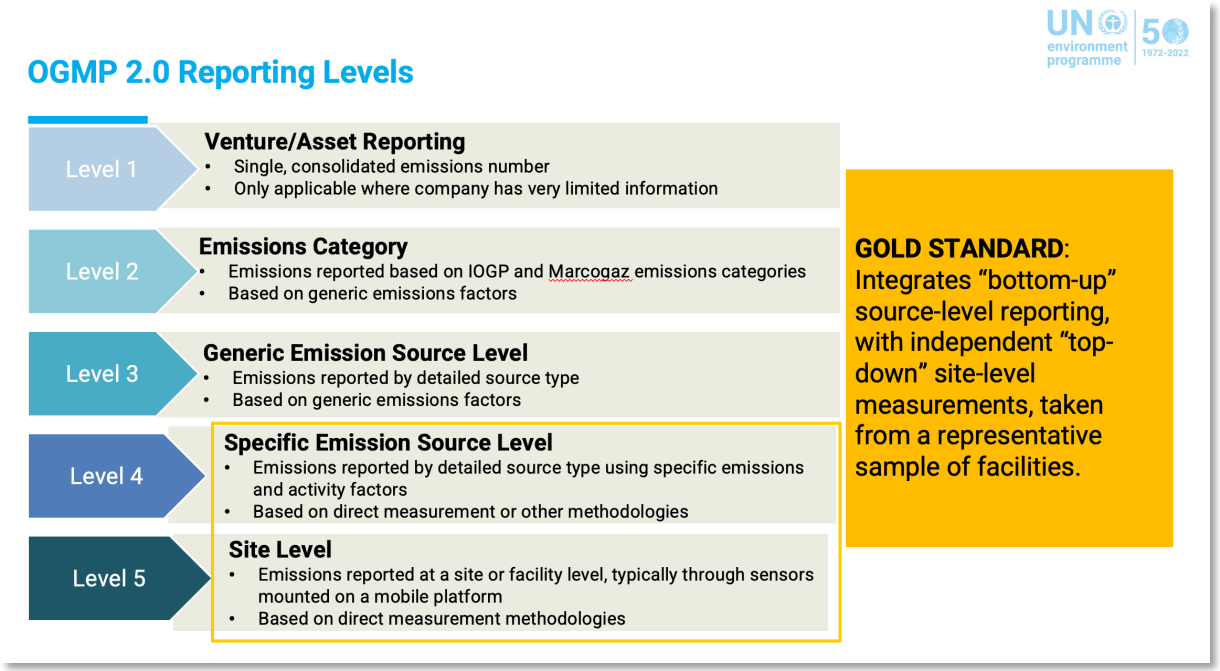
*** Measurement, Reporting and Verification**

1. Overview of Methane Emission Management

OGMP2.0 Reporting Framework

5 Reporting Levels

- **Level 1. Venture/Asset Reporting**
  → Business/asset level reporting: Report of single, consolidated emissions for all assets or countries
- **Level 2. Emissions Category**
  → Emission reporting based on emission categories (fugitive emission, venting etc.) established by IOGP and Marcogaz. Calculated using **generic emission factors**.
- **Level 3. Generic Emission Source Level**
  → Emission reporting by detailed source. Calculate using **generic emission factors**.
- **Level 4. Specific Emission Source Level**
  → Emission calculations shall be based on **specific emission factors** for each emission source, taking into account direct measurements.
- **Level 5. Site Level**
  → In addition to Level 4, perform direct measurements at the site or facility level and verify the Level 4 values.



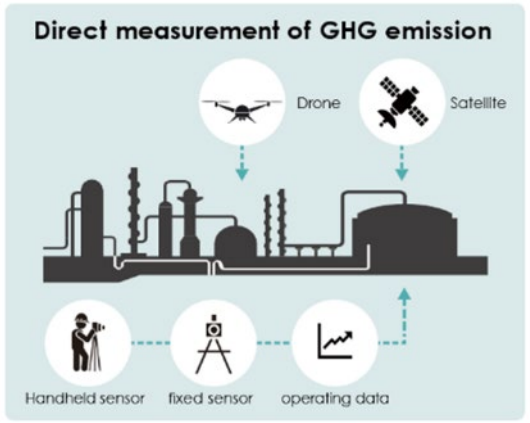
OGMP2.0 Reporting Level
Reference: UNEP

Level 4 and Level 5 are classified as Gold Standard, and partner companies are encouraged to obtain Gold Standard certification. It is also recommended that partner companies establish clear and reliable plans for achieving Gold Standard certification.

2. HiGHGuard® GHG Quantification Service by JGC

Initiative of Methane emission management

Total Engineering



1 Technical evaluation

- ✓ **Only company in Asia** to evaluate methane quantification technology in own facilities.

2 Project execution

- ✓ Methane emission quantification project

3 Technical consultation

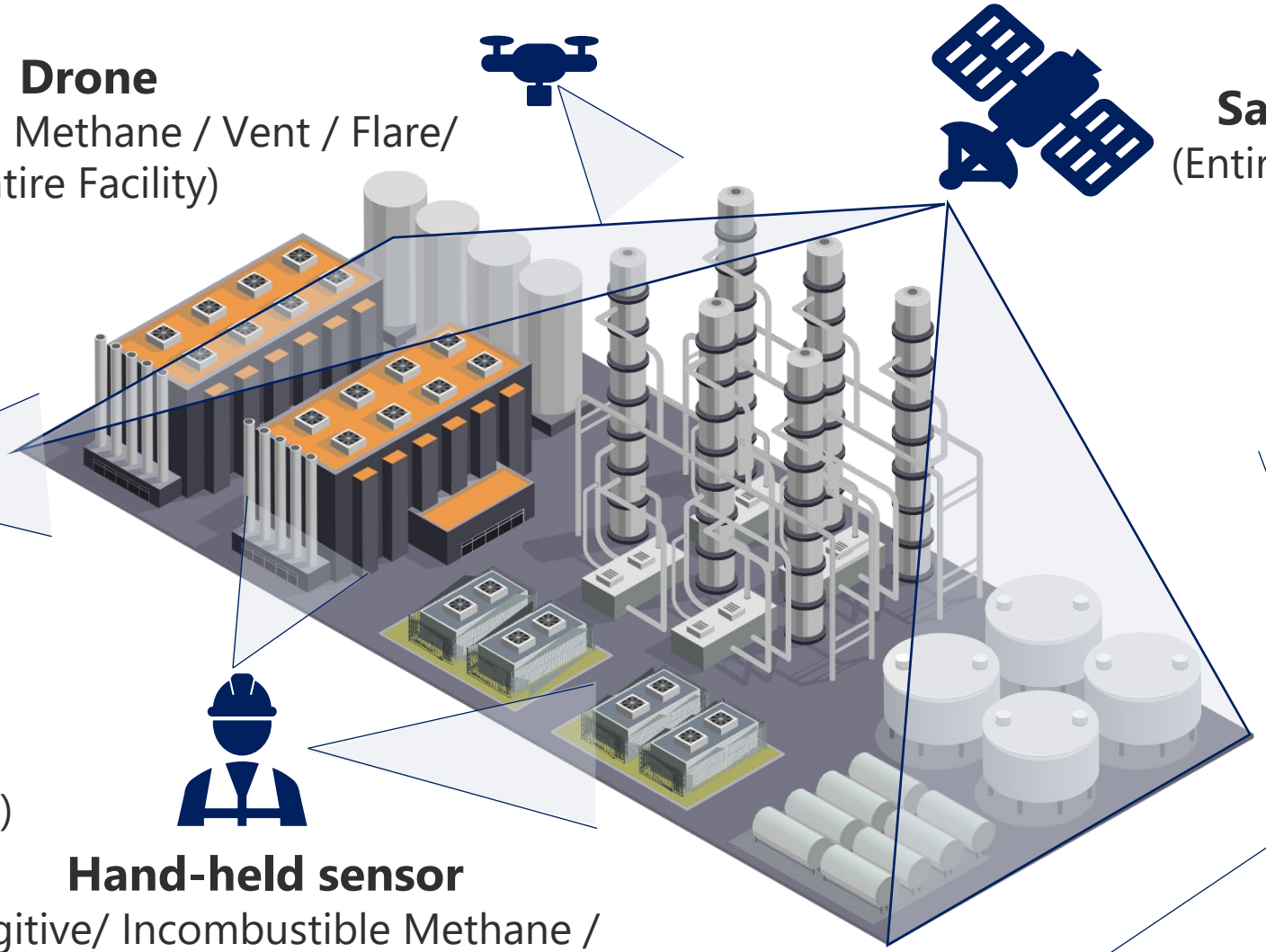
- ✓ Zero routine flare
- ✓ Operation optimization

Full range solution for methane abatement

What we can offer >>>

- ✓ Technical evaluation for methane quantification technology
- ✓ Project coordination and execution (**OGMP2.0 L4/L5 measurement**)
- ✓ **OGMP2.0 L4/L5 reporting, quantification**
- ✓ Technical consultation such as ZRF study

2. HiGHGuard® GHG Quantification Service by JGC



Drone
(Incombustible Methane / Vent / Flare/ Entire Facility)

Satellite
(Entire Facility)

OGI camera
(Fugitive/ Vent / Flare)

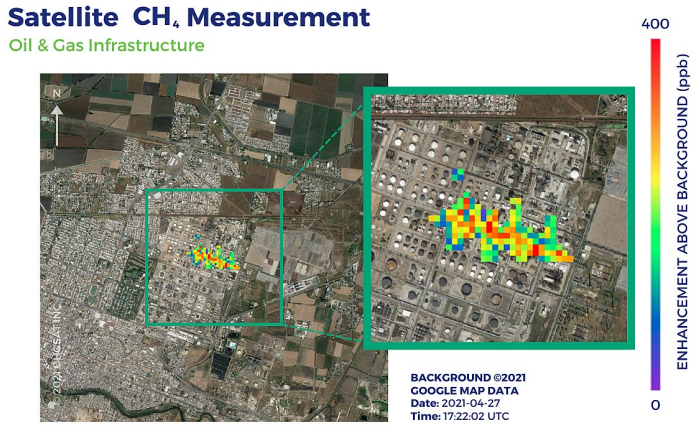
Hand-held sensor
(Fugitive/ Incombustible Methane / Vent)

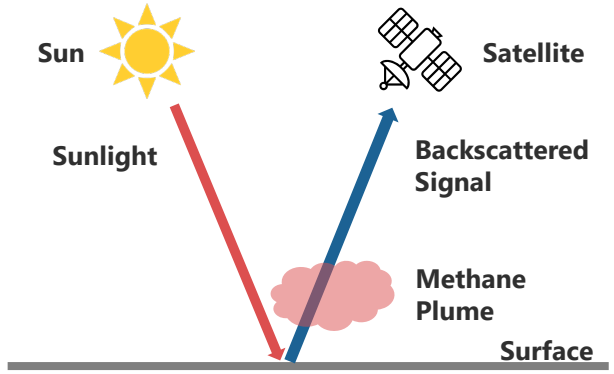
Operational Data Analysis
(Entire Facility)

3. Technical Overview of Satellite/Aircraft Measurements

Satellite

- The satellite fitted with sensors orbits the area of interest for the measurement.
- The major sensor technology is Shortwave Infrared (SWIR) Spectroscopy. Sensor detects how methane absorbs specific wavelengths of reflected sunlight.
- Measurement performance varies widely in sensor technologies; e.g. wide coverage & low resolution, or narrow coverage & high resolution.
- Detectable methane volume range is 100 – 4,200 kg/hr. Generally, higher resolution leads to lower detection limit.

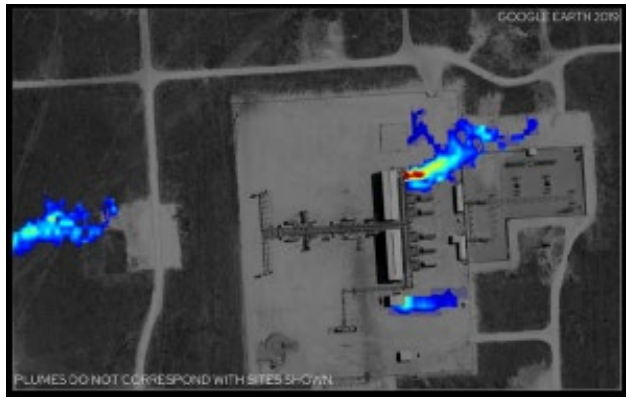


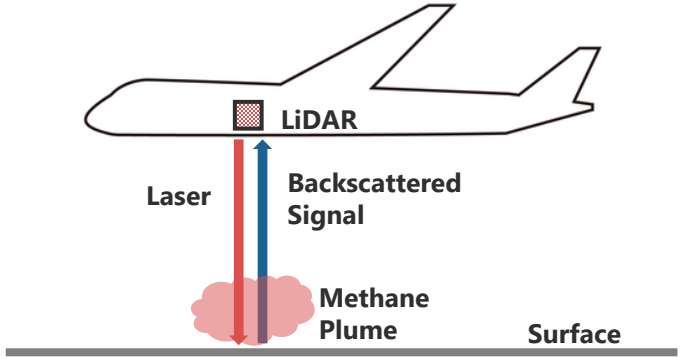


3. Technical Overview of Satellite/Aircraft Measurements

Aircraft

- The aircraft fitted with sensors flies over the area of interest at altitudes from hundreds of meters to over 10 km.
- The major detection technology is LiDAR. The system emits a laser beam to ground surface at a specific wavelength that is strongly absorbed by methane, and detects how methane absorbs in the backscattered signal.
- Detectable methane volume is 2.5 - 10 kg/hr depending on sensor technologies.





3. Technical Overview of Satellite/Aircraft Measurements

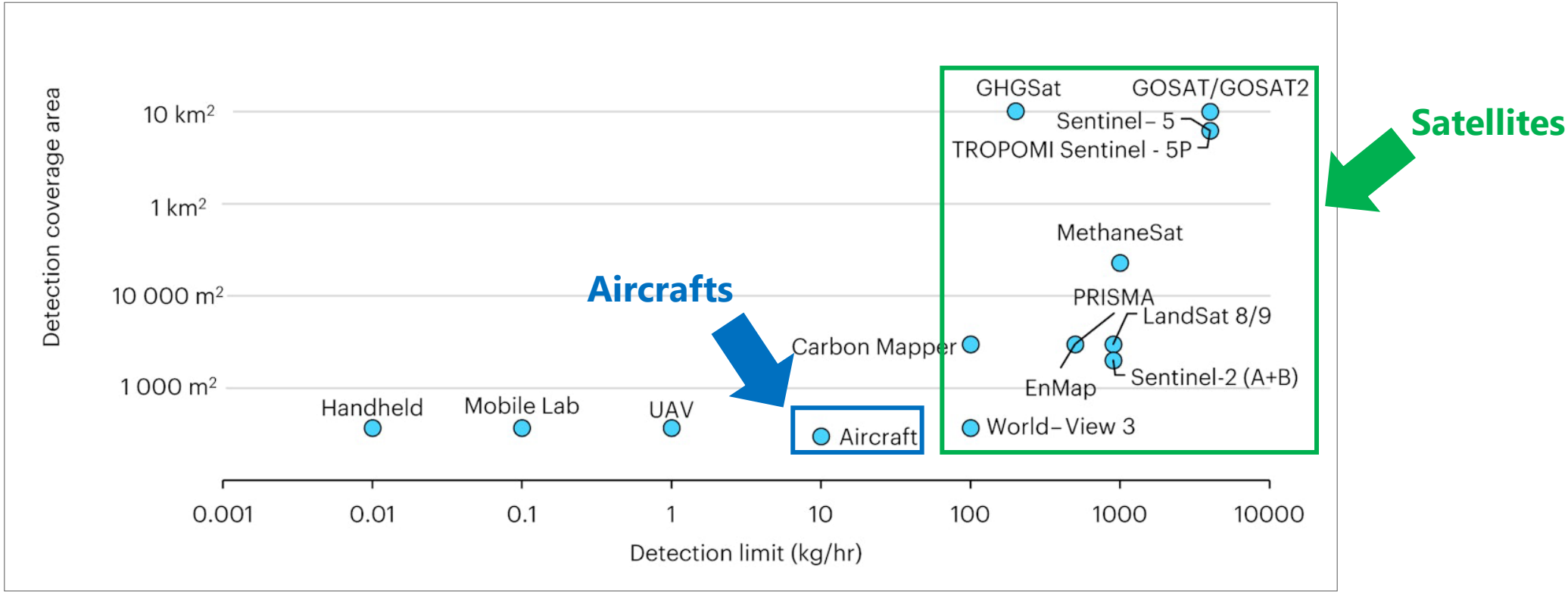
Technology	Satellite	Aircraft	At-site Measurement
Coverage	Global	Regional / Local	Local
Resolution	Low (tens to hundreds of meters)	Moderate (meters)	High (less than meters)
Min. Detection Limit	High (large plumes)	Moderate (moderate leaks)	Low (small leaks)
Revisit Frequency	Daily to weekly	On-demand	On-demand
Cloud Sensitivity	High	Low	Low
Offshore measurement	△(Limited)	○	○

3. Technical Overview of Satellite/Aircraft Measurements

Technology	Pros	Cons
Satellite 	1. Global coverage across the entire planet 2. Frequent revisit (daily/weekly) 3. Long-term monitoring 4. Suitable to detect “super emitter” 5. No entry to site	1. Highly dependent on weather condition (cannot measure through cloud cover) 2. Measurement area depends on orbit 3. Limited to offshore measurement (due to the characteristic of reflection from sea water) 4. Lower spatial resolution 5. Not suitable to component level measurement
Aircraft 	1. Higher spatial resolution (compared to satellite) 2. Suitable to detect “super emitter” 3. Suitable to offshore measurement 4. No entry to site	1. Higher measurement cost with aircraft operations 2. Measurement area is limited due to logistic of aircraft (take-off/landing points are required nearby the area of measurement) 3. Dependent on weather condition (flights may be affected by bad weather) 4. Spot measurement only

3. Technical Overview of Satellite/Aircraft Measurements

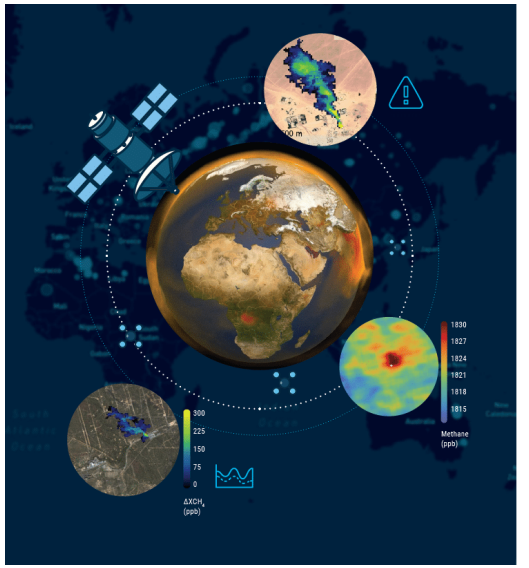
- Satellite measurement has wide range of detection limit and detection coverage area depending on their sensor technologies. Aircraft measurement has lower detection limit and detection coverage area than satellites.
- Satellite and aircraft measurements must be used considering the **higher minimum detection limit (kg/hr)** than other bottom-up measurement techniques.



Source: IEA, Reports, Global methane tracker 2024

4. Organization Deploying Satellite Measurements

- **IMEO's Methane Alert and Response System (MARS)** is the first public global satellite detection and notification system for methane emissions around the world. Using data from satellite instruments (TROPOMI, PRISMA, Sentinel-2, Landsat, EnMAP and EMIT), coupled with advanced AI, IMEO notifies governments and companies of emissions for mitigation action.



- **IEA's Global Methane Tracker 2024** incorporated satellite measurement results as part of their latest estimates of emissions across the sectors, combining with bottom-up monitoring.

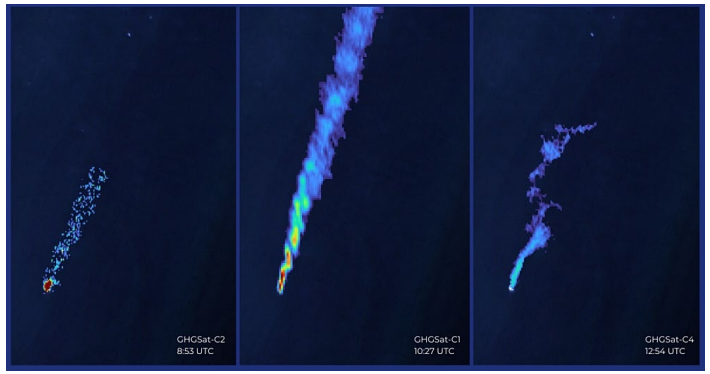
5. Measurement Examples by Satellites

1. Nord stream pipeline leaks

In September 2022, The Nord Stream pipeline leaks released a large amount of methane. This event is considered as the largest human-caused methane release in history.

Satellite was used for investigation of the emissions.

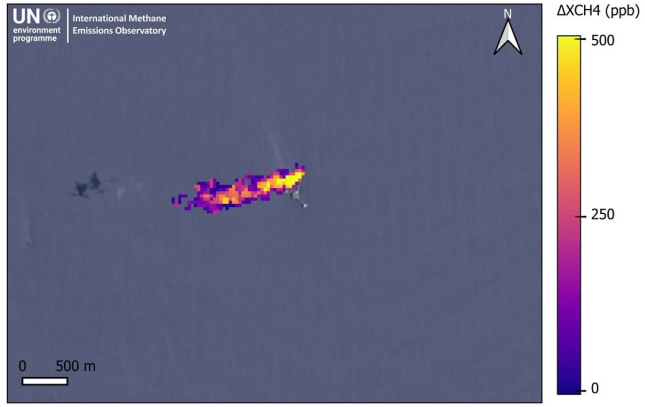
Source: Danish Ministry of Defense



Source: GHGSAT

2. Offshore leak from platform in the Gulf of Thailand

Emissions from a natural gas platform in the Gulf of Thailand, operated by a joint venture between PETRONAS and PTTEP have been observed at least 60 times by satellite since 2013.



Source: IMEO

5. Measurement Examples

3. GOSAT GW

The **G**lobal **O**bserving **SAT**ellite for **G**reenhouse gases and **W**ater cycle "IBUKI GW" (GOSAT-GW) was successfully launched on the H-IIA Launch Vehicle No. 50 from the Tanegashima Space Center on June 29, 2025.

In the LNG PCC 2025, it was stated that MOE, NIES and UNEP's IMEO will collaborate on the usage of data from GOSAT-GW.

Joint Statement on Technical Collaboration and Data Transparency on Methane Abatement from LNG Value Chain

On June 20, 2024, we, the Ministry of Economy, Trade and Industry of Japan (METI), the Ministry of Environment of Japan (MOE), Japan Organization for Metals and Energy Security (JOGMEC) and National Institute for Environmental Studies (NIES), Japan hereby issue this joint statement to pursue specific technical collaboration and data transparency to accelerate the reduction of methane emissions across the LNG value chain in collaboration with the International Methane Emissions Observatory hosted by the United Nations Environment Programme (IMEO).

4. MOE, NIES and UNEP's IMEO will collaborate on the usage of data from GOSAT-GW when it becomes available, and IMEO will integrate the data from GOSAT-GW into IMEO's Methane Alert and Response System (MARS), which notifies government and industry stakeholders of large emissions to enable swift mitigation.

6. Measurement Company List

Satellite

- More than **10** companies are providing satellite measurement services.
- Some companies launch satellite by themselves for the measurement, while the others processes the existing satellite measurement data with their own analysis technologies for quantification.

6. Measurement Company List

Aircraft

- More than **10** companies are providing aircraft measurement services.

Ball
FLYLOGIX
LIDAR SERVICES
SkySkopes
INSIGHT M
EXPLICIT emissions data
ADLARES
Xplorate
BRIDGER PHOTONICS
CHAMPIONX
PERGAM-SUISSE AG
SIERRA-OLYMPIA TECHNOLOGIES INC.
TELOPS

6. Measurement Company List

Satellite

#	Company Name	Base
1	GHGSat	USA
2	JAXA	Japan
3	ESA	EU (Headquarter in Paris)
4	KAYRROS	France
5	MethaneSAT	USA
6	CNES and DLR for MERLIN (Methane Remote Sensing Lidar Mission) Project	Germany and France
7	Bluefield	USA
8	Carbon Mapper	USA
9	Maxar Technologies	Canada
10	NASA / US Geological Survey (USGS)	USA

#	Company Name	Base
11	Orbital Sidekick	USA
12	SATLANTIS	USA
13	ASI	Italy
14	AIRMO	Germany

6. Measurement Company List

Aircraft

#	Company Name	Base
1	BRIDGER PHOTONICS	USA
2	Ball Aerospace	USA
3	FlyLogix	UK
4	LiDAR Service International	Canada
5	SkyScopes	USA
6	ChampionX	USA
7	PERGAM SUISSE	Swiss
8	ADLARES	Germany
9	Insight M	USA
10	Xplorate	Australia

#	Company Name	Base
11	Sierra Olympic	USA
12	Explicit	Denmark
13	TELOPS	Canada

7. Summary

- **Methane emission measurement is becoming more and more crucial in O&G sector**
- **JGC provides comprehensive services for methane emission management (HiGHGuard®)**
- **In OGMP2.0 framework, satellites and aircrafts measurements are considered as a key technology of Level-5 measurement combining with bottom-up approach**
- **Satellite and aircraft measurement is suitable to detect "super emitter" for wide coverage**
- **Methane measurement by satellites has some technical challenges at offshore, however recently it is becoming possible to perform the measurements**
- **Methane measurements by satellites are deployed by international organization such as IMEO and IEA**
- **The number of satellite and aircraft measurement companies is increasing, and it is expected that more measurement data will become available for use in the future.**